



# Grape

April 2019

## PEST MANAGEMENT GUIDELINES FOR AGRICULTURE

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### The UC IPM Pest Management Guidelines are available from:

- **Online:** <http://www.ipm.ucanr.edu>
- **UC Cooperative Extension:** County Offices
- **University of California**

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510-665-2195; 800-994-8849

**Updates:** These guidelines are updated regularly. Check with your University of California Cooperative Extension Office or the UC IPM 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.

# Table Grape Year-Round IPM Program (Reviewed 7/15)

## ANNUAL CHECKLIST

These practices are recommended for a monitoring-based IPM program that reduces environmental quality problems related to pesticide use. Track your progress through the year using this form.

Each time a pesticide application is considered, review the Pesticide Application Checklist at the bottom of this form for information on how to minimize environmental quality problems. This program covers the major pests of table grapes. Details on carrying out each practice, information on additional pests, and additional copies of this form are available from the UC IPM Pest Management Guidelines: Grape at <http://www.ipm.ucanr.edu/PMG>.

This year-round program applies only to table grapes. For wine and raisin grapes, see the WINE AND RAISIN GRAPE YEAR-ROUND PROGRAM.

<b>✓ Done</b>	<h3>Delayed-dormancy</h3> <p>San Joaquin Valley: February · Coachella Valley: December to January</p> <p><b>What should you be doing at this time?</b></p>						
	<p>On a warm day (above 65°F), monitor trunks, cordons, and spurs for:</p> <ul style="list-style-type: none"> <li>• Mealybugs</li> <li>• Ants associated with mealybugs and European fruit lecanium scale</li> <li>• Overwintering spider mites (orange)</li> <li>• Cutworms</li> </ul> <p>Keep records (<i>example form available online</i>). Manage if needed according to the Pest Management Guidelines.</p>						
	<p>Just before budbreak, in the San Joaquin Valley, place omnivorous leafroller pheromone traps in the vineyard.</p> <ul style="list-style-type: none"> <li>• Check traps twice weekly until a biofix date is established; thereafter, check traps weekly.</li> <li>• Record biofix for the first moth.</li> </ul> <p>Keep records (<i>example form available online</i>).</p>						
	<p>Just before budbreak, place sticky traps in and around the vineyard for glassy-winged sharpshooter.</p> <ul style="list-style-type: none"> <li>• Change traps weekly.</li> </ul> <p>Keep records (<i>example form available online</i>).</p>						
	<p>Vineyard floor management before bud break:</p> <ul style="list-style-type: none"> <li>• Control weeds with mowing, cultivation, or herbicides</li> <li>• Mow tall cover crop</li> </ul>						
	<p>Other pests, pest damage or diseases you may see:</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%;">• Rodents</td> <td style="width: 50%;">• Bud beetles</td> </tr> <tr> <td>• Branch and twig borer</td> <td>• Dead spurs from trunk diseases</td> </tr> <tr> <td>• Click beetles</td> <td></td> </tr> </table>	• Rodents	• Bud beetles	• Branch and twig borer	• Dead spurs from trunk diseases	• Click beetles	
• Rodents	• Bud beetles						
• Branch and twig borer	• Dead spurs from trunk diseases						
• Click beetles							

<b>✓ Done</b>	<h3>Budbreak</h3> <p>(San Joaquin Valley, March; Coachella Valley, January to February)</p> <p><b>What should you be doing at this time?</b></p>
	<p>On a warm day (above 65° F), monitor trunks, cordons, and spurs for:</p> <ul style="list-style-type: none"> <li>• Mealybugs</li> <li>• Ants associated with mealybugs and European fruit lecanium scale</li> <li>• Overwintering spider mites (orange)</li> <li>• Cutworms</li> </ul>

