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# UC IPM

## Pest Management Guidelines:

# ASPARAGUS

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July 2016

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

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

**Note to readers:** These guidelines represent the best information currently available to the authors and are intended to help you in making the best choices for an IPM program. Not all formulations or registered materials 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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# Asparagus Year-Round IPM Program

(Reviewed 9/11)

## ANNUAL CHECKLIST

### Supplement to UC IPM Pest Management Guidelines: Asparagus

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

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

This year-round IPM program covers the major pests of fresh asparagus and nursery production of crowns in the Sacramento-San Joaquin River Delta, Central Coast, southern San Joaquin Valley, and southern desert valleys. Details on carrying out each practice, example monitoring forms, and information on additional pests can be found in the Pest Management Guidelines. Track your progress through the year with this annual checklist form.

Done	<b>Preplant</b> <b>Special issues of concern related to environmental quality: volatile organic compounds (VOCs)</b> <b>Mitigate pesticide effects on air and water quality.</b>
	Select the field: <ul style="list-style-type: none"><li>Consider soil type, cropping and pest history, and plant back restrictions from previous crop.</li><li>Select fields with no perennial weeds present.</li><li>Take a soil sample for nutrient, salinity, and pH analysis to determine field suitability and soil nutrient management.</li></ul> Select a field that has been rotated out of asparagus for a minimum of 7 years (preferably longer) to reduce Fusarium, weed problems, and salt buildup.
	Monitor for garden symphylans according to the Asparagus Pest Management Guidelines. If symphylans are present, consider preplant fumigation or planting the field to a different crop.
	Survey and manage weeds. <ul style="list-style-type: none"><li>Keep records, noting the presence, location, and extent of problematic weeds.</li><li>Preirrigate weeds and cultivate to reduce the weed seedbank.</li></ul>
	Clean equipment and tractors between fields to prevent the spread of soilborne diseases and weed seeds.
	Select an appropriate variety with good yield potential and disease resistance.
	Prepare the field: <ul style="list-style-type: none"><li>Consider drip irrigation for ease of pesticide application, water conservation, and to prevent offsite water and pesticide movement.</li><li>Disc to incorporate crop residues.</li><li>Apply fertilizer based on soil test results.</li><li>Prepare beds with good drainage.</li></ul>

◦ Done	<b>Planting through first year</b> <b>Special issues of concern related to environmental quality:</b> air quality. <b>Mitigate pesticide effects on air and water quality.</b>
	What should you be doing at this time?
	Acquire transplants from a nursery that fumigates or has clean stock.
	Examine ferns twice weekly for: <ul style="list-style-type: none"> <li>◦ European asparagus aphid—shake or beat ferns to detect presence, and consider burning where permitted or discing old ferns according to the Asparagus Pest Management Guidelines.</li> <li>◦ Beet armyworm—treat according to the Asparagus Pest Management Guidelines when larvae are present in the ferns.</li> <li>◦ Rust lesions—treat according to the Asparagus Pest Management Guidelines when rust first appears.</li> </ul>
	Manage weeds: <ul style="list-style-type: none"> <li>◦ Choose appropriate preemergence herbicides based on planting method (seedlings versus crowns).</li> <li>◦ Cultivate if needed until ferns become too tall.</li> <li>◦ Spot spray herbicides to eliminate perennial weeds that may be invading the site.</li> <li>◦ Prevent the introduction of perennial weed propagules by cleaning equipment before entering the field.</li> </ul>
	If thrips damage is observed (needle drop), treat according to the Asparagus Pest Management Guidelines.
	Other pests you may see: <ul style="list-style-type: none"> <li>◦ Asparagus beetle</li> <li>◦ Asparagus miner</li> <li>◦ Western yellowstriped armyworm</li> </ul>

  

◦ Done	<b>First year through dormant season</b> <b>Mitigate pesticide effects on air and water quality.</b>
	Chop and incorporate, or burn where allowed, any fern growth.
	Destroy volunteer asparagus outside the field.
	Manage weeds according to the Asparagus Pest Management Guidelines.

  

◦ Done	<b>Spear emergence through harvest</b> <b>Special issues of concern related to environmental quality:</b> runoff <b>Mitigate pesticide effects on air and water quality.</b>
	On spears, look for: <ul style="list-style-type: none"> <li>◦ Cutworm damage</li> <li>◦ Garden symphylan damage and note for future management</li> <li>◦ Rust lesions</li> <li>◦ Crown and spear rot</li> <li>◦ Purple spot lesions</li> </ul> Treat as needed according to the Asparagus Pest Management Guidelines.

◦ Done	<b>Spear emergence through harvest</b> <b>Special issues of concern related to environmental quality:</b> runoff <b>Mitigate pesticide effects on air and water quality.</b>
	Manage weeds: <ul style="list-style-type: none"> <li>◦ Cultivate weeds when shaping beds for the harvest season.</li> <li>◦ Apply appropriate preemergence herbicides for the weed spectrum at the site.</li> <li>◦ Apply herbicides during the harvest period to control weeds that were not controlled by preemergence herbicides.</li> <li>◦ Monitor for new invasions of perennial weeds and control by hand or spot spraying as appropriate.</li> </ul>
	If crown and spear rot is observed during harvest treat according to the Asparagus Pest Management Guidelines.
	End harvest when production declines to 70% of the season's highest yield to maintain crown vigor.
◦ Done	<b>Postharvest (fern stage: end of harvest to beginning of dormancy)</b> <b>Special issues of concern related to environmental quality:</b> air quality, runoff or leaching, drift, and tailwater runoff. <b>Mitigate pesticide effects on air and water quality.</b>
	Monitor for European asparagus aphid and their damage: <ul style="list-style-type: none"> <li>◦ Shake or beat samples to look for aphids and their natural enemies.</li> <li>◦ Look for bonsai growth.</li> <li>◦ Treat according to the Asparagus Pest Management Guidelines.</li> </ul>
	Examine ferns twice weekly for: <ul style="list-style-type: none"> <li>◦ Beet armyworm—treat according to Asparagus Pest Management Guidelines when larvae are visibly present in the ferns.</li> <li>◦ Rust lesions—treat according to the Asparagus Pest Management Guidelines when rust first appears.</li> </ul>
	If thrips damage is detected (needle drop), treat according to the Asparagus Pest Management Guidelines.
	Manage weeds: <ul style="list-style-type: none"> <li>◦ Till beds after final harvest.</li> <li>◦ Apply herbicides to control perennial weeds such as bermudagrass.</li> <li>◦ Cultivate weeds if necessary just before ferns grow too tall for tractors to enter the field.</li> </ul>
	Other pests you may see: <ul style="list-style-type: none"> <li>◦ Asparagus beetle</li> <li>◦ Asparagus miner</li> <li>◦ Western yellowstriped armyworms</li> </ul>
◦ Done	<b>Dormant season</b> <b>Mitigate pesticide effects on air and water quality.</b>
	Clean field of crop debris by thoroughly discing (or burning where permitted) to reduce European asparagus aphid, asparagus miner, cutworm, purple spot, and rust.
	After ferns are chopped, apply an herbicide according to the Asparagus Pest Management Guidelines.
	Destroy volunteer asparagus outside the field.

Done	<b>Pesticide application checklist</b> When planning for possible pesticide applications in an IPM program, consult the Pest Management Guidelines, and review and complete this checklist to consider practices that minimize environmental and efficacy problems.
	<ul style="list-style-type: none"> <li>Choose a pesticide from the Pest Management Guidelines for the target pest, considering:           <ul style="list-style-type: none"> <li>Impact on natural enemies and pollinators. For more information see Protecting Natural Enemies and Pollinators at <a href="http://www.ipm.ucdavis.edu/mitigation/protect_beneficials.html">http://www.ipm.ucdavis.edu/mitigation/protect_beneficials.html</a>.</li> <li>Potential for water quality problems using the UC IPM WaterTox database. See <a href="http://www.ipm.ucdavis.edu/TOX/simplewatertox.html">www.ipm.ucdavis.edu/TOX/simplewatertox.html</a>.</li> <li>Impact on aquatic invertebrates. For more information, see <i>Pesticide Choice</i>, UC ANR Publication 8161 (PDF), <a href="http://anrcatalog.ucdavis.edu/pdf/8161.pdf">http://anrcatalog.ucdavis.edu/pdf/8161.pdf</a>.</li> <li>Chemical mode of action, if pesticide resistance is an issue. For more information, see <i>Herbicide Resistance: Definition and Management Strategies</i>, UC ANR Publication 8012 (PDF), <a href="http://anrcatalog.ucdavis.edu/pdf/8012.pdf">http://anrcatalog.ucdavis.edu/pdf/8012.pdf</a>.</li> <li>Endangered species that may be near your site. Find out using the Department of Pesticide Regulation's PRESCRIBE program. (<a href="http://www.cdpr.ca.gov/docs/endspec/prescint.htm">http://www.cdpr.ca.gov/docs/endspec/prescint.htm</a>)</li> </ul> </li> </ul>
	<b>Before an application</b>
	Ensure that spray equipment is properly calibrated to deliver the desired pesticide amount for optimal coverage. (See <a href="http://www.ipm.ucdavis.edu/training/incorporating-calibration.html">www.ipm.ucdavis.edu/training/incorporating-calibration.html</a> )
	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. <ul style="list-style-type: none"> <li>Wind speed over 5 mph</li> <li>Temperature inversions</li> <li>Just prior to rain or irrigation (unless it is an appropriate amount, such as when incorporating a soil-applied pesticide)</li> <li>At tractor speeds over 2 mph</li> </ul>
	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).
	<b>After an application</b>
	Record application date, product used, rate, and location of application.
	Follow up to confirm that treatment was effective.
	<b>Consider water management practices that reduce pesticide movement off-site.</b>
	Consult relevant publications <ul style="list-style-type: none"> <li><i>Reducing Runoff from Irrigated Lands: Orchard Floor Management Practices to Reduce Erosion and Protect Water Quality</i>, UC ANR Publication 8202 (PDF), <a href="http://anrcatalog.ucdavis.edu/pdf/8202.pdf">http://anrcatalog.ucdavis.edu/pdf/8202.pdf</a>.</li> <li><i>Reducing Runoff from Irrigated Lands: Causes and Management of Runoff from Surface Irrigation in Orchards</i>, UC ANR Publication 8214 (PDF), <a href="http://anrcatalog.ucdavis.edu/pdf/8214.pdf">http://anrcatalog.ucdavis.edu/pdf/8214.pdf</a>.</li> <li><i>Protecting Surface Water from Sediment-Associated Pesticides in Furrow-Irrigated Crops</i>, UC ANR Publication 8403 (PDF), <a href="http://anrcatalog.ucdavis.edu/pdf/8403.pdf">http://anrcatalog.ucdavis.edu/pdf/8403.pdf</a>.</li> </ul>
	Consult the Department of Pesticide Regulation Groundwater Protection Program (GWPA) Web site for pesticide information and mitigation measures. ( <a href="http://www.cdpr.ca.gov">http://www.cdpr.ca.gov</a> )
	Install an irrigation recirculation or storage and reuse system. Redesign inlets into tailwater ditches to reduce erosion.
	Use drip rather than sprinkler or flood irrigation.

<ul style="list-style-type: none"> <li>Done</li> </ul>	<b>Pesticide application checklist</b> When planning for possible pesticide applications in an IPM program, consult the Pest Management Guidelines, and review and complete this checklist to consider practices that minimize environmental and efficacy problems.
	Limit irrigation to amount required using soil moisture monitoring and evapotranspiration (ET). (For more information, see <i>Reducing Runoff from Irrigated Lands: Understanding Your Orchard's Water Requirements</i> , UC ANR Publication 8212 (PDF), <a href="http://anrcatalog.ucdavis.edu/pdf/8212.pdf">http://anrcatalog.ucdavis.edu/pdf/8212.pdf</a> .)
	Consider using cover crops.
	Consider vegetative filter strips or ditches. (For more information, see <i>Vegetative Filter Strips</i> , UC ANR Publication 8195 (PDF), <a href="http://anrcatalog.ucdavis.edu/pdf/8195.pdf">http://anrcatalog.ucdavis.edu/pdf/8195.pdf</a> .)
	Apply polyacrylamides in furrow and sprinkler irrigation systems to prevent off-site movement of sediments.
	Redesign inlets and outlets into tailwater ditches to reduce erosion. (For more information, see <i>Reducing Runoff from Irrigated Lands: Tailwater Return Systems</i> , <a href="http://anrcatalog.ucdavis.edu/pdf/8225.pdf">http://anrcatalog.ucdavis.edu/pdf/8225.pdf</a> .)
	<ul style="list-style-type: none"> <li>Consider practices that reduce air quality problems.</li> </ul>
	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.

## General Information

(Section reviewed 2/12)

# RELATIVE TOXICITIES OF INSECTICIDES USED IN ASPARAGUS TO NATURAL ENEMIES AND HONEY BEES (2/12)

Common name (trade name)	Mode of action <sup>1</sup>	Selectivity <sup>2</sup> (affected groups)	Predatory mites <sup>3</sup>	General predators <sup>4</sup>	Parasites <sup>4</sup>	Honey bees <sup>5</sup>	Duration of impact to natural enemies <sup>6</sup>
<i>Bacillus thuringiensis</i> ssp. <i>Aizawai</i>	11A	narrow (caterpillars)	L	L	L	II	short
carbaryl (Sevin) bait	1A	narrow (cutworms, army- worms, etc.)	L	L	L	III	short
carbaryl (Sevin) XLR Plus	1A	broad (insects)	L	H	H	I	long
chlorantraniliprole (Coragen)	28	narrow (primarily caterpillars)	L	L	L/M	III	short
chlorpyrifos (Lorsban)	1B	broad (insects, mites)	M	H	H	I	moderate
methomyl (Lannate)	1A	broad (insects)	H	H	H	I	moderate
permethrin (Ambush, Pounce)	3A	broad (insects)	L	H	H	I	long
petroleum oils	un	broad (exposed insects)	L <sup>7</sup>	L	L	II	short
pymetrozine (Fulfill)	9B	narrow (aphids)	L	L	L	II	short
pyrethrin (PyGanic)	3A	broad (insects)	—	M	M	I	short
spinetoram (Radiant)	5	narrow (caterpillars, thrips, aphids)	L/H	M <sup>8</sup>	L/M	II	moderate <sup>9</sup>
spinosad (Entrust, Success)	5	narrow (caterpillars, thrips, aphids)	L/H	M <sup>8</sup>	L/M	II	short to moderate <sup>8</sup>

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

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 Web site at <http://www.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 Ratings (*available online at <http://ipm.ucanr.edu/beeprcaution/>*).

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

7 Rating depends on rate used.

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

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

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



## IRRIGATION (7/13)

Efficient irrigation is required for high crop productivity, control of soilborne pathogens, and environmental water quality. In the San Joaquin and Central Coast production regions, typically 1.5 to 2.5 feet of water is applied annually, with 4 to 5 feet applied in the Imperial Valley. In some areas of the Delta, asparagus crops may be supplied with much of their water from a shallow water table.

A good irrigation program follows these basic guidelines.

- Monitor soil moisture using the feel and appearance method or tools such as tensiometers or gypsum blocks.
- Apply irrigation water according to crop evapotranspiration (ETc) to assure plant needs are met through all growth stages and reduce incidence of diseases such as crown and spear rot.
- Keep records of irrigation and rainfall amounts.
- Do not irrigate deeper or more frequently than necessary.
- Avoid applying too much water to prevent soil oversaturation (soil with moisture in excess of levels recommended for the current stage of growth).
- Use efficient irrigation systems designed to give uniform water distribution.

### IRRIGATION METHODS

#### Furrow irrigation

Irrigation frequency varies with the climate, soil type and water table, but ranges from 10 to 30 days or more. Typically 3 to 6 inches of water is applied at each irrigation, depending on soil texture and the degree of water depletion since the previous irrigation.

#### Drip irrigation

Subsurface drip irrigation systems are the most efficient, typically requiring 10 to 20% less water than sprinklers and they can be used to apply fertilizer and some pesticides (e.g., fertigation or chemigation). They also allow for irrigation during the harvest period without interfering with crews and equipment. Furthermore, this irrigation method eliminates surface runoff. However, drip systems require significant resources to maintain and management may be particularly challenging when used on very coarse or very heavy soils. Rodents may need to be controlled to prevent damage to buried drip systems.

One line of drip tape per bed is placed 3 to 6 inches below the depth of the crown. Use tapes at least 10 ml thick to prevent puncture; thicker is better. Time between drip irrigations can range from once per week early in the season to 2 to 3 times per week during peak water demand.

### IRRIGATION AT THE DIFFERENT GROWTH STAGES

#### Stand Establishment

During the first year the crop is small so evapotranspiration and the crop coefficient are low; therefore, irrigation is required infrequently.

#### Mature Asparagus

##### Spear growth to harvest

In desert regions where rainfall is low, irrigations are scheduled preharvest to moisten soil and periodically during harvest. Irrigating during harvest is also recommended for crops in Central Coast areas due to the long harvest period. In furrow-irrigated fields, irrigation is often applied to alternate furrows so workers can walk through dry furrows instead of bed tops.

##### Postharvest

During the fern stage, irrigate to match the ETc demand of the crop. See below for information on scheduling irrigation. As the fern begins to senesce in the fall, cease irrigation to deter new growth as the crop approaches dormancy.

##### Dormant Season

Depending on the growing region, the soil profile is replenished during dormancy by winter rains, irrigation, or flooding.

## IRRIGATION SCHEDULING

Timing of irrigation during the growing season is based on soil moisture measurements and a water budget, which can be determined using evapotranspiration data. A combination of methods is usually best and disease potential must be considered.

### Monitoring soil moisture

A major factor in determining the allowable soil moisture depletions is soil texture; clay loam soils hold more water than do sandy loams and, therefore, have longer intervals between irrigations. For typical asparagus plantings, avoid exceeding depletion of more than 50% of the soil's water holding capacity; that is equivalent to approximately 40 to 80 centibars of tension. Detailed information on determining allowable soil moisture depletions and on developing an irrigation schedule is in *Scheduling Irrigations: When and How Much Water to Apply*, UC ANR Publication No. 3396.

Always check soil moisture before applying water and estimate how much available water remains in the crop rooting depth. Use a soil tube to take soil from the rooting zone at several points in each field. The feel and appearance of the soil as outlined in the table below can be used as a guide for judging the depletion level in soil taken from the root zone.

### Judging Depletion of Soil Water by Feel and Appearance.

Coarse-textured soils	Inches of water needed <sup>1</sup>	Medium-textured soils	Inches of water needed <sup>1</sup>	Fine-textured soils	Inches of water needed <sup>1</sup>
Soil looks and feels moist, forms a cast or ball, and stains hand.	0.0	Soil dark, feels smooth, and ribbons out between fingers; leaves wet outline on hand.	0.0	Soil dark, may feel sticky, stains hand; ribbons easily when squeezed and forms a good ball.	0.0
Soil dark, stains hand slightly; forms a weak ball when squeezed.	0.3	Soil dark, feels slick, stains hand; works easily and forms ball or cast.	0.5	Soil dark, feels slick, stains hand; ribbons easily and forms a good ball.	0.7
Soil forms a fragile cast when squeezed.	0.6	Soil crumbly but may form a weak cast when squeezed.	1.0	Soil crumbly but pliable; forms cast or ball, will ribbon; stains hand slightly.	1.4
Soil dry, loose, crumbly.	1.0	Soil crumbly, powdery; barely keeps shape when squeezed.	1.5	Soil hard, firm, cracked; too stiff to work or ribbon.	2.0

<sup>1</sup> Amount needed to restore 1 foot of soil depth to field capacity when soil is in the condition indicated.

Water needs may vary from one part of a field to another, especially if the field includes different soil types or slopes. Plants in a sandy streak or where water holding capacity is less, may show stress sooner than the rest of the crop. Watch these weak areas to gain advance notice of when irrigation is needed for the rest of the field. However, schedule irrigations according to the need shown by most of the crop.

Instruments are available that measure the moisture content of the soil such as tensiometers, gypsum blocks, and neutron probes. To obtain reliable readings, you must install these instruments in areas representative of the field, or spots where water stress occurs more readily. At each site, install one soil moisture probe at the rooting depth of the current growth stage, and a second probe 24 inches deep. Follow the recommendations of irrigation experts in using soil probes for irrigation scheduling. Aerial infrared photography can also help identify areas of moisture stress within fields.

### Estimating ETc

Soil moisture can be monitored indirectly using a water budget to estimate how much water the crop uses daily, considering climatic conditions, planting time, and crop season. However, while water budgets provide estimates of crop water use, there are many variable factors such as cultivar, disease, weeds, insects, physical characteristics of individual fields, and management factors that affect actual water use. It is recommended to Using a direct measurement of soil moisture is recommended when making the final decision about when to irrigate.

Crop evapotranspiration (ETc) is the crop water use, determined by evaporation of water from the soil and transpiration of water from plant leaves. If you know how much available water is in the crop rooting depth at

field capacity and how much is lost through ET each day, you can estimate the remaining water at any time by adding the daily ET values.

Calculate the ET between irrigations with the equation:  $ET_c = K_c \times ET_o$

where  $K_c$  is the crop coefficient, and  $ET_o$  is the reference crop evapotranspiration, which can be found on the CIMIS website (CIMIS = California Irrigation Management Information System) in daily, real-time, or monthly average values.

### **Salinity**

Soil salinity is the level of soluble salts present; low salinity is desirable. As soil salinity increases, the likelihood of crop damage increases and remedial actions are justified. Actions include leaching the soil profile, using overhead sprinklers to create a zone of lower concentration around the seedlings or transplants, and switching to a higher-quality irrigation source to prevent further buildup (high soil salinity could be the result of using marginal-quality irrigation water). However, studies have shown asparagus is quite salt-tolerant, with soil salinity values of up to 6 dS/m (deciSiemens per meter) having little to no impact on yield.

## FERTILIZATION<sup>(7/13)</sup>

Soil testing is the primary tool for assessing phosphorus (P) and potassium (K) nutritional needs of asparagus before planting and for established plantings of asparagus. Nitrogen (N) fertilization follows general guidelines based on the age of asparagus and is discussed below. Excessive applications of N and P can be detrimental to the environment through runoff into surface waters. Nitrates can also leach into groundwater. Careful management of these nutrients can minimize these environmental problems.

### PREPLANT

Preplant fertilization of P and K should be based on soil tests. For the most accurate estimation of soil nutrient availability, collect and analyze soil. Although asparagus roots can extend 3 to 4 feet deep, collecting soil from the top 12 inches is sufficient to obtain accurate results. Collect a composite sample of a minimum of 12 soil cores from each field; if zones of different soil texture exist within the same field, take separate samples to represent each major soil type. The following table suggests appropriate soil levels for phosphorus and potassium:

#### Element (soil test procedure)

Soil test interpretation	Phosphorus (Bicarbonate extraction) in ppm	Potassium (ammonium acetate extraction) in ppm
Low	<10	<200
Medium	10–15	100–150
High	>15	>100

Key: < = less than; > = greater than; ppm = parts per million

For phosphorus and potassium, a low soil-test value suggests the need to fertilize; at medium soil levels, yield response to fertilizer application is possible; at high soil levels, yield response is less likely. Phosphorus is generally applied preplant as a banded or broadcast application prior to direct seeding or planting transplants or crowns; potassium can be applied preplant, sidedressed during fern stage, or fertigated (injected into drip irrigation water) during the growing season or when planting crowns.

When preparing a field for an asparagus planting, it is recommended to add no more than 100 pounds of phosphate ( $P_2O_5$ ) per acre when soil levels are greater than 20 ppm, and 200 pounds or more for soil levels of 10 ppm or less. For fields with soil K-test values of less than 100 ppm, up to 200 lb potassium (K<sub>2</sub>O) per acre can be applied.

### Early Establishment

The use of soil tests for nitrogen management in asparagus has not been researched. A moderate nitrogen application (100 lb nitrogen/acre) is recommended to build up the crown tissue for the first year of fern growth. However, the first 2 to 3 years after establishment, higher rates of up to 200 lb nitrogen per acre are warranted in order to build up nitrogen levels in the crowns of the plant.

### Established Asparagus

Once an asparagus planting is established and producing, the annual phosphorous and potassium removal is modest; maintenance applications in the range of 50 lb  $P_2O_5$  per acre and 50 to 75 lb K<sub>2</sub>O per acre should be sufficient to maintain soil fertility. Fertilization timing varies widely, but phosphorous and potassium are generally applied before the harvest period.

Maintenance levels of nitrogen in the range of 100 to 150 lb per acre should be sufficient to maximize yield. Application timing varies, but nitrogen applications are commonly split between the preharvest and postharvest period. Nitrogen application is most efficient during active fern growth.

In established asparagus, nutrients are typically applied as a sidedressing but can be applied through fertigation if drip irrigation is used.

## *Insects*

(Section reviewed 6/09)

### ARMYWORMS (2/12)

**Scientific Names:** Western yellowstriped armyworm: *Spodoptera praefica*  
 Beet armyworm: *Spodoptera exigua*

#### DESCRIPTION OF THE PESTS

Beet armyworms may be abundant on asparagus ferns in low desert valleys of Imperial and Riverside counties anytime from May to October. In other locations they are relatively minor pests. The adult is a small, mottled gray or dusky-winged moth. Females deposit pale greenish or pinkish, striated eggs on the asparagus ferns in small or large masses covered with white cottony material. The eggs hatch in a few days and the tiny caterpillars begin feeding on the cladophylls (branchlets) in the plant canopy. Larger larvae feed on the epidermis of the branches of the ferns. The caterpillars become full grown in about 2 to 3 weeks and are about 1.25 inches long. They may be olive green to almost black in color with a yellow stripe on each side of the body. Beet armyworms may become abundant and cause severe injury to asparagus ferns in summer and fall.

Western yellowstriped armyworm may be abundant on asparagus ferns in low desert valleys of Imperial and Riverside counties anytime from June through October but in other areas is a relatively minor pest. The adult is a small, mottled gray or dusky-winged moth. Females deposit eggs, laid in clusters and covered with a gray, cottony material, on the asparagus. The eggs hatch in a few days and the tiny caterpillars begin feeding on the cladophylls (branchlets) in the plant canopy. Larger larvae feed on the epidermis of the fern's branches. The caterpillar is usually black with two prominent stripes and many narrow bright ones on each side. At maturity it is about 1.5 to 2 inches long.

#### DAMAGE

Larvae feed mostly at night on the epidermis of asparagus fern branches, often girdling the branch and causing the ferns to die.

#### MANAGEMENT

Good weed management can help prevent the build up of armyworms. Treatments may be necessary when armyworms are in the field and damage is occurring.

##### Organically Acceptable Methods

Sprays of *Bacillus thuringiensis* and the Entrust formulation of spinosad are acceptable for use on an organically certified crop.

##### Monitoring and Treatment Decisions

Armyworm eggs and larvae are easier to find on weeds near asparagus fields than in the fields when the ferns are large. *Chenopodium* spp. (e.g. lambsquarters, goosefoot) are particularly attractive to beet armyworm during fern stage. Monitor fields twice weekly because populations can build quickly. Adult beet armyworm activity can be monitored by using pheromone traps placed along the edges of fields. This technique is good for detecting populations of migrating moths.

Treat when larvae are visibly present in the ferns. Treatments are most effective when larvae are small; large larvae are more difficult to kill, especially with *Bacillus thuringiensis* products. Treat at dusk or at night; larvae are more active at dusk until twilight, and insecticides such as *Bacillus thuringiensis* products are susceptible to photo degradation.

Common name (example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
<i>The following materials are listed in order of usefulness in an IPM program, taking into account efficacy, information related to natural enemies and honey bees and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.</i>			
A. CHLORANTRANILIPROLE (Coragen) MODE-OF-ACTION GROUP NUMBER: 28 COMMENTS: Do not apply more than 15.4 fl oz Coragen or 0.2 lbs a.i. of products containing chlorantraniliprole / acre / crop.	3.5–5 fl oz	4	1
B. BACILLUS THURINGIENSIS ssp. AIZAWAI# (Various products) MODE-OF-ACTION GROUP NUMBER: 11.B1 COMMENTS: Apply when armyworms are small. Not harmful to natural enemies.	Label rates	4	0
C. METHOMYL* (Lannate) LV SP MODE-OF-ACTION GROUP NUMBER: 1A COMMENTS: Apply at 5–7 day intervals as needed. Do not apply more than 4.5 lb a.i. / acre / crop.	1.5–3 pt 0.5–1 lb	48 48	1 1
D. SPINOSAD (Entrust)# (Success) MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: Make applications only to asparagus ferns; do not apply within 60 days of spear harvest. Do not apply more than 0.28 lb a.i. / acre / crop.	1.25–2 oz 4–6 fl oz	4 4	See comments See comments
E. CARBARYL (Sevin) Bait 5% MODE-OF-ACTION GROUP NUMBER: 1A COMMENTS: Use in fields where armyworms are migrating into the asparagus field from another crop. Repeat 7–14 days later if necessary. Ground application. Do not apply more than 20 lb / acre to spears.	30–40 lb	12	1
F. PERMETHRIN* (Ambush, Pounce) MODE-OF-ACTION GROUP NUMBER: 3 COMMENTS: Apply by ground equipment only. Do not apply more than 0.4 lb a.i. / acre / season.	3.2–6.4 oz	12	1

\*\* See label for dilution rates.

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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 Web site at <http://www.irac-online.org/>.

## ASPARAGUS BEETLES (2/12)

**Scientific Names:** Asparagus beetle: *Crioceris asparagi*  
 Spotted asparagus beetle: *Crioceris duodecimpunctata*

### DESCRIPTION OF THE PESTS

Asparagus beetle larvae are dark green-gray grubs about 1/3 inch (9 mm) long when fully grown. Adults are blue-black beetles with a red prothorax. Their elytra (wing covers) have yellow spots and red borders.

Spotted asparagus beetle larvae are orange colored and adults are reddish orange with six prominent black spots on each wing cover.

### DAMAGE

Asparagus beetles injure the plant by feeding on the tips of tender young shoots. After leaves come out, asparagus beetles and their larvae gnaw on the surface of the stems and devour the leaves. If injury to the fern is severe, the crown is weakened, particularly if the asparagus stand is young.

### MANAGEMENT

Although they are found wherever asparagus is grown, asparagus beetles are not normally serious pests in California. Some local infestations do occur, however, and control measures may be necessary to prevent serious injury to the asparagus stand, particularly when the stands are young. If beetles are feeding on spears early in the season, let some plants near the edge of the field produce fern growth to attract the beetles away from the spears. If necessary, treat these areas.

Common name (example trade name)	Amount per acre**	R.E.I.† (hours)	P.H.I.‡ (days)
<i>The following materials are listed in order of usefulness in an IPM program, taking into account efficacy, information related to natural enemies and honey bees and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.</i>			
A. SPINETORAM (Radiant) SC MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: Apply only postharvest to ferns; do not apply within 60 days of spear harvest.	4-8 fl oz	4	See comments
B. METHOMYL* (Lannate) LV SP MODE-OF-ACTION GROUP NUMBER: 1A COMMENTS: Apply at 5-7 day intervals as needed. Do not apply more than 4.5 lb a.i./acre/crop.	1.5-3 pt 0.5-1 lb	48 48	1 1
C. CARBARYL* (Sevin XLR Plus) MODE-OF-ACTION GROUP NUMBER: 1A COMMENTS: Apply to ferns or brush growth. Repeat applications as necessary but not closer than 7 days and not more than 5 applications per year.	2-4 qt	12	1
D. PERMETHRIN* (Ambush, Pounce) MODE-OF-ACTION GROUP NUMBER: 3 COMMENTS: Apply by ground equipment only. Do not apply more than 0.4 lb a.i./acre/season.	3.2-6.4 oz	12	1

Common name (example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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\*\* See label for dilution rates.

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

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

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



## ASPARAGUS MINER (6/09)

**Scientific Names:** *Ophiomyia simplex*

### DESCRIPTION OF THE PEST

Adult asparagus miners are present in May and again in late summer. They are shiny black, slightly humpbacked flies that are about 0.1 inch (2.5 mm) long. Tiny, whitish eggs (0.001 inch) are laid at the base of the stem and are seldom seen because they are deposited beneath the epidermis of an asparagus stalk. The white-colored larva is about 0.015 inch (0.4 mm) long when it hatches from the egg and grows to about 0.2 inches long. Dark brown, flattened, pupae can be seen beneath the epidermis at the end of mines and measure up to 0.17 inch (4 mm) long. Asparagus miner overwinters in the pupal stage either in the stalk or in the soil.

### DAMAGE

Asparagus miner larvae occasionally injure asparagus during the fern growth stage but in California are not usually found damaging spears. Larvae mine just beneath the surface of fern stalks. Often the miner feeds upward in a meandering pattern and then turns downward as it continues to feed and can occasionally girdle the stalk causing the fern to yellow. Under heavy infestation, multiple mines may be seen in a single fern stalk. A direct association of asparagus miner feeding during the fern stage of plant development and yield losses in asparagus spear yield has not been conclusively shown.

### MANAGEMENT

Asparagus miner populations have been reported to be reduced by several parasitic wasps (*Dacnusa rondani*, *Dacnusa bathyzona*, *Pleurotropis epigonus*, and *Sphegigaster* spp.), all of which attack pupae. If a heavy infestation is found, burning to destroy the pupae may help reduce the overwintering population (where burning of shredded asparagus ferns is still allowed in California). Spraying insecticides to control asparagus miner is rarely if ever justified.

#### Organically Acceptable Methods

Encouraging natural enemies.

## CUTWORMS (2/12)

**Scientific Names:** Variegated cutworm: *Peridroma saucia*  
Darksided cutworm: *Euxoa messoria*

### DESCRIPTION OF THE PESTS

Cutworm larvae feed at night and come in various colors and patterns but always appear as smooth-skinned caterpillars to the naked eye. They frequently roll into a C-shape when disturbed. The mature variegated cutworm larva is yellow to brown, a little over an inch long (3 cm), with a row of 4 to 6 yellow or pink diamond-shaped spots down the back. The mature dark-sided cutworm is somewhat larger than the variegated cutworm (1.5–2 inches, 4–5 cm) and gray to greenish gray in color with irregular, longitudinal stripes.

Adult cutworm moths are rather nondescript with dark gray or brown front wings that have irregular spots or bands and lighter hind wings.

### DAMAGE

Larvae feed at night on the tender tips of new asparagus spears where they eat small holes. One-sided feeding may also cause the spears to curl. The variegated cutworm also feeds underground and at the soil surface. Fern damage is generally rare.

### MANAGEMENT

Carry out good weed control in and around the field and incorporate field trash and previous crop residues thoroughly to reduce egg and worm overwintering. Look for damage symptoms and confirm cutworm's presence by digging into the soil an inch or so around a damaged spear.

Begin applications when insects first appear. If infestations are localized, consider spot treatments.

#### Organically Acceptable Methods

Good weed management and field cultivation are acceptable to use in an organically certified crop.

Common name (example trade name)	Amount per acre**	R.E.I.† (hours)	P.H.I.‡ (days)
<i>The following materials are listed in order of usefulness in an IPM program, taking into account efficacy, information related to natural enemies and honey bees and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.</i>			
A. CARBARYL (Sevin) Bait 5% MODE-OF-ACTION GROUP NUMBER: 1A COMMENTS: Apply when pests appear in damaging numbers, and repeat 7–14 days later if necessary. Ground application. Do not apply more than 20 lb/acre to spears.	30–40 lb	12	1
B. METHOMYL* (Lannate) LV MODE-OF-ACTION GROUP NUMBER: 1A COMMENTS: Use low rate for variegated cutworm. Apply at 5- to 7-day intervals as needed. Do not apply more than 4.5 lb a.i./acre/crop.	1.5–3 pt	48	1
C. PERMETHRIN* (Ambush, Pounce) MODE-OF-ACTION GROUP NUMBER: 3 COMMENTS: Apply by ground equipment only. Do not apply more than 0.4 lb a.i./acre/season.	3.2–6.4 oz	12	1

Common name (example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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\*\* See label for dilution rates.

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

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

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

# EUROPEAN ASPARAGUS APHID (2/12)

**Scientific Name:** *Brachycorynella asparagi*

## DESCRIPTION OF THE PEST

The European asparagus aphid is a small blue-green to gray-green aphid about 0.06 inch (1.5 mm) in length. The aphid is often covered with a powdery wax. Unlike most aphids, the cornicles of European asparagus aphid are reduced to practically invisible openings on the abdomen. The cauda, a projection at the very rear tip of the abdomen, is relatively long compared with other aphid species and has sides that are nearly parallel. The antennae are short.

The wingless forms of the aphids like to feed where the needles of the fern attach to the petioles. Their small size and coloration make them difficult to spot even upon close examination. Winged forms often occur in very large numbers that may appear as a large cloud. The aphid overwinters as eggs deposited on the old fern or in cracks in the soil.

## DAMAGE

Damage from European asparagus aphid is primarily from a toxin that the aphids inject into the plant when feeding. The toxin causes shortened internodes on subsequent growth, resulting in a tufted appearance that is called bonsai growth. While other factors can cause a limited amount of this type of distorted growth, heavy European asparagus aphid infestations produce this distortion in great profusion. Heavy populations also produce massive amounts of honeydew that may lead to considerable ant activity.

Because asparagus is a perennial plant, the important damage is the impact of the European asparagus aphid feeding on the subsequent year's growth. The distorted growth is unable to adequately nourish the plant's crown and it will desiccate after 1 or 2 years feeding by this pest. The toxin may also cause a delay in bud break in spring followed by a profusion of small spears produced simultaneously. The impact is especially pronounced on newly established or weak plantings, and in seedling beds.

## MANAGEMENT

Cleaning fields of crop debris and encouraging natural enemies are important in managing this pest. Monitor field edges regularly to detect the appearance of populations.

### Biological Control

Natural enemies, especially parasitic wasps and lady beetles, help control European asparagus aphid populations. Most of the parasites, such as *Diaeretiella rapae*, have their greatest impact on heavy populations after the damage is done. A species of *Trioxys* imported and released to control European asparagus aphid has had little success to date. General predators, such as the convergent lady beetle, may feed on some European asparagus aphids, but the European asparagus aphid's rate of reproduction can overwhelm the predators' impact. Encourage natural populations of parasites by delaying pesticide applications where possible.

### Cultural Control

Mowing, chopping up, and then incorporating ferns during the dormant season may substantially reduce eggs in the area. Burning is also effective where permitted.

### Organically Acceptable Methods

Cultural and biological control, and sprays of insecticidal oils and PyGanic are acceptable to use in an organically certified crop.

### Monitoring and Treatment Decisions

European asparagus aphid populations start very slowly and in widely dispersed patches, then seem to nearly explode. Populations often begin near field edges, so monitor the edges of fields regularly whenever fern is present. It is best to collect plant samples and shake or beat them on a hard, light-colored surface (the side of a white 5-gallon bucket or hood of a pick-up, for example) to dislodge both the aphids and their natural enemies. Visual inspection of the ferns is not reliable, even for experienced scouts.

No definite threshold has been established and any threshold will vary with the condition of the field and time of the season. A high percentage of plants infested is more important than a high number of aphids on a few plants. The earlier in the season, the more likely a small infestation will become a problem. Waiting for appearance of

distorted plants or large amounts of white cast skins under plants may allow populations to reach dangerous levels before the infestation is detected. Treat when numbers of aphids begin to increase faster than beneficials.

Common name (example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
<p><i>The following materials are listed in order of usefulness in an IPM program, taking into account efficacy, information related to natural enemies and honey bees and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.</i></p>			
A. PYMETROZINE (Fulfill) MODE-OF-ACTION GROUP NUMBER: 9B COMMENTS: Apply to asparagus ferns after harvest has been completed.	2.75 oz	12	See comments
B. PYRETHRIN# (PyGanic) 1.4EC MODE-OF-ACTION GROUP NUMBER: 3 COMMENTS: Apply in sufficient water for thorough coverage, and begin treatments when insects first appear. Air blast applications are more effective than concentrate applications. The restricted reentry interval is 12 hours. Although OMRI approved for organically certified crops, check with certifier for any restrictions that apply.	1–4 pt	12	0
C. NARROW RANGE OIL# MODE OF ACTION: Contact including smothering and barrier effect. COMMENTS: Less effective than first two materials listed above but an option for organic growers.	1–2 gal/100 gal water	See label	0

\*\* See label for dilution rates.

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

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

# Acceptable for organically grown produce.

# GARDEN SYMPHYLAN (2/12)

**Scientific Name:** *Scutigerella immaculata*

## DESCRIPTION OF PEST

Garden symphylans are slender, white arthropods, closely related to insects, about 0.33 inch (8 mm long), with 10 to 12 prolegs and distinct antennae. These fast-moving arthropods live in soil and move up and down in the soil profile with the moisture. They run when exposed to light. They occur mainly in soil with high organic matter and can cause considerable damage in asparagus plantings.

## DAMAGE

Garden symphylans cause injury by chewing large numbers of small, round holes in storage roots, crowns, and on the belowground portion of the spears. They also predispose the asparagus plants to additional damage from disease organisms (*Fusarium*, *Phytophthora*, etc.) that invade the wounds they create. The insects are a particular problem during periods of extended wet weather in northern California production areas, primarily the Delta, or on water-saturated soils. A good indication that these insects are present is circular areas in the field or along edges of the field in which there is little or no asparagus or weed growth.

The practice of mounding soil against the spears to produce white asparagus increases the damage potential of this pest. Since the demise of the white asparagus industry in California, crop loss has been reduced.

## MANAGEMENT

Monitoring with bait traps and examining harvested spears can help detect the presence of symphylans, although no treatment thresholds have been developed. Cultivation and flooding may provide control.

### Cultural Control

Flooding has been used to control symphylans in some situations, but has been unsuccessful in others. Flooding requires at least 2 to 3 weeks, is more likely to be effective in late spring or summer (when fields are fallow) and is probably most effective where there is a high water table. Symphylans may be found more than 3 feet below the soil surface and flooding to this level in many soils is difficult. Even in the best circumstances, flooding will only reduce populations; they can be expected to increase when conditions are again favorable.

Cultivation to dry out the surface soil of the beds has reduced injury by driving the insects deeper into the soil.

### Organically Acceptable Methods

Flooding fields before planting or in winter and cultivation are both organically acceptable control strategies.

### Monitoring and Treatment Decisions

Confirm symphylan presence by digging a few feet below the surface with a shovel and examining moist soil. Research from other areas of the country and in other California crops such as lettuce and tomato indicate that symphylans can be detected with bait traps, but their success may depend on location, weather, and soil conditions. Symphylans are most easily detected in moist, warm soil. Baits placed on dry soil or on very hot or cold soils are unlikely to attract symphylans even when present, as symphylans migrate deeper in dry or hot soils and are less active in cold soil. Scrape off the top layer of dry soil to expose moist, firm soil. Cut a potato in half longitudinally and scratch the cut surface just before placing it on the soil to ensure that the surface is moist; use half of a potato, not a sliver or a chip. Cover the bait with an opaque pot or cup to block out light and air, and mark the spot with a flag. Symphylans have a spotty (aggregated) distribution pattern so use at least 30 bait traps per field. After 1 to 5 days, examine the cut potato surface and the soil it was resting on for evidence of symphylans.

Treatment thresholds are not well defined for symphylans in asparagus. If symphylans are present, fumigate or plant the field with a different crop. Because symphylans are likely to occur in the same areas over many years, these pests are very difficult to manage in permanent crops like asparagus.

Symphylans may be detected in established fields by examining the base of the harvested spear for small punctures. Also, if weak areas appear in fields and weeds are not present in that portion of the field but are doing well in other areas, suspect garden symphylans.

Common name (example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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*The following materials are listed in order of usefulness in an IPM program, taking into account efficacy, information related to natural enemies and honey bees, and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.*

#### PREPLANT

- |    |                                     |             |        |    |
|----|-------------------------------------|-------------|--------|----|
| A. | 1,3-DICHLOROPROPENE*<br>(Telone II) | Label rates | 5 days | NA |
|----|-------------------------------------|-------------|--------|----|
- COMMENTS: 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. Fumigate only as a last resort when other management strategies have not been successful or are not available.

#### POSTPLANT

- |    |                                |       |    |     |
|----|--------------------------------|-------|----|-----|
| A. | CHLORPYRIFOS*<br>(Lorsban) 15G | 10 lb | 24 | 180 |
|----|--------------------------------|-------|----|-----|
- MODE-OF-ACTION GROUP NUMBER: 1B  
COMMENTS: Lorsban 15G used as a single application in the first year when there is no harvest or in subsequent years as a postharvest treatment. Lorsban Advanced applied at least 2 weeks before harvest; use allowed under a Supplemental Label. Limited to ground application. Avoid drift and tailwater runoff into surface waters. Additional application restrictions may apply; for more information on current California permit restrictions, see the Department of Pesticide Regulation's Chlorpyrifos Interim Recommended Permit Conditions.

\*\* See label for dilution rates.

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

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

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

NA Not applicable.

# THRIPS (2/12)

**Scientific Names:** Bean thrips: *Caliothrips fasciatus*  
Onion thrips: *Thrips tabaci*

## DESCRIPTION OF THE PESTS

Thrips are small, slender insects with mouthparts developed primarily for sucking and rasping. The adults measure about 0.04 inch (1 mm) in length and have two pairs of narrow wings that are fringed with hairs. Immature thrips are wingless, whitish to yellowish in color. Adults emerge continuously throughout the warm months. Adults and immatures may be found in asparagus ferns at any time during the summer and fall when ferns are growing. Eggs are deposited in plant tissue and hatching occurs in about 5 days during the summer months; the immature stages take about 5 to 7 days to complete development.

## DAMAGE

Thrips are most noticeable and of greatest concern on young seedling plants but can severely damage mature ferns of asparagus. Their feeding will make the plants look ragged, cause the ferns to turn yellowish gray, and can cause the cladophylls (branchlets) to drop. Thrips remove moisture from the fern, causing a shortening and twisting of the cladophylls as well as some twisting of the stalks. This results in a loss of crop vigor and even the death of the tops of small seedlings.

Thrips tend to be a problem mainly from April to June in the Delta area when surrounding crops and weeds begin to dry, causing thrips to seek more succulent vegetation. Thrips attack all plantings of asparagus but are particularly injurious to asparagus crown nurseries, direct-seeded new plantings, seedling transplanted fields, and new 1-year-old crown plantings because these plantings are in fern when the thrips are immigrating in from surrounding fields in mid-spring.

In the Imperial Valley, bean thrips attacks ferns during summer and can cause severe damage, even in mature stands. Further, the stress of losing foliage during summer makes the crops more susceptible to attack from *Fusarium* sp.

## MANAGEMENT

Good weed management in the asparagus field and surrounding crops and areas is an important aspect of managing thrips. Monitor young plantings in mid-spring for thrips when the fern is present and flowering. Treat if needle drop is observed.

## ORGANICALLY ACCEPTABLE METHODS

Weed management in and around the field and sprays of the Entrust formulation of spinosad are acceptable for use in organically managed fields.

Common name (example trade name)	Amount per acre**	R.E.I.† (hours)	P.H.I.† (days)
<i>The following materials are listed in order of usefulness in an IPM program, taking into account efficacy, information related to natural enemies and honey bees and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.</i>			
A. SPINOSAD			
(Entrust)‡	1.25–2 oz	4	See comments
(Success)	4–6 fl oz	4	See comments
MODE-OF-ACTION GROUP NUMBER: 5			
COMMENTS: Make applications only to asparagus ferns. Do not apply more than 0.28 lb a.i. / acre / crop.			



Common name (example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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\*\* See label for dilution rates.

- ‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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 Web site at <http://www.irac-online.org/>.
- # Acceptable for use on organically grown produce.

## *Diseases*

(Section reviewed 6/09)

### **ASPARAGUS VIRUS I and II** (6/09)

**Pathogens:** Asparagus virus I and Asparagus virus II

#### **SYMPTOMS**

*Asparagus viruses I and II* produce no distinct symptoms unless both viruses infect the plant. Either virus by itself may only slightly reduce vigor. When both are present in the same plant, survival and vigor are severely reduced, especially in young plants. The combination of both viruses may be partly responsible for the reduction in the profitable life of asparagus plantings. Also, when plants are infected with both viruses, they become more susceptible to Fusarium wilt.

#### **COMMENTS ON THE DISEASES**

Both viruses are transmitted by aphids. *Asparagus virus II* is also transmitted through seed and may be transmitted in pollen from male plants to seed produced by female plants. *Asparagus virus II* is more prevalent in older cultivars, such as Mary Washington. *Asparagus virus II* may be transmitted mechanically on harvest knife blades, mowers, cultivation equipment, or any other activity that moves plant sap from one plant to another.

#### **MANAGEMENT**

Plant virus-free seed grown from healthy plants or plant transplants grown from tissue culture to eliminate the viruses.

##### **Organically Acceptable Methods**

Purchase of virus-free seed or transplants is acceptable for use in an organically certified crop.

# CROWN and SPEAR ROT (6/09)

**Pathogens:** *Phytophthora megasperma* var. *sojae* and other *Phytophthora* spp.

## SYMPTOMS

Phytophthora spear rot is characterized by soft, water-soaked lesions on shoots at, slightly above, or below the soil level. The lesions elongate rapidly and become light brown. As the lesion collapses and shrivels, the affected side of the spear becomes flattened, and the shoot becomes extremely curved and may even collapse. This symptom is not diagnostic, however, as insect and mechanical injury can result in crooked spears. Infected young storage roots appear water soaked but firm.

Crowns infected with *Phytophthora* spp. have yellow-orange colored tissue. In severe infections the tissue appears waterlogged and fibrous.

## COMMENTS ON THE DISEASE

*Phytophthora* is a soilborne fungus; it infects the shoot near or just below the soil line during very wet periods. Heavy spring rains can induce severe disease losses. Although crown and spear rot is erratic in California, the fungus is present in all production areas of the state. Desert areas, however, usually escape the disease unless conditions are unusually wet. Infected spears, if hydrocooled during packing for market, may contaminate the water and spread the pathogen to other spears, causing extensive rot during transit.

## MANAGEMENT

Whenever possible, plant in *Phytophthora*-free soil and use disease-free transplants. Provide good drainage and do not overwater. If symptoms occur, treatment may be necessary.

### Organically Acceptable Methods

Avoid *Phytophthora*-infested soils and use disease free transplants when growing an organically certified crop.

Common name (example trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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*The following materials are listed in order of usefulness in an IPM Program. Also, consider information relating to environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.*

A.	MEFENOXAM (Ridomil Gold) EC	1 pt	48	1
	MODE-OF-ACTION GROUP NAME (NUMBER): Phenylamide (4)			
	COMMENTS: Cutting beds: Apply 30–60 days before the first cutting. For additional control, make another application just before the beginning of harvest. New plantings: Apply after planting seedlings or after covering 1-year-old crowns.			
B.	FOSETYL-AL (Aliette)	5 lb	12	110
	MODE-OF-ACTION GROUP NAME (NUMBER): Phosphonate (33)			
	COMMENTS: Apply once over the top to fully expanded asparagus ferns. Control with fosetyl-al is erratic.			

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

## FUSARIUM CROWN and ROOT ROT (6/09)

**Pathogens:** *Fusarium oxysporum* f. sp. *asparagi*, *Fusarium verticillioides*, *Fusarium proliferatum*

### SYMPTOMS

Mature plants infected with *Fusarium* gradually decline in productivity and growth. During the summer, infected plants are characterized by one to several stunted, bright yellow ferns. A reddish brown vascular discoloration, which may extend into the crown, is present at the base of stalks infected by *Fusarium oxysporum* f. sp. *asparagi*. Crowns and belowground portions of stems exhibit reddish flecks or sunken brown lesions, which can be seen by cutting them open. Reddish brown, elliptical lesions occur on storage roots of infected plants. Feeder roots, most of which may be rotted off completely, show reddish brown discoloration.

### COMMENTS ON THE DISEASE

*Fusarium* crown and root rot is the major disease of asparagus worldwide. The fungus survives in the soil indefinitely, and may spread as a seedborne contaminant. Spread is by movement of infested soil within the field, on transplants grown in infested soil, and on plants grown from contaminated seed. Infection occurs at any point below ground; all three fungi can colonize the crown and roots; *F. oxysporum* f. sp. *asparagi* can also invade the xylem tissue. Adverse environmental factors and the interactions of *Fusarium* crown and root rot with other diseases or insects add stress to plants and further reduce plant vigor. Excessive cutting periods (greater than 75 days) may also weaken asparagus and increase susceptibility to wilt.

### MANAGEMENT

Use clean seed in noninfested soil to produce disease-free seedlings, transplants, or crowns. Long rotations out of asparagus are beneficial. Minimize plant stress as much as possible. Hybrid varieties such as UC 157, Apollo, and Jersey Giant have increased plant vigor, which provides a degree of tolerance but not resistance, to this disease. Avoid extended harvest periods and end harvest when production declines to 70% of the season's highest yield to maintain crown vigor. Maintain crown vigor with proper irrigation and fertilization.

#### Organically Acceptable Methods

Good field sanitation, resistant varieties, and good cultural practices are all acceptable to use in an organically certified crop.

## PURPLE SPOT (2/12)

**Pathogen:** *Stemphylium vesicarium*; (sexual stage): *Pleospora allii*

### SYMPTOMS

Purple spot is of major concern when new spears are emerging and being harvested. The pathogen produces elliptical, slightly sunken lesions 0.03 to 0.06 inch across and up to 0.125 inch long. Initially lesions are reddish-purple and later develop a tan-brown center, especially if the lesion is large. Lesions usually appear on the lower half of new spears and are very superficial. The internal tissue of the spear is not affected.

### COMMENTS ON THE DISEASE

Purple spot is worse following cool, wet weather during spear emergence. The disease is usually most intense where debris from the previous year's fern growth is lying on the soil surface. The sexual stage, *Pleospora allii*, develops on this debris. Wounding of the spear is not necessary for infection; however, wounds created by blowing sand can increase the incidence of disease.

Once dry weather conditions develop, the disease subsides.

### MANAGEMENT

Good field sanitation is important in managing purple spot and other diseases. Last season's fern growth, which is the primary inoculum source, should be burned (where permitted), chopped and incorporated, or removed from the field before new spears emerge. Destroy volunteer asparagus within 400 yards of commercial asparagus fields. One of the best solutions is to incorporate the cut fern with a power-driven rotary tiller two times, once in each direction. Chemical treatments are not recommended in California for this disease.

#### Organically Acceptable Methods

Cultural control methods and good field sanitation are acceptable for use in an organically certified crop.

# RUST (6/09)

**Pathogen:** *Puccinia asparagi*

## SYMPTOMS

Rust is most common on fern growth after the harvest season is over. Infections begin in spring from spores that overwintered on crop debris. These infections produce the orange stage (pycnia and aecia) of the disease. Occasionally, this stage can be found in spring on emerging spears from new or established plantings. The orange stage is characterized by light green patches on new spears that mature into yellow or pale orange pustules in concentric ring patterns. Spores produced by these spring stages are airborne to new fern growth. Infection occurs and brick red pustules develop on stalks, branches, and leaves of the fern. These red pustules produce airborne, rust-colored spores (urediospores) in a powdery mass, which can reinfect the fern and increase disease incidence. Fern yellowing and browning, defoliation, and dieback may occur. As ferns mature and senesce, or autumn weather begins, the black spore stage may develop. The same pustules that produced the red spores begin producing black spores (teliospores). The pustule will slowly convert in appearance to a powdery mass of jet-black spores. These black spores are the overwintering stage of the fungus.

The overall effect of rust on asparagus is reduced plant vigor the following year and reduced yields.

## COMMENTS ON THE DISEASE

Rust diseases have several stages, some of which may occur on different hosts. In asparagus rust, however, all the life stages (orange spore in spring, red spore in summer, and black spore in fall and winter) occur on asparagus. Therefore, what may appear to be a different disease, could be a different stage of rust.

Rust is favored by temperatures between 55° and 90°F. Several hours of dew or rain (free water) are necessary for spores to germinate and infect the host.

## MANAGEMENT

Good field sanitation and irrigation practices are important components of managing rust. Treatments are necessary when monitoring indicates rust is present.

### Cultural Control

Provide adequate irrigation during the spring and summer fern period so that plants are neither over- nor under-watered. Orient rows with the prevailing wind, if possible, to allow free flow of air through the field. This will allow faster drying of the soil surface when irrigations or rainfall occur. At the end of the fern season, cut and destroy diseased ferns. One of the best solutions is to incorporate the cut fern with a power driven rotary tiller two times, once in each direction. The fern may also be removed from the field. Cut young spears to keep infections from occurring, thus breaking the cycle of the fungus in spring. Destroy volunteer asparagus within 400 yards of commercial asparagus fields.

### Organically Acceptable Methods

Cultural control and sulfur dust treatments are acceptable to use in an organically certified crop.

### Monitoring and Treatment Decisions

Monitor spears and ferns for the appearance of rust lesions. Begin treatments when rust first appears.

Common name (example trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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*The following materials are listed in order of usefulness in an IPM Program. Also, consider information relating to environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.*

A.	CHLOROTHALONIL (Chlorothalonil 720) SC	2–4 pt	12	See comments
	MODE-OF-ACTION GROUP NAME (NUMBER): Multi-site contact (M5)			
	COMMENTS: Do not apply within 120 days of spear harvest for the following season. Research from Michigan indicates very effective.			

Common name (example trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
B. MYCLOBUTANIL (Rally) 40WSP MODE-OF-ACTION GROUP NAME (NUMBER): Demethylation inhibitor (3) COMMENTS: Begin applications to the developing ferns after harvest has taken place. See label for restrictions.	5 oz	24	See label
C. MANCOZEB (Penncozeb, Manzate, Dithane) 75 MODE-OF-ACTION GROUP NAME (NUMBER): Multi-site contact (M3) COMMENTS: Apply at first sign of rust and repeat at 10-day intervals until disease pressure subsides. Do not apply during harvest. Do not apply more than 6.4 lb a.i./season. Apply only on asparagus ferns after spears have been harvested.	2 lb	24	120
D. MICRONIZED SULFUR# (Thiolux) DF MODE-OF-ACTION GROUP NAME (NUMBER): Multi-site contact (M2) COMMENTS: Although this material is registered, it does not provide very effective control. Use after cutting stops. May repeat at 7- to 10-day intervals throughout the season.	10–30 lb	24	0

‡ Restricted entry interval (R.E.I.) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (P.H.I.) 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://www.frac.info/>). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

# Acceptable for organically grown produce.

## Weeds

(Section reviewed 6/09)

# INTEGRATED WEED MANAGEMENT (2/12)

Asparagus is a perennial crop that is produced in several regions of California. Major counties of production include San Joaquin and Monterey. Each of these areas has specific weed problems and differences in climate and soil types that affect weed management decisions.

Weed management in asparagus can be divided into two periods: stand establishment, which lasts about 2 years, and mature plantings. Weed control during stand establishment is complicated in asparagus by the fact that three methods of establishment are used: direct seeding, transplanting seedlings, or transplanting dormant crowns. During stand establishment, tailor weed management techniques to the establishment method. If weeds are left uncontrolled during this period, a weak asparagus stand can develop and limit the potential of the field for the rest of its stand life. Producing a uniform, vigorous asparagus stand and maintaining it in this condition can mitigate most weed control problems. Asparagus is a very good competitor with most annual weeds when it is a mature fern, especially if the stand is uniform and vigorous.

Once established, an asparagus field has a stand life of from 5 to 20 years. At first, in newly established fields, annual weeds are the main problem, but as time passes, perennial weeds often become the major concern. These perennial weeds include yellow nutsedge, field bindweed, swamp smartweed, johnsongrass, and bermudagrass. If perennial weeds become established, they can be troublesome throughout the growing period by reducing crown vigor and density and ultimately asparagus yield and quality. Perennial weeds are difficult to control culturally or chemically without injury to the asparagus, therefore prevention becomes a major tool in combating these weed pests.

To help prevent infestation of the field by perennial weeds, be sure that seeds, tubers, stolons, rhizomes, and rootstocks of perennial weeds are not moved into asparagus fields with planting materials or on cultivation equipment. If spot infestations of perennial weeds are noted in the field, mark the area with flags and mechanically remove the infestation. Following removal, monitor the area for at least 2 to 7 years to make sure that reinfestation from propagules or seed does not occur.

Established asparagus fields are harvested from early spring through early summer. Spears, which develop from the underground crown, are cut on a 1- to 3-day cycle, depending on temperature. During the harvest period, spears provide virtually no shade to reduce weed competition. Annual weeds can be a problem in established stands at this time because the beds are open and exposed to light. It is most important to have beds weed-free to facilitate harvest and increase soil temperature.

Preemergence herbicides can be applied either pre- or post-cutting to control many of the annual weeds that cause problems in the crop. On the other hand, monitoring for perennial weeds must be carried out throughout the year and treatment made as soon as they are detected. Initially, perennial weeds tend to develop at the head and tail of fields; spot-treat infestations immediately with a foliar herbicide to prevent their spread into the field. If they do spread and weeds have to be removed mechanically, harvest will be interrupted for about 10 days while the field is disced, which reduces profits.

After the last harvest of the season, asparagus spears are allowed to grow into the fern stage, during which the asparagus plant replenishes the carbohydrate supply in the crown for the next season. The period between harvesting spears and allowing the spears to grow into ferns is a good time for controlling both annual and perennial weeds. Also light tillage can be utilized and some herbicides can be applied in a timely manner. Once the spears have grown into ferns, cultivation and hand removal of weeds during the fern stage is difficult because equipment movement is restricted due to the dense fern growth. However, dense fern growth restricts light thereby minimizing much of the late emerging annual weed growth.

When a field is taken out of asparagus, rotate it to annual crops for several years to reduce levels of perennial weeds, soilborne disease inoculum, and salt buildup in the soil. If perennial weed populations are very high, it may be necessary to fallow the field for a year, using a combination of tillage and herbicides to return the field to a condition suitable for other crops.



Weed management is most effective when herbicides are used in conjunction with cultural practices. Cultural practices such as proper field selection, fallow treatment, cultivation, and hand removal help to improve herbicide performance by leaving fewer weeds; therefore a combination of both cultural and chemical control methods can give the best overall result.

Herbicides are often used in sequence or in combination to broaden the weed control spectrum; a single herbicide will seldom control all weeds present. To avoid a buildup of resistant weeds, use preemergence herbicides in combination or alternated with another preemergence herbicide.

## MONITORING

Monitor fields that are intended for planting to asparagus several seasons before planting. Keep an inventory of the weeds encountered and their relative abundance in the field. Such a record can be helpful in planning which cultural techniques will be most helpful and which herbicides are most likely to be successful. Perennial weeds can be a major problem in asparagus plantings. Select alternative fields for asparagus if yellow nutsedge, johnsongrass, bermudagrass, swamp smartweed, or field bindweed are present.

## WEED MANAGEMENT BEFORE PLANTING

Choose fields that are known to be free of perennial weeds. Fallow the field for as long as possible before planting, irrigating often to germinate weeds and cultivating shallowly to destroy them. Do not cultivate too deeply as a new supply of weed seed may be brought up from deeper soil layers.

Before planting, metam sodium or other soil fumigants are often used to control soilborne diseases and nematodes, but these materials can also be used to control annual weeds and reduce perennial weed propagules. Take care to assure that the soil is well cultivated and moist for at least 1 week before an application of metam sodium.

Paraquat (Gramoxone Inteon) and glyphosate (Roundup) can be used as preplant or preemergence treatments to control emerged weeds before planting or before asparagus emergence. Make sure the emerged asparagus is not contacted by these herbicides or the plants will be killed.

## WEED MANAGEMENT AFTER PLANTING

During the first 2 years after planting, the asparagus plants become established. Weed control is critical to the long-term well-being of the crop during this period, and it relies on both cultural and chemical controls.

### Stand Establishment

For all three methods of stand establishment, planting beds are used and fields can be lightly cultivated several times during the season to throw soil onto the bed tops, thus keeping weed competition to a minimum.

### *Direct Field Seeding*

In direct seeding, asparagus is seeded into raised beds that may be cultivated during stand establishment to control weeds in the furrow and bed shoulders. The seedling asparagus is slow to emerge, requiring from 14 to 21 days. Once emerged it continues to grow slowly and is not competitive with most weed seedlings. This emphasizes the need to plant into fields that have a low soil weed seedbank or that have been fallow irrigated and cultivated to reduce the weed seedbank. If it is necessary to remove weed seedlings from the rows of seedling asparagus, this can be done with herbicides or by hand removal. Weed management at this stage is important in order to establish a uniform, competitive asparagus stand. Control weeds for the first 3 to 4 months in seedling asparagus until a heavy fern cover is established.

Linuron (Lorox) controls a broad spectrum of broadleaf and grass weeds and has both soil and foliar activity. Apply linuron as a directed spray to minimize contact with asparagus foliage when asparagus seedlings have from 6 to 18 inches of growth.

Sethoxydim (Poast) is used for controlling most annual grass species, except annual bluegrass. It is also effective in the control of some perennial grass species, however, more than one application is necessary. Its effectiveness requires that grasses not be under moisture stress. Later growth stages of annual grasses are more difficult to control.

Fluazifop-p-butyl (Fusilade) is a selective systemic grass herbicide that must be applied before grasses are 3 to 4 inches tall for best control. Asparagus seedlings are relatively tolerant of fluazifop, which can be applied as a broadcast application.

### ***Transplanting Seedlings***

Planting of 10- to 12-week-old transplants hastens the establishment process compared to direct seeding. Transplants are planted into trenches and usually sprinkler irrigated. This procedure allows weeds to germinate within the planted area. The young asparagus seedling is a poor competitor; thus early weed management is essential for plant survival and growth. As with direct-seeded asparagus, it is necessary to control weeds until a heavy uniform fern cover is established. The same materials used for direct-seeded asparagus can be used for transplanted seedlings.

### ***Crown Planting***

Crown planting is done when the asparagus crowns are dormant. The crowns are set into trenches and covered with 2 to 4 inches of soil, followed by rainfall or furrow or sprinkler irrigation to settle the soil around the crowns. Weed emergence soon follows, often before asparagus emergence. Rapidly growing weeds must be removed from within the planted beds. As the asparagus grows, the furrow and sides of the beds can be cultivated, which throws some soil onto the bed tops. This soil fills in around the plants and provides some weed control as small weed seedlings may be buried. As with the previous two methods of stand establishment, timely cultivations and hand removal of weeds or herbicide treatments are needed during the first season until a uniform fern cover is produced.

Paraquat (Gramoxone Inteon) is a contact herbicide that is effective against both grasses and broadleaf weeds and must be applied before asparagus spears emerge. It is most effective when applied as a broadcast application to weeds that are in the two- to four-leaf stage.

Linuron (Lorox) can be used on crown-planted seedling fields to control a broad spectrum of broadleaf and grass weeds and has both soil and foliar activity. Use linuron as a directed spray to minimize contact with asparagus foliage when asparagus seedlings have from 6 to 18 inches of growth.

Diuron (Karmex and others) may be used in the San Joaquin Delta only on high organic matter or clay content soils. It is a broad-spectrum preemergence herbicide that is useful in controlling emerging annual weeds; however, it is not very effective in the control of common groundsel, sowthistle, volunteer cereals, and wild oats.

Fluazifop may be applied for grass control after the asparagus spears have emerged. It is most effective when applied before the grasses are 6 inches tall.

### ***Established Asparagus***

The term "established asparagus" refers to plantings that are 2 or more years old. Once crop plants are established, focus weed management efforts first on limiting establishment and spread of perennial weeds, which can reduce the vigor and quality of the asparagus stand, and second on controlling annual weeds to avoid competition during the cutting season.

Weed control in established asparagus is only possible during a relatively short window of opportunity that lasts about 4 months. This period begins with preharvest cultivations, when beds are tilled and shaped before the harvest season. It also includes the harvest period, when shallow cultivations can be used to control weeds; limit cultivation to the furrows, however, because cultivation on the bed tops will interrupt harvest for a period of up to 10 days. The postharvest cultivation, which is possible until the fern limits mechanical activity, is the last chance during the growing season to control weeds by cultivation; after this time the asparagus fern becomes too tall to permit cultivation. Perennial weeds can be difficult to control because of the relatively limited opportunity to cultivate.

### ***Preemergence (When spears are not present)***

Glyphosate (Roundup) and paraquat (Gramoxone Inteon) may be used on established beds before spears emerge to control newly emerged annual weeds. Asparagus emerged at the time of application will be injured by these herbicides and spears will be unmarketable.

Metribuzin (Metribuzin 75) has preemergent and postemergent activity on newly emerged annual weeds. If the field is to be cultivated or rototilled, apply after bed preparation. Irrigation or rainfall is necessary to activate this herbicide.

Diuron (Karmex and others) is useful for the control of many emerging annual weeds, but does not control common groundsel, sowthistle, volunteer cereals, and wild oats. Apply it as a band or broadcast application to weed-free beds and incorporate it mechanically or with irrigation if rainfall does not occur. Do not use it on soils with less than 2% organic matter; use lower rates on coarse-textured soils.

Flumioxazine (Chateau) is useful for the control of a wide-spectrum of broadleaf weeds. Apply it no less than 14 days before spears emerge and before weeds emerge, or burn the weeds back with a tank-mix material. Requires 0.25 inch of rainfall or irrigation to activate.

Halosulfuron (Sanda) can be applied before the cutting season to control broadleaf weeds. Do not use an adjuvant with sprays applied before the harvest period.

Napropamide (Devrinol) is useful in the control of winter annual weeds, such as common groundsel, which are difficult to control with other asparagus herbicides. It has no postemergent activity and should be used after bed preparation before weeds emerge. Napropamide requires shallow mechanical incorporation (one to two inches deep), and if rainfall does not occur, it must be irrigated.

Trifluralin (Treflan and others) and pendimethalin (Prowl H20) are active in the control of many grasses and broadleaf weeds with the exception of those in the sunflower, mustard, little mallow (cheeseweed), and legume families. Use trifluralin and pendimethalin before spears emerge. Trifluralin can be used after the cutting season but before ferns develop. They have no postemergent activity on weeds and must be applied prior to weed germination. Trifluralin can suppress the growth of bermudagrass if applied at this time. Trifluralin will also suppress field bindweed at high label rates. Trifluralin must be mechanically incorporated immediately after application two times in opposite directions with discs or rolling cultivators or one time with a power-driven incorporator.

Linuron (Lorox) can be used before harvest. Linuron has a broad spectrum of annual weed control activity. It also has both foliar and soil activity. Its residual soil activity is shorter than other residual asparagus herbicides. This makes it a better choice to use in the last season of an asparagus planting to avoid long-lasting soil residues that could affect succeeding crops. See herbicide labels for plantback restrictions.

### *Postemergence (After spears emerge)*

Dicamba (Banvel) is useful for the control of annual broadleaved weeds and troublesome perennials, such as field bindweed and swamp smartweed. It is applied immediately after spear cutting or as directed sprays to avoid spear and fern contact. Spears that are twisted or malformed as a result of treatment should be cut and discarded. Be sure to comply with all state and county regulations as to proximity to susceptible crops and other restrictions regarding their use.

Linuron (Lorox) can be applied immediately after cutting, but do not harvest within one day after application.

Halosulfuron (Sanda) can be applied during the cutting season to control broadleaf weeds. Do not use an adjuvant with sprays applied during the harvest period.

The grass herbicides sethoxydim (Poast) and fluazifop-p-butyl (Fusilade) can be used on emerged spears. Both have a one-day preharvest interval and work best on actively growing grasses.

### *Postharvest (Before or at the onset of the fern growth)*

Halosulfuron (Sanda) can be applied following the cutting season to control broadleaf weeds and yellow nutsedge. A nonionic surfactant or crop oil concentrate may be used with postharvest applications only.

Diuron (Karmex and others) can be used during the postharvest period, but care needs to be taken to not exceed the seasonal limitations.

Linuron (Lorox) can be used during the fern stage by using sprays directed to the base of the fern.

Metribuzin (Metribuzin 75) can be used following the final harvest but before spears emerge that will form the fern.

Trifluralin (Treflan and others) can be mechanically incorporated following harvest and before fern growth to suppress grasses and broadleaf weeds.

The grass herbicides sethoxydim (Poast) and fluazifop-p-butyl (Fusilade) can be used on emerged spears and both have a one-day preharvest interval. They all work best on actively growing grasses.

Glyphosate (Roundup) may also be used as a postharvest treatment when all remaining spears have been removed (clean cut). It is useful in controlling emerged annual and perennial weeds; use higher rates of application to control perennials. Direct contact of the spray with asparagus fern can cause serious injury. Glyphosate is useful for spot treating perennial weeds around the edges of asparagus fields to prevent these weed infestations from spreading into the field on incorporation and cultivation equipment.

## SPECIAL WEED PROBLEMS (6/09)

### BERMUDAGRASS

Bermudagrass is a vigorous spring- and summer-growing perennial that grows from seed but can also be spread during cultivation and incorporation procedures from its extensive system of rhizomes and stolons. It is very competitive with asparagus for moisture, nutrients, and light. Its presence in cutting beds interferes with spear harvest. If bermudagrass develops in the head or tail ends of a field or in localized areas, spot treat it with glyphosate and/or fluazifop-p-butyl (Fusilade) immediately to prevent the spreading of vegetative propagules.

### FIELD BINDWEED

Field bindweed is a vigorous perennial weed that either grows from seed, which can survive for up to 30 years in the soil, or from stolons, rhizomes, or extensive roots. Due to the longevity of the seed, it is critical to destroy plants before they can produce seed. The plants may be spread vegetatively through stem or root sections during cultivation or incorporation operations. If field bindweed appears in or around the field, spot treat it with high label rates of trifluralin to prevent it from spreading.

### JOHNSONGRASS

Johnsongrass is a perennial weed that spreads from seed or from an extensive system of underground rhizomes. It grows vigorously in spring and summer when it overtops the fern and competes for light, moisture, and nutrients. It interferes with harvest by providing a physical barrier to cutting. If johnsongrass develops in or around the field, spot treat it with glyphosate or sethoxydim to prevent the spread of its rhizomes.

### NUTSEDGE

Yellow and purple nutsedges are perennial weeds that commonly reproduce from underground tubers that survive for 2 to 5 years in the soil. The tubers are easily spread by cultivation equipment and power incorporators. Each tuber contains several buds that are capable of producing plants. One or two buds germinate to form a new plant; however, if destroyed by cultivation or an herbicide, then a new bud is activated. Control is best accomplished by continuous cultivation during a summer fallow period before planting an asparagus field. On sandy soils in the San Joaquin Valley, purple nutsedge populations can be significantly reduced but not eradicated by dry fallowing for 5 to 6 weeks. If nutsedge develops on the edges of established fields, spot treat it with glyphosate to prevent new infestations from becoming established in the field.

### SWAMP SMARTWEED

Swamp smartweed, also known as swamp knotweed, is a deep-rooted perennial weed that is particularly a problem in poorly drained fields. It produces a substantial amount of seed, and once established is very difficult to control due to its deep fleshy taproot. It can regenerate from this root even though the top of the plant is severed by cultivation. The thick taproot also poses a problem at asparagus harvest, interfering with the cutting of the asparagus spears. If swamp smartweed is a problem, clear cut the spears and treat with dicamba to burn back this weed.

# COMMON AND SCIENTIFIC NAMES OF WEEDS IN ASPARAGUS (6/09)

Common Name	Scientific Name
Barnyardgrass	<i>Echinochloa crus-galli</i>
Bermudagrass	<i>Cynodon dactylon</i>
Bindweed, field	<i>Convolvulus arvensis</i>
Bluegrass, annual	<i>Poa annua</i>
Burclover, California	<i>Medicago polymorpha</i>
Chickweed, common	<i>Stellaria media</i>
Cocklebur	<i>Xanthium</i> spp.
Crabgrasses	<i>Digitaria</i> spp.
Filarees	<i>Erodium</i> spp.
Fleabane, hairy	<i>Conyza bonariensis</i>
Foxtail, yellow	<i>Setaria pumila</i>
Foxtails	<i>Setaria</i> spp.
Groundsel, common	<i>Senecio vulgaris</i>
Henbit	<i>Lamium amplexicaule</i>
Horseweed	<i>Conyza canadensis</i>
Johnsongrass	<i>Sorghum halepense</i>
Knotweed, common	<i>Polygonum arenastrum</i>
Ladysthumb	<i>Polygonum persicaria</i>
Lambsquarters, common	<i>Chenopodium album</i>
Lettuce, prickly	<i>Lactuca serriola</i>
Mallow, little	<i>Malva parviflora</i>
Morning glories	<i>Ipomoea</i> spp.
Mustards	<i>Brassica</i> spp.
Nettle, burning	<i>Urtica urens</i>
Nightshades	<i>Solanum</i> spp.
Nutsedge, purple	<i>Cyperus rotundus</i>
Nutsedge, yellow	<i>Cyperus esculentus</i>
Oat, wild	<i>Avena fatua</i>
Pigweeds	<i>Amaranthus</i> spp.
Polypogon, rabbitfoot	<i>Polypogon monspeliensis</i>
Purslane, common	<i>Portulaca oleracea</i>
Rocket, London	<i>Sisymbrium irio</i>
Ryegrasses	<i>Lolium</i> spp.
Shepherd's-purse	<i>Capsella bursa-pastoris</i>
Smartweed, swamp	<i>Polygonum coccineum</i>
Sowthistles	<i>Sonchus</i> spp.
Sprangletops	<i>Leptochloa</i> spp.
Sweetclovers	<i>Melilotis</i> spp.
Thistle, Russian	<i>Salsola tragus</i>

# SUSCEPTIBILITY OF SPRING & SUMMER WEEDS IN ASPARAGUS TO HERBICIDE CONTROL (2/12)

	PREEMERGENCE						POSTEMERGENCE									
	DIU	FLM	LIN	MET	PEN	TRI	DIC*	FLU	GLY	HAL	LIN	MET	NAP	PEL	PAR*	SET
ANNUAL WEEDS																
Barnyardgrass	C	—	C	P	C	C	N	C	C	P	C	P	C	C	P	C
Burclover, California	C	—	C	C	—	N	C	N	P	—	C	C	P	—	P	N
Chickweed, Common	C	C	C	C	C	C	C	N	C	C	C	C	C	C	P	N
Cocklebur	C	—	C	C	N	N	C	N	C	C	C	C	N	—	P	N
Crabgrasses	C	P	C	C	C	C	N	C	C	—	C	C	C	—	C	C
Fleabane, Hairy	C	C	C	C	N	N	C	N	C	—	C	C	N	P	P	N
Foxtail, Yellow	C	—	C	C	C	C	N	C	C	—	C	C	C	—	C	C
Foxtails	C	—	P	C	—	C	N	C	C	—	C	C	C	—	C	C
Horseweed	C	C	C	C	N	N	C	N	C	—	C	C	N	—	P	N
Knotweed, Common	C	C	P	C	C	C	C	N	C	—	P	C	C	C	P	N
Ladysthumb	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lambsquarters, Common	C	C	C	C	C	C	C	N	C	N	C	C	C	P	P	N
Lettuce, Prickly	C	C	C	C	N	N	C	N	C	C	C	C	C	—	C	N
Mallow, Little (Cheeseweed)	C	C	C	C	—	P	C	N	N	—	C	C	P	C	N	N
Nightshades	C	C	C	C	N	N	C	N	C	N	C	C	N	—	C	N
Pigweeds	C	C	C	C	C	C	C	N	C	P	C	C	C	P	C	N
Purslane, Common	C	C	C	P	C	C	C	N	C	P	C	P	C	C	C	N
Rabbitfootgrass	C	C	C	—	C	C	N	C	C	—	C	—	—	C	P	C
Sprangletop	N	P	N	C	C	C	N	C	P	—	N	C	C	N	N	P
Thistle, Russian	C	—	N	P	P	C	C	N	C	—	N	P	C	C	P	N
PERENNIAL WEEDS																
Bermudagrass, Established	N	—	—	N	N	N	N	N	C	N	N	—	N	N	N	P
Bermudagrass, Seedling	N	—	—	N	C	C	N	C	C	N	N	—	C	N	P	C
Bindweed, Established	N	N	—	N	N	P	P	N	P	—	N	—	N	N	N	N
Bindweed, Seedling	C	—	—	N	P	P	P	N	C	—	N	—	N	—	P	N
Johnsongrass, Established	N	—	—	N	N	N	N	C	C	—	N	—	N	N	N	C
Johnsongrass, Seedling	C	—	—	N	C	N	N	C	C	—	N	N	C	C	C	C
Nutsedge, Purple	N	N	N	N	N	N	N	N	P	C	N	N	N	N	N	N
Nutsedge, Yellow	N	P	N	P	N	N	P	N	P	C	N	P	N	N	N	N
Smartweed, Swamp	N	—	N	P	—	N	P	N	C	P	N	P	N	—	N	N
C = control    P = partial control    N = no control    — = no information																
DIC	= dicamba* (Banvel)			MET			= metribuzin (Metribuzin 75)									
DIU	= diuron (Karmex, etc.)			NAP			= napropamide (Devrinol)									
FLU	= fluazifop-p-butyl (Fusilade DX)			PAR			= paraquat* (Gramoxone Inteon)									
FLM	= flumioxazine (Chateau)			PEL			= pelargonic acid (Scythe)									
GLY	= glyphosate (Roundup, Touchdown)			PEN			= pendimethalin (Prowl H2O)									
HAL	= halosulfuron (Sanda)			SET			= sethoxydim (Poast)									
LIN	= linuron (Lorox)			TRI			= trifluralin (Treflan and others)									
* Permit required from county agricultural commissioner for purchase or use.																

# SUSCEPTIBILITY OF WINTER WEEDS IN ASPARAGUS TO HERBICIDE CONTROL (2/12)

	PREEMERGENCE						POSTEMERGENCE									
	DIU	FLM	LIN	MET	PEN	TRI	DIC*	FLU	GLY	HAL	LIN	MET	NAP	PEL	PAR*	SET
<b>ANNUAL WEEDS</b>																
Bluegrass, annual	C	—	C	C	C	C	N	N	C	N	C	C	C	C	C	N
Filarees	C	C	C	C	N	N	C	P	P	—	C	C	C	P	C	P
Groundsel, common	N	C	P	N	N	N	P	N	C	C	P	N	C	C	C	N
Henbit	C	C	C	C	C	N	C	N	C	—	C	C	P	—	C	N
Mustards	C	C	C	C	—	N	C	N	C	C	C	C	P	C	C	N
Nettle, burning	C	C	C	C	N	P	C	N	C	C	C	C	P	—	C	N
Oat, wild	P	C	P	C	P	P	N	C	C	—	P	C	C	—	P	C
Rocket, London	C	—	C	C	P	N	P	N	C	C	C	C	P	C	C	N
Ryegrasses	P	—	C	C	C	C	N	C	C	N	C	C	C	—	C	C
Shepherd's-purse	C	C	P	C	P	N	C	N	C	C	P	C	P	C	C	N
Sowthistles	C	C	C	C	N	N	C	N	C	C	C	C	C	—	C	N
Sweetclovers	C	—	C	C	—	N	C	N	P	—	C	C	P	—	P	N
Volunteer cereals	C	—	P	P	C	P	N	C	C	—	P	P	C	—	C	P

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

DIC	= dicamba* (Banvel)	MET	= metribuzin (Metribuzin 75)
DIU	= diuron (Karmex, etc)	NAP	= napropamide (Devrinol)
FLU	= fluzifop-p-butyl (Fusilade DX)	PAR	= paraquat* (Gramoxone Inteon)
FLM	= flumioxazine (Chateau)	PEL	= pelargonic acid (Scythe)
GLY	= glyphosate (Roundup, Touchdown)	PEN	= pendimethalin (Prowl H2O)
HAL	= halosulfuron (Sanda)	SET	= sethoxydim (Poast)
LIN	= linuron (Lorox)	TRI	= trifluralin (Treflan and others)

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



# HERBICIDE TREATMENT TABLE (2/12)

Herbicide (example trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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*When choosing a pesticide, consider information relating to environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.*

## PREPLANT

A.	METAM SODIUM* (Vapam) COMMENTS: Fumigants such as metam sodium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone. Fumigate only as a last resort when other management strategies have not been successful or are not available.	50–75 gal	See label	NA
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## STAND ESTABLISHMENT

A.	GLYPHOSATE (Roundup) ... or ... (Touchdown Total)  WSSA MODE-OF-ACTION GROUP NUMBER: 9 COMMENTS: A nonselective foliar herbicide used to control small annual weeds in finished beds before the asparagus emerges. Asparagus emerged at the time of treatment will be killed.	0.25–0.453 lb a.i. 0.34–3.3 qt  0.375–3.75 lb a.i. 0.35–3.6 qt	4  12	NA  NA
B.	PARAQUAT* (Gramoxone Inteon) WSSA MODE-OF-ACTION GROUP NUMBER: 22 COMMENTS: A nonselective foliar herbicide without soil activity applied as a band or broadcast treatment before or after planting, but before the asparagus emerges. Asparagus that has emerged at the time of application will be killed. Apply when weeds are succulent and less than 16 inches high; larger weeds are less affected. Surfactant is needed. Late afternoon applications increase activity.	0.65–1 lb a.i. 2.6–4 pt	24	See label
C.	PELARGONIC ACID (Scythe) MODE OF ACTION: Unknown. COMMENTS: A contact, nonselective foliar herbicide without residual activity. The degree of control is greater when weeds are actively growing, small, and immature; larger weeds are less affected. Apply as a band treatment over the crop row or as a broadcast treatment at or before planting. Provides control of annuals and some suppression of perennials. For best results, target weeds should be thoroughly wetted with spray solution but not to the point of runoff. Use 75–200 gal spray solution/broadcast acre, with higher volume used when weed density is high. A 3–5% solution is sufficient for most annual weeds while perennial or large annual weeds require a 7% solution.	2.25–14 gal/broadcast acre 3%–7% spray solution	12	0
D.	LINURON (Lorox) WSSA MODE-OF-ACTION GROUP NUMBER: 7 COMMENTS: Can be applied over the top to direct-seeded, transplanted, or crown plantings when ferns have 6–18 inches of growth. Has excellent activity on small emerged annual weeds. Do not apply with an adjuvant or in a fertilizer mix.	0.5–1 lb a.i. 1–2 lb	24	1
E.	SETHOXYDIM (Poast) WSSA MODE-OF-ACTION GROUP NUMBER: 1 COMMENTS: For use on direct-seeded or transplanted plantings. Apply to actively growing grasses that are not under moisture stress; best applied 2–4 days after a rain or irrigation. Apply in 10–20 gal water plus an oil concentrate at the rate of 1 qt/acre. Rates dependent on grass size and species. Follow label instructions regarding the use of adjuvants.	0.281–0.468 lb a.i. 1.5–2.5 pt	12	1

Herbicide (example trade name)	Amount per acre	R.E.I.† (hours)	P.H.I.† (days)
F. DIURON (Karmex, etc.) WSSA MODE-OF-ACTION GROUP NUMBER: 7 COMMENTS: For use on crown-planted plants in the San Joaquin Delta only. Considered to be a groundwater contaminant and requires a use permit within Groundwater Protection Areas. Soils should have greater than 2% organic matter; crowns must be buried at least 2 inches deep. Use lower rates on coarse-textured soils.	0.8–1.6 lb a.i. 1–2 lb	12	0
G. FLUAZIFOP-P-BUTYL (Fusilade DX) WSSA MODE-OF-ACTION GROUP NUMBER: 1 COMMENTS: For use on asparagus that is either direct-seeded, transplanted, or crown planted. Apply in 20–40 gal water/acre along with a 1% crop oil concentrate. Rates depend on grass size and species. Follow label instructions regarding the use of adjuvants.	0.1875 lb a.i. 12 oz	12	1

**ESTABLISHED CUTTING BEDS***Preemergence (When spears are not present)*

A. GLYPHOSATE (Roundup) ... or ... (Touchdown Total)	0.25–0.453 lb a.i. 0.25–5 qt  0.375–3.75 lb a.i. 0.35–3.6 qt	4  12	NA  NA
WSSA MODE-OF-ACTION GROUP NUMBER: 9 COMMENTS: A nonselective foliar herbicide used to control small annual weeds in finished beds before spears emerge. Asparagus spears emerged at the time of treatment will be damaged and should be discarded. Use the higher rate to control perennial weeds.			
B. PARAQUAT* (Gramoxone Inteon) WSSA MODE-OF-ACTION GROUP NUMBER: 22 COMMENTS: A nonselective foliar herbicide without soil activity applied as a band or broadcast treatment before spears emerge. Asparagus that has emerged at the time of application will be damaged. Apply when weeds are succulent and 16 inches high; larger weeds are less affected. Surfactant is needed. Late afternoon applications increase activity.	0.65–1 lb a.i. 2.6–4 pt	24	See label
C. PELARGONIC ACID (Scythe) MODE OF ACTION: Unknown. COMMENTS: A contact, nonselective foliar herbicide without residual activity. The degree of control is greater when weeds are actively growing, small, and immature; larger weeds are less affected. Apply as a band treatment over the crop row or as a broadcast treatment at or before planting. Provides control of annuals and some suppression of perennials. For best results, target weeds should be thoroughly wetted with spray solution but not to the point of runoff. Use 75–200 gal spray solution per broadcast acre, with higher volume used when weed density is high. A 3–5% solution is sufficient for most annual weeds while perennial or large annual weeds require a 7% solution.	2.25–14 gal/broadcast acre 3%–7% spray solution	12	0
D. METRIBUZIN (Metribuzin 75) WSSA MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: Apply to soil; metribuzin has both soil and foliar activity on newly emerged annual weeds. Soil should not be moved after application. Rainfall or irrigation necessary for activation of this herbicide.	0.9975–1.995 lb a.i. 1.33–2.66 lb	12	14
E. DIURON (Karmex, etc.) WSSA MODE-OF-ACTION GROUP NUMBER: 7 COMMENTS: Apply as a band or broadcast treatment to weed free beds no earlier than 4 weeks before spears emerge; a second application may be made following harvest. Incorporate mechanically or with irrigation if rainfall does not occur. Considered to be a groundwater contaminant and requires a use permit within Groundwater Protection Areas. Do not use on soils with less than 2% organic matter; use lower rates on coarse-textured soils.	0.8–3.2 lb a.i. 1–4 lb	12	0

Herbicide (example trade name)	Amount per acre	R.E.I.† (hours)	P.H.I.† (days)
F. NAPROPAMIDE (Devrinol) 50 DF WSSA MODE-OF-ACTION GROUP NUMBER: 15 COMMENTS: Apply to weed-free soil in established beds. Requires shallow (1–2 inch) mechanical incorporation, and if rain fall does not occur, it must be irrigated.	4 lb a.i. 8 lb	24	0
G. PENDIMETHALIN (Prowl H2O) WSSA MODE-OF-ACTION GROUP NUMBER: 3 COMMENTS: With a single application apply up to 8.2 pints/acre to the soil surface at least 14 days before harvest. On sandy soils, do not apply more than 2.4 pints/acre. Application must be made prior to spear emergence and prior to weed emergence. This material will not control emerged weeds.	1.1–3.8 lb a.i. 2.4–8.2 pt	24	14
H. TRIFLURALIN (Treflan, and others) WSSA MODE-OF-ACTION GROUP NUMBER: 3 COMMENTS: Apply to established asparagus after bed preparation but before spears emerge. Trifluralin has no postemergence activity on weeds and must be mechanically incorporated immediately after application with disks or rolling cultivators in two directions or with a power driven incorporator in one direction. Higher rates necessary for the suppression of field bindweed.	0.5–2 lb a.i.	12	0
I. LINURON (Lorox) WSSA MODE-OF-ACTION GROUP NUMBER: 7 COMMENTS: A soil-applied herbicide noted for its foliar activity on small seedling, broadleaf weeds and for its relatively short soil residual activity. Can be applied immediately after cutting, but do not harvest within one day after application. Do not apply more than 4 lb a.i./acre/season with a maximum of 3 applications per year.	0.5–1 lb a.i. 1–2 lb	24	1
J. FLUAZIFOP-P-BUTYL (Fusilade) DX WSSA MODE-OF-ACTION GROUP NUMBER: 1 COMMENTS: Do not apply more than 24 fl oz/acre/season. Do not make sequential applications at less than a 3-week interval.	0.1875 lb a.i. 12 oz	12	1
K. SETHOXYDIM (Poast) WSSA MODE-OF-ACTION GROUP NUMBER: 1 COMMENTS: Apply to actively growing grasses that are not under moisture stress; best applied 1–2 days after a rain or irrigation. Rate depends on grass size and species. Follow label instructions regarding the use of adjuvants.	0.281–0.468 lb a.i. 1.5–2.5 pt	12	1
L. FLUMIOXAZIN (Chateau) WSSA MODE-OF-ACTION GROUP NUMBER: 14 COMMENTS: Apply no less than 14 days before spears emerge and before weeds emerge, or burn weeds back with a tank-mix material. Requires 0.25 inch of rainfall or irrigation to activate the material.	0.19 lb a.i. 6 oz	12	14
M. HALOSULFURON (Sanda) WSSA MODE-OF-ACTION GROUP NUMBER: 2 COMMENTS: May be applied before harvest season. Works best on nutsedge when it is actively growing (i.e. following an irrigation). Do not use adjuvant with any applications made before or during harvest. Check label for regional constraints.	0.023–0.046 lb a.i. 0.5–1 oz	12	1

Herbicide (example trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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**ESTABLISHED CUTTING BEDS***Postemergence (After spears emerge)*

A.	DICAMBA* (Banvel) WSSA MODE-OF-ACTION GROUP NUMBER: 4 COMMENTS: Apply immediately after cutting but at least 24 hours before the next harvest. Postharvest applications should be done as directed sprays to avoid fern contact. Do not use in Coachella Valley. Do not exceed 1 pt/acre/season.	0.25–0.5 lb a.i. 0.5–1 pt	24	1
B.	LINURON (Lorox) COMMENTS: A soil-applied herbicide noted for its foliar activity on small seedling, broadleaf weeds and for its relatively short soil residual activity. Can be applied immediately after cutting, but do not harvest within one day after application. Do not apply more than 4 lb a.i./acre/season with a maximum of 3 applications per year.	0.5–1 lb a.i. 1–2 lb	24	1
C.	HALOSULFURON (Sanda) WSSA MODE-OF-ACTION GROUP NUMBER: 2 COMMENTS: May be applied before or during harvest season. Works best on nutsedge when it is actively growing (i.e. following an irrigation). Do not use adjuvant with any applications made before or during harvest. Check label for regional constraints.	0.0234–0.0703 lb a.i. 0.5–1.5 oz	12	1
D.	FLUAZIFOP-P-BUTYL (Fusilade) DX WSSA MODE-OF-ACTION GROUP NUMBER: 1 COMMENTS: Do not apply more than 24 fl oz/acre/season. Do not make sequential applications at less than a 3-week interval.	0.1875 lb a.i. 12 oz	12	1
E.	SETHOXYDIM (Poast) WSSA MODE-OF-ACTION GROUP NUMBER: 1 COMMENTS: Apply to actively growing grasses that are not under moisture stress; best applied 1–2 days after a rain or irrigation. Rate depends on grass size and species. Follow label instructions regarding the use of adjuvants.	0.281–0.468 lb a.i. 1.5–2.5 pt	12	1

**ESTABLISHED CUTTING BEDS***Postharvest and fern stage*

A.	GLYPHOSATE (Roundup) ... or ... (Touchdown Total) WSSA MODE-OF-ACTION GROUP NUMBER: 9 COMMENTS: A nonselective foliar herbicide used to control both annual and perennial weeds. Use on clean cut beds after all remaining spears have been removed. Higher rates of application are necessary for the control of perennial weeds. Direct contact of the spray to asparagus can cause serious injury. Useful as a spot treatment for the control of perennial weeds at field edges. Do not apply within a week before the first asparagus spears emerge.	0.25–0.453 lb a.i. 0.34–3.3 qt 0.375–3.75 lb a.i. 0.35–3.6 qt	4 12	See label See label
B.	HALOSULFURON (Sanda) WSSA MODE-OF-ACTION GROUP NUMBER: 2 COMMENTS: May be applied at end of harvest season. Under heavy nutsedge pressure split applications are recommended. Works best on nutsedge when it is actively growing (i.e. following an irrigation). Use drop nozzles to improve coverage on weeds and reduce contact with fern.	0.0234–0.0703 lb a.i. 0.5–1.5 oz	12	1

Herbicide (example trade name)	Amount per acre	R.E.I.† (hours)	P.H.I.† (days)
C. DIURON (Karmex, etc.) WSSA MODE-OF-ACTION GROUP NUMBER: 7 COMMENTS: Can be applied following the harvest period. Do not exceed seasonal application limits.	0.8–3.2 lb a.i. 1–4 lb	12	0
D. TRIFLURALIN (Treflan, and others) WSSA MODE-OF-ACTION GROUP NUMBER: 3 COMMENTS: Can be mechanically incorporated to suppress bermudagrass and other grasses following the harvest period but before fern growth.	0.5–2 lb a.i.	12	0
E. LINURON (Lorox) WSSA MODE-OF-ACTION GROUP NUMBER: 7 COMMENTS: Can be used as a directed spray to the base of the fern.	0.5–1 lb a.i. 1–2 lb	24	1
F. FLUAZIFOP-P-BUTYL (Fusilade) DX WSSA MODE-OF-ACTION GROUP NUMBER: 1 COMMENTS: Can be used before the fern stage to suppress bermudagrass and other grasses.	0.1875 lb a.i. 12 oz	12	1
G. SETHOXYDIM (Poast) WSSA MODE-OF-ACTION GROUP NUMBER: 1 COMMENTS: Apply to actively growing grasses that are not under moisture stress; best applied 1-2 days after a rain or irrigation. Rate depends on grass size and species. Follow label instructions regarding the use of adjuvants.	0.281–0.468 lb a.i. 1.5–2.5 pt	12	1
H. METRIBUZIN (Metribuzin 75) WSSA MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: Apply after last harvest of the season but before fern growth begins.	0.9975–1.995 lb a.i. 1.33–2.66 lb	12	14

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

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

NA Not applicable.

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://www.hracglobal.com>.

## *Vertebrates*

# MANAGING VERTEBRATES (7/16)

Bird and mammal pests are found in and around virtually every cropping system in the state, although they may not always present a significant problem. In some crops, damage caused by birds generally results in a loss of a portion of the current crop but does not decrease future yield potential. Some pests, however, can cause major problems by feeding on shoots, and roots, which can stunt growth or kill plants. Injury to trees by rodents or rabbits, for example, is often serious, killing the plant outright or causing permanent damage that lowers yields for years following the initial feeding. Some pests will chew or destroy flexible irrigation lines and emitters. Other pests will dig holes through the soil surface, thereby channeling surface irrigation water to undesired areas. Food safety also becomes an issue if pest residues come into contact with the marketable commodity.

Manage your fields in order to keep pest numbers low and to discourage new invasions so that significant damage does not occur.

- Before planting, remove vertebrate pests and destroy habitats (such as burrows) within the field boundaries. Preventive measures cost less and are more successful before planting, when one can easily see the pests or their habitats.
- Be aware of the location, as vertebrate pests can easily reinvade if the field is adjacent to rangeland, waterways, or unmanaged areas. It is much easier to manage vertebrate pests by implementing controls on the perimeter versus inside.
- Baiting, fencing, fumigating burrows, shooting, and trapping are easier and usually more effective if employed before you plant instead of after.
- Where feasible, deep plow and disc to destroy burrows, disperse or kill resident populations, and reduce the risk of reinvansion by pocket gophers, voles, and (to a lesser extent) ground squirrels.

Guidelines for reducing vertebrate pest problems and making control more economical:

- Correctly identify the species causing the problem using damage signs, burrows or habitat, tracks, feces, etc.
- If feasible, alter the habitat to make the area less favorable to the pest species (e.g., eliminate cover crops and weeds or keep them mowed low.)
- Take early action and use the control methods appropriate for the crop and time of year. Consider the environment and nontarget species when choosing a control method.
- Establish a monitoring system to detect reinfestation so you can determine when additional corrective measures or controls are necessary.

A successful pest management program requires good records and regular monitoring. Some vertebrate pest populations can easily "explode" because of high reproductive rates and abundant food. Keep a record of the management procedures you use and their effectiveness. Good records will help you plan and improve future control strategies.

For most vertebrate pests, there is more than one control option for reducing numbers and damage. The following table summarizes the various control measures appropriate for common vertebrate pests. Details on how to use these controls are given in the individual pest sections.

Pest	Control Measures								
	Habitat modification	Trapping	Baiting	Fencing	Tree guards	Frightening	Shooting	Fumigating	Repellents Fumigating
Deer				X	X	X	X <sup>1</sup>		X
Eastern fox squirrel		X					X		
California ground squirrel	X	X	X				X	X	
Pocket gophers	X	X	X					X	
Rabbits	X	X <sup>2</sup>	X	X	X		X		X
Rats	X	X	X					X	
Voles	X		X	X	X				
Coyote		X					X		
Wild pig		X		X			X		
Birds <sup>3</sup>	X	X		X		X	X		X

1 During hunting season or with a permit.

2 Cottontails are relatively easy to trap. Jackrabbits are difficult to trap, but trapping may be useful.

3 Not all of these techniques will be effective for all species. More specific information can be found in the bird section.

Adapted from Salmon and Lickliter 1984. Wildlife Pest Control Around Gardens and Homes. UC ANR Publication 21385.

Vertebrate control equipment and supplies (baits, fumigants, propane exploders, traps, etc.) are available at local retail outlets such as farm supply and hardware stores. In addition, some county agricultural commissioner's offices make certain rodenticides and fumigants available to growers. For further information or sources of special control materials, consult your local Cooperative Extension advisor or agricultural commissioner's office.

### Legal aspects of vertebrate pest management

Under the California Fish and Game Code, if California ground squirrels, meadow voles, pocket gophers, eastern fox squirrels, roof rats, black-tailed jackrabbits, cottontail rabbits, American crows, house sparrows, starlings, and yellow-billed magpies are causing or are anticipated to cause crop depredation, the owner or tenant of a property may use lethal methods to remove them at any time.

For other pests such as deer, wild pigs, western gray squirrels, and most bird species, depredation permits are required for removal. However, these regulations can change at any time, so it is always a good idea to check current California Fish and Game Code (<http://leginfo.legislature.ca.gov/faces/codes.xhtml>) to ensure removal of a particular species is legal.

### Pesticides

Only pesticides that are registered with the California Department of Pesticide Regulation (DPR) can legally be used for vertebrate pest control. Registered materials are listed in DPR's databases. You may also contact your county agricultural commissioner for current product registrations and the latest information on legal pesticide use, including current information on restrictions that apply to pest control activities in order to protect endangered species. *Follow label directions carefully* and understand the hazards when using poison baits and fumigants.

The U.S. Environmental Protection Agency (EPA) has placed restrictions on most rodenticides used to control vertebrates in agricultural production. The applicator must have a permit to purchase and use the product. These products will be identified with an asterisk (\*).

## Trapping

Trapping is often used to control vertebrate pests. Mark all traps clearly with the owner's name and contact address or phone number. In California, trapping mammals, even for pest purposes, requires a trapping license issued by the California Department of Fish and Wildlife. However, rats, mice, moles, voles, and pocket gophers do not have this requirement. Additionally, you do not need a trapping license for ground squirrels or rabbits if trapping on your own property for pest control purposes. However, if trapping either of these species for profit (e.g., pest control operator), a trapping license is required.

## Protected species

In some areas of California, crop fields are located within the range of federally- and state-protected threatened or endangered species. Species likely to be of concern include the San Joaquin kit fox, several species of kangaroo rats, and, where burrow fumigants are used, the blunt-nosed leopard lizard, California red-legged frog, and California tiger salamander.

## Typical guidelines

Special guidelines apply to the use of toxic baits and fumigants for vertebrate pest control in these areas. These include

- Modification of ground squirrel bait stations to exclude protected species
- Restrict broadcast applications of bait
- Prohibit fumigation at certain locations or during some times of the year
- Require that applications be supervised by someone trained to avoid harming endangered species

Your county agricultural commissioner has the latest detailed maps that show the ranges of endangered species and the latest information on restrictions that apply to pest control activities in those areas. You can also get more information on endangered species regulations from the DPR website (<http://www.cdpr.ca.gov/docs/endspec/>).

For more information on vertebrate management, see the Vertebrate Pest Control Handbook online (<http://vpcrac.org/about/vertebrate-pest-handbook/>).



## POCKET GOPHERS (7/16)

**Scientific Name:** *Thomomys* spp.

### DESCRIPTION OF THE PEST

Pocket gophers are stout-bodied rodents with short legs. Adults:

- 6 to 8 inches long
- brown, gray, or yellowish
- large clawed front paws
- small ears and eyes
- a short, scantily haired tail

On each side of the mouth pocket gophers have external cheek pouches or “pockets” used extensively for carrying food.

Pocket gophers are rarely seen above ground. They live almost entirely underground spending most of their time in a tunnel system they construct 6 to 12 inches beneath the soil surface. A single burrow system can cover several hundred square feet and consists of main tunnels with lateral branches used for feeding or for pushing excavated soil to the surface. Because gophers are extremely territorial, you rarely find more than one gopher per burrow system, unless it is during the breeding season or females are tending their young.

The conspicuous, fan-shaped soil mounds over tunnel openings are the most obvious sign of a gopher infestation. These tunnel openings are almost always closed with a soil plug unless the gopher is actively excavating a tunnel.

Gophers feed primarily on the roots of herbaceous plants. They may also come aboveground to clip small plants within a few inches of the tunnel opening and pull vegetation into the burrow to eat.

Gophers breed throughout the year on irrigated land, with a peak in late winter or early spring. Females bear as many as three litters each year, although typically only one or two per year, each averaging five young. Once weaned, the young gophers travel to a favorable location to establish their own burrow system. Some take over previously vacated burrows. The buildup of gophers in crop fields is favored by extensive weed growth, including nutsedge, or the presence of many cover crops, especially perennial clovers and legumes.

### DAMAGE

Pocket gophers can be serious pests. They are active throughout the year and if uncontrolled and food is plentiful, can increase to 30 to 40 gophers per acre.

While herbaceous cover crops are their preferred food, pocket gophers also feed on the bark of tree crowns and roots, particularly when cover crops or weeds dry up. Bark consumption may be extensive enough to girdle and kill young vines or trees or reduce the vigor of older vines or trees. Usually gophers feed on trees from underground so the damage may not be evident until they show signs of stress. Pocket gophers also feed on the roots of vegetable and berry plants. Plants with more fibrous root systems often suffer minimal damage; plants with large taproots are most susceptible. Gophers sometimes gnaw on plastic irrigation lines. These holes lead to uneven water distribution, with some areas receiving too much water, and other parts not receiving any. Fixing pocket gopher punctures of subsurface drip tape can be time-consuming and quite expensive. Tunnel systems often lead to a loss or diversion of irrigation water and may lead to severe erosion.

## MANAGEMENT

Persistent efforts can control pocket gophers and even eliminate them. Pocket gopher damage typically occurs belowground; therefore, it often goes undetected until individual plants or trees exhibit stress. By that time the tree or plant may be beyond saving. Gopher activity is readily detected, however; just look for fresh mounds of soil. Gophers make the greatest numbers of fresh mounds in the spring and fall, when the soil is amply moist.

Take action as soon as you see any sign of gopher activity. Common control methods include trapping, aluminum phosphide\* fumigation, or hand-applied poison bait. Trapping and hand-baiting can be used at any time of year, but they are easier when the soil is moist and not dry and hard; aluminum phosphide\* must be used when the soil is moist. Control of vegetative cover can reduce the attractiveness of fields to gophers by removing preferred food sources (e.g., nutsedge, clovers, and legumes). In addition, consider managing gophers in adjacent areas to reduce the potential for gopher reinvasion.

Gopher control is best done in late fall through late winter when mounding activity is high. Additionally, because numbers are usually lowest during early winter, management during this time of year can be more effective than after gophers have reproduced.

### Biological Control

Snakes, owls, and hawks are usually not sufficient to effectively control gophers. These predators consume a number of gophers but usually not enough to keep populations at low enough numbers to eliminate the need for additional control measures.

### Cultural Control

#### *Flood irrigation*

If flood irrigation is possible, it can help control gophers; they are not aquatic. This type of irrigation often drives gopher activity to the edges of the field where they are more easily located to control, if not killed by flooding. Growers and their dogs can also actively seek out voles at this time to further reduce population size.

#### *Tilling*

When taking a field out of production, deep tilling of soil will kill some gophers and destroy most or all burrow systems in a field. This can slow reinvasion rates and provides more time to get gopher populations under control.

### Monitoring and Treatment Decisions

The best times to monitor for gopher activity are after irrigation and when mound building peaks in fall and spring.

- Monitor monthly.
- Pay close attention to field perimeters to determine whether gophers are invading the field from adjacent property.
- Monitor closely in weedy areas such as roadsides and in young orchards with extensive weed growth or ground cover. This type of vegetation is more likely to support gophers, and low-growing vegetation makes signs of burrowing activity more difficult to see.
- Look for darker-colored mounds, which indicate newly removed, moister soil.
- If you find mounds, trees or vines showing signs of stress, or both, look for girdling of roots or crowns at or below the soil.

#### *Treatment options*

The preferred control methods are baiting with multiple-dose anticoagulants, strychnine\* or zinc phosphide\*; trapping; and burrow fumigation. Neither chemical nor mechanical repellents have been found effective against pocket gophers. Remove vegetative cover and preferred food sources (e.g., clovers and legumes) to reduce the attractiveness of cover crops in orchards and vineyards to gophers. Often, a single approach is not sufficient to effectively control gophers. An integrated approach that uses more than one control option should provide greater control.

Strychnine\*, zinc phosphide\*, anticoagulants\*, and aluminum phosphide\* are currently restricted materials that require a permit from the county agricultural commissioner for purchase or use in agricultural fields. Be aware that restrictions for use of baits and fumigants around buildings may exist. However, restriction criteria of baits and fumigants often change, so it is best to consult your local agricultural commissioner before using any baits or fumigants to assure full compliance with current laws and regulations.

All treatment options require access to the main tunnel, located about 6 to 12 inches belowground. Finding the main tunnel takes practice, skill, and the use of a probing device. To find a main tunnel:

1. Locate a fresh gopher mound. The key is to look for mounds that contain moist dirt.
2. Start by finding the plug of the mound.
3. Begin probing anywhere from 4 to 12 inches behind this plug.
4. You will know you have found the tunnel when you feel a drop in the probe (i.e., less resistance) of a couple of inches. Tunnels typically run in only one or two directions. Occasionally you will have tunnels running in three or more directions.

### **Baiting**

While multi-dose anticoagulants (e.g., chlorophacinone\* and diphacinone\*) are available for gopher control, single-dose acute baits (e.g., strychnine\* and zinc phosphide\*) have historically been the most effective.

Gophers often back-fill old tunnels with loose soil and these backfilled tunnels can feel like open tunnels to inexperienced bait applicators. Applying bait in these backfilled tunnels will greatly limit the efficacy of this management approach; gophers will not find bait placed here.

Before initiating a baiting program, train all bait applicators to identify backfilled tunnel systems. An effective way to conduct this training is to:

1. Have novice bait applicators probe for open (non-back-filled) tunnel systems.
2. Once they have found a tunnel, they dig down into these tunnel systems to verify whether they are open or backfilled.
3. Repeat until the bait applicator successfully identifies open tunnel systems with at least 90% accuracy.

Following these methods should result in consistently more efficacious control efforts when using baits and burrow fumigants.

Apply bait below ground. For small infestations or where the use of a mechanical burrow builder is not feasible, use a probe to find the main tunnel next to a fresh mound or between two fresh mounds. Once you find the main tunnel,

1. Enlarge the probe opening by rotating the probe back-and-forth
2. Place a small amount of grain or pelletized bait in the burrow; a funnel can also be used to pour the bait into the tunnel.
3. Place a dirt clod, stone, or another covering over the hole to keep out light and prevent soil from falling onto the bait.

Place bait in two or three places along the tunnel. This hand-application method can be used for single-dose or multiple-dose baits.

If gophers have infested a large area, reservoir-type hand probes designed to deposit single-dose baits are available. Bait application is faster with these devices because they eliminate the need to stop and place the bait by hand. Once you have located a tunnel using the probe, a trigger releases a measured amount of bait into the tunnel. It is important to check the probe periodically to make sure that it has not been clogged with soil. Generally, strychnine\* or zinc phosphide\* bait is used with such an applicator because it can dispense only a small quantity of bait at a time. Anticoagulant\* baits are less toxic and require greater volumes of bait to be effective, thereby limiting the utility of bait probes for these baits.

A mechanical burrow builder can also be effective and economical for infestations that cover large areas. This device is pulled behind a tractor to construct artificial gopher tunnels into which it places bait. Artificial burrows either intercept some of the gopher's natural burrows, or the gopher will soon discover the artificial burrow and consume the bait. Prior to using this application device, it is important to know the average depth of active pocket gopher burrows before setting up the burrow builder. Use a probe to find burrows and a shovel to verify they are active (open). After starting the application, use a shovel to occasionally open a small section of the artificial burrow and inspect its depth and condition. It is also important that the compaction / drive wheels properly compact the soil over the burrow. Soil moisture is important, as tunnels created in dry soil will cave in, while tunnels created in wet soil may not form properly. Soil moisture must be intermediate to produce a well-formed, smooth, artificial burrow. Follow the manufacturer's manual to properly set the depth and calibration of bait application. All baits used in burrow builders are restricted-use materials. Use of a mechanical burrow builder may be feasible in situations such as unplanted borders or between widely spaced young trees when the terrain is relatively level and the soil is not too rocky or before planting a field. However, because the burrow builder creates an extensive network of burrows, only use it when gopher numbers are high as these new burrows will increase the speed with which gophers can invade new areas.

### *Trapping*

Traps are effective against small numbers of gophers but are labor intensive. As such, they can be relatively expensive to use over large acreage. However, trapping often results in greater control of gophers than baiting, so the cost may be offset by effectiveness. Use either pincher traps (most common) or box-type kill traps. The smaller size and lower cost of pincer traps typically makes them a more practical choice in a field setting. Pincher traps such as the Macabee, Cinch, or Gophinator have a vertical metal or wire pan which the gopher triggers by pushing against it. Studies have shown the Gophinator and Cinch traps to be more effective than other tested traps.

Pincher-type traps can be placed in the main tunnel of a gopher burrow system or in lateral tunnels. Setting traps in lateral tunnels is quicker and easier than trapping in the main tunnel. However, trapping in lateral tunnels may be less effective at certain times of the year (e.g., summer) and for more experienced gophers (e.g., adult males).

To place traps in the main tunnel find a fresh mound and probe as described in the Treatment Decisions section. When found, clear out the tunnel until the opening is just wide enough to insert the traps. Place traps in the main tunnel, one facing each direction the tunnel goes.

1. Set traps and place them entirely into the tunnels. The number of traps required will depend on the number of tunnels present.
2. Stake the traps by fastening wire, light cable, or twine to the trap and stake to prevent predators from carrying away traps with catches. Stakes also serve as markers to indicate trap location.
3. You can cover up the trap-hole with sod, plywood, canvas, or some other material to keep light from entering the tunnel system. However, a recent study has shown that covering trap-holes has only a minor effect on capture success. When trapping a large area, leave trap-holes uncovered to save substantial time; however covering trap-holes may keep children and pets out of traps, if this is a concern.
4. If there is no evidence that a gopher has visited the trap within 24 hours, move it to a new location.

To place traps in lateral tunnels, remove the plug from a fresh mound and place the trap entirely into the lateral tunnel. In many areas, the plugs in these lateral tunnels are quite extensive; in these situations, trapping laterals becomes counterproductive given the extensive period of time required to remove these plugs.

### *Fumigants*

Most fumigants, such as gas cartridges, are not effective because gophers quickly seal off their tunnels when they detect the smoke or poison gases. However, aluminum phosphide\* can be

effective if applied underground into tunnels during a time of year when soil is moist enough to retain the toxic gas, typically in late winter to early spring, or year round in irrigated crops. In fact, burrow fumigation with aluminum phosphide\* is typically the most consistently efficacious option for gopher control as long as sufficient soil moisture is present.

Application of aluminum phosphide\* is similar to hand-baiting.

1. Use a probe to locate the main tunnel.
2. Once the tunnel has been found, wiggle the probe to enlarge the hole large enough to dispense the aluminum phosphide\* tablets into the tunnel.
3. Follow label instructions on the number of tablets to place into the tunnel.
4. Cover the probe hole with a rock or dirt clod, being careful not to bury the tablets under loose dirt.
5. Treat each tunnel system twice.

When using aluminum phosphide\*, be sure to carefully follow all label directions and safety instructions.

As of 1 January 2012, the use of pressurized-exhaust machines that inject carbon monoxide into burrow systems has become a legal technique for controlling burrowing mammals in California. The California Department of Pesticide Regulation is now developing regulations for use of this method of control. This approach appears to be somewhat effective at controlling pocket gophers, although early studies have not shown it to be as effective as burrow fumigation with aluminum phosphide\* or trapping.

#### *Gas explosive device*

The use of a gas explosive device that combines propane with oxygen has been used to kill gophers through a concussive force. This device has the added benefit of destroying part or all of the gopher's tunnel system, potentially slowing reinvasion rates. Exercise caution when using these devices because of the potential for unintended damage to property, injury to users and bystanders, potential for starting fires in dry environments, and destruction of turf. Additionally, these devices can be quite loud, making them unsuitable in residential areas. Studies on the efficacy of this device have not been positive. Alternative options such as burrow fumigation, trapping, and baiting appear to be more effective.

#### *Repellents*

No scientific data has been reported to show that chemical repellents effectively keep gophers from inhabiting fields, orchards, or vineyards. A new repellent for use in subsurface drip tape has been developed that may offer some promise although it has yet to be sufficiently tested to verify efficacy.

#### *Frightening devices*

Frightening gophers with sound or vibrations also does not appear to be effective.

\* User must be a certified applicator or be under the supervision of someone who is. Some products also require a permit from the county agricultural commissioner for purchase or use.

## RABBITS (7/16)

**Scientific Names:** Black-tailed Jackrabbit: *Lepus californicus*  
Cottontail and Brush Rabbits: *Sylvilagus* spp.

### DESCRIPTION OF THE PEST

Although jackrabbits are the most common of the rabbit-type pests, they are technically classified as a hare. Jackrabbits:

- About the size of a large house cat
- Very long ears
- Short front legs
- Long hind legs

Jackrabbits live in open areas of the Central Valley, coastal valleys, and foothills and are active all year from early evening to early morning. They are seldom found in dense brush or woodlands. A good sign that jackrabbits are present is their coarse, circular fecal droppings or pellets found scattered over an area.

They make a depression underneath bushes or other vegetation where they remain secluded during the day. Jackrabbits breed from early spring to late summer.

Females may produce more than one litter a year, especially where irrigated crops are available. The average litter contains four pups, which are born fully haired, open eyed, and become active within a few hours.

Cottontail and brush rabbits are smaller than jackrabbits and have shorter ears. They nest where thick shrubs, woods, or rocks and debris provide dense cover. Their young are born naked and blind and stay in the nest for several weeks.

Rabbits are active all year. Jackrabbits frequently damage crops bordering open areas, such as grassy fields and rangeland. Cottontail and brush rabbits prefer crops near brushy habitats, ravines, riparian areas, and woodlands favored by these species.

What rabbits eat is variable depending on location and the availability of appropriate plants. They prefer succulent green vegetation; grasses and herbaceous plants typically make up the bulk of their diet. Feeding usually begins during the evening hours and continues throughout the night into the early morning. Rabbits do not need to drink water.

If food and other necessary resources are found in one place, rabbits will stay in the area. If food and areas for shelter are separated, they will move between these areas in the morning and evening. Daily travel by jackrabbits of 1 to 2 miles round trip between these areas can occur. These travels are habitually made on the same trails every day, producing noticeable paths through herbaceous vegetation.

### DAMAGE

In vegetable crops, rabbits occasionally feed on new plant growth, particularly during the early growing season. In asparagus, they occasionally feed on spears during the harvest season.

Jackrabbits can carry tularemia, otherwise known as rabbit fever. This disease is relatively rare in humans but can be contracted by handling an infected rabbit with bare hands or by eating insufficiently cooked rabbit meat. Do not handle rabbits with bare hands.

### MANAGEMENT

Manage rabbits before severe damage occurs. Common control methods for rabbits include fencing, trunk guards, repellants, baiting, trapping, and shooting depending on the species and crop. Unfortunately, habitat control and trapping are not typically effective for jackrabbits given their ability to cover great distances between forage and shelter locations. The choice of control method should depend on the urgency of the problem and the situation.

## Biological Control

Predators such as coyotes and hawks are usually not sufficient to effectively control rabbits. Although these predators consume a number of rabbits, it is usually not adequate to keep populations low enough to eliminate the need for additional control measures.

## Cultural Control

### *Fencing*

Rabbit-proof fencing prevents damage to young fields, orchards, or vineyards.

1. Make the fence at least 3 feet tall using woven wire or poultry netting with a mesh diameter of 1 inch or less.
2. Bend the bottom 6 inches of mesh at a 90-degree angle and bury it 6 inches deep, facing away from the area to be protected, to keep rabbits from digging under the fence.

If you are building a fence to exclude deer, and rabbits are a potential problem, it is a good idea to add rabbit-proof fencing along the bottom.

### *Habitat modification*

Rabbits often invade from adjacent fields, but unless the land is under the grower's direct management, habitat modification of the outlying habitat is usually impractical. The removal of preferred foods such as cover crops and weeds may reduce the number of rabbits that visit the crop and make them easier to detect. However, removal of vegetative cover may temporarily increase damage as the desired crop would be the only food source left for rabbits. Therefore, except for removal of old prunings and brush piles, habitat modification to reduce damage is rarely practical.

## Monitoring and Treatment Decisions

Rabbits often breed, bear young, and live outside fields, orchards, and vineyards. They move in to feed at night so you may not see them during daylight hours. Therefore, monitor in the early morning, late evening, or at night (using a spotlight). Monitor spears near harvest.

If you find damage:

- Look for droppings and tracks that indicate rabbits may be the cause. Voles also chew the bark from the trunk, but the bark damage caused by rabbits extends higher on the tree and the tooth marks are distinctly larger.
- Monitor the perimeters in early morning or late evening to see where rabbits are entering and to get an idea of how many are involved.
- Estimate the number of jackrabbits at night by using a spotlight and looking for "eye shine."

### *Baiting*

Poison baits may be practical for controlling large numbers of rabbits in large areas. Before baiting, consult the county agricultural commissioner for restrictions related to endangered species. Follow label directions carefully.

Only multiple-dose anticoagulant baits (i.e., chlorophacinone\* and diphacinone\*) are registered for use against rabbits. These baits are available from many county agricultural commissioners' offices. All field-use anticoagulant baits are now **restricted use materials**; you will need to be certified to use these baits for rabbit control. They come in grain formulations that may be used along field edges, but not within the field itself.

Multiple-dose baits for rabbit control must be placed in bait stations specifically designed for rabbits.

1. Place bait stations containing bait near trails and secure them so they cannot easily be tipped over.
2. Use as many stations as necessary to ensure that all rabbits have easy access to bait, spacing them 50 to 200 feet apart along the perimeter where rabbits are entering the field.
3. Inspect the bait stations every morning for the first several days to keep bait supplies replenished; it may take this long before the rabbits become accustomed to feeding at the stations. Increase either the amount of bait in the stations or the number of stations if all the bait is consumed in a single night.
4. Replace any bait that becomes wet or moldy.
5. Continue baiting until feeding ceases and you no longer observe any rabbits.

It usually takes 2 to 4 weeks or more before results are seen with multiple-dose baits.

Bait should be covered or removed during daylight hours to prevent consumption by diurnal seed-eating birds. Make sure to take precautions to prevent domestic animals and wildlife from having access to the bait. Dispose of unused bait properly at the end of the baiting program. When baiting for rabbits, you should remove all aboveground carcasses by burying them underground, or by bagging and disposing them in the trash. This will reduce potential secondary poisoning hazards.

### *Shooting*

Shooting, applying repellents, and trapping may provide effective control for low numbers of rabbits or may be used to temporarily reduce damage until other measures such as fences or tree guards are installed.

- When low numbers of rabbits are present and causing damage, shooting can be an effective control if shooting is allowed in your area. If only a small number is involved, shooting may be all that is necessary to prevent significant damage while crops are susceptible. For best results, patrol systematically in the early morning or at dusk.
- Keep in mind that lead ammunition is being phased out across the state. Additional information on this lead ban can be found at Department of Fish and Game website <https://www.wildlife.ca.gov/hunting/nonlead-ammunition>.

### *Repellents*

Repellents are occasionally effective at deterring rabbit damage to some crops, particularly orchard and vine crops. However, no effective rabbit repellents are available for use in most vegetable and forage crops. To apply repellents in orchard and vineyard crops, spray or brush the repellent on trunks during the dormant season or on foliage or trunks during the growing season. Labels specify the proper application method, rate, and timing. Repeat applications as needed to protect new growth and to replenish any repellent that is washed off by rain or sprinkler irrigation. Effectiveness of repellents often is dependent on availability of alternative food sources. If additional food sources are abundant, repellents sprayed on target plants may be effective. If additional food sources are scarce, repellents may have little effect.

### *Trapping*

Trapping generally is ineffective against jackrabbits because they do not readily enter traps. Box-type traps, especially the Critter Getter DK-3 baited with apple slices or dried apricots, can provide effective control of cottontails or brush rabbits when populations are small. Pre-baiting with a small amount of bait has been found to improve results.

- \* User must be a certified applicator or be under the supervision of someone who is. Some products also require a permit from the county agricultural commissioner for purchase or use.



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### Precautions for Using Pesticides

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

### Legal Responsibility

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

### Transportation

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

### Storage

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

### Container Disposal

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

### Protection of Nonpest Animals and Plants

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

### Posting Treated Fields

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

### Preharvest Intervals

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

### Permit Requirements

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

### Maximum residue levels

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

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