✓ Done	<h2>Budbreak</h2> <p>(San Joaquin Valley, March; Coachella Valley, January to February)</p> <p><b>What should you be doing at this time?</b></p>
	Keep records ( <i>example form available online</i> ). Manage if needed according to the Pest Management Guidelines.
	In the San Joaquin Valley continue to check pheromone traps twice weekly for omnivorous leafroller, if biofix has not been reached. <ul style="list-style-type: none"> <li>Record biofix for the first moth (<i>example monitoring form available online</i>).</li> <li>Check traps weekly after biofix date is established.</li> </ul>
	Monitor for powdery mildew using the risk assessment index followed by visual inspections. Treat if needed according to the Pest Management Guidelines.
	If rainfall is predicted after budbreak, consider treating for phomopsis cane and leaf spot in sensitive varieties (Thompson Seedless, Redglobe).
	Note locations of vines showing poor budbreak for future assessment of abiotic disorders or diseases.
	Check sticky traps for glassy-winged sharpshooters. Keep records ( <i>example form available online</i> ).
	Survey weeds to plan a weed management strategy if not completed earlier in the season. If herbicides are to be used: <ul style="list-style-type: none"> <li>Record observations (<i>example form available online</i>).</li> <li>Make your selection based on weed survey observations.</li> </ul>
	Other pests you may see: <ul style="list-style-type: none"> <li>Grape bud beetle</li> <li>Red-headed and green sharpshooter</li> </ul>

✓ Done	<h2>Rapid shoot growth</h2> <p>(San Joaquin Valley, March to May; Coachella Valley, February to May)</p> <p><b>What should you be doing at this time?</b></p>
	Look for spider mites and their natural enemies on emerging leaves weekly. Map areas of concern for bloom monitoring.
	Monitor leafhoppers weekly, starting a month after budbreak or when first nymphs appear. When samples reach 10 leafhoppers per leaf: <ul style="list-style-type: none"> <li>Keep records (<i>example form available online</i>).</li> <li>Treat if needed according to the Pest Management Guidelines.</li> </ul>
	Manage mealybugs ( <i>Pseudococcus</i> , vine): Place vine mealybug pheromone traps in the vineyard: <ul style="list-style-type: none"> <li>Southern San Joaquin Valley, April 1</li> <li>Coachella Valley, March 1</li> <li>Check traps every 2 weeks</li> </ul> <p>For vine mealybug sanitize equipment before moving to uninfested areas in the vineyard. Coordinate movement of equipment and crews so that vine mealybug is not transported from infested to uninfested vineyards.</p> <p>If grape or vine mealybug nymphs/females are found on the vine, treat according to the Pest Management Guidelines.</p>
	Monitor caterpillars if they have been a problem in the past: <ul style="list-style-type: none"> <li>Western grapeleaf skeletonizer</li> <li>Grape leafroller</li> <li>Omnivorous leafroller</li> </ul> <p>Map areas of concern for bloom monitoring.</p>
	Continue checking pheromone traps for omnivorous leafroller.
	If European fruit lecanium scale has been a problem in the past, monitor female development on old wood.

✓ Done	<h2>Rapid shoot growth</h2> <p>(San Joaquin Valley, March to May; Coachella Valley, February to May)</p> <h3>What should you be doing at this time?</h3>
	Manage native gray or Argentine ants if mealybugs and scale are a problem.
	Check sticky traps for glassy-winged sharpshooters. Keep records ( <i>example form available online</i> ).
	Watch for wilting shoots to determine if caused by: <ul style="list-style-type: none"> <li>• Powdery mildew</li> <li>• Botrytis shoot blight</li> <li>• Branch and twig borer</li> </ul>
	Monitor visually for powdery mildew infections and by using mildew risk index. Treat if needed according to the Pest Management Guidelines.
	Survey weeds to plan a weed management strategy. If herbicides are to be used: <ul style="list-style-type: none"> <li>• Make your selection based on weed survey observations.</li> <li>• Record your observations (<i>example form available online</i>).</li> </ul>
	Look for these diseases: <ul style="list-style-type: none"> <li>• Eutypa dieback</li> <li>• Esca</li> <li>• Pierce's disease</li> <li>• Phomopsis cane and leafspot</li> </ul> <p>If infected plants are found, consult the Pest Management Guidelines.</p>
	Other pests you may see: <ul style="list-style-type: none"> <li>• Thrips</li> <li>• Red-headed and green sharpshooters</li> </ul>

✓ Done	<h2>Bloom to veraison</h2> <p>(San Joaquin Valley, early May to July; Coachella Valley, April)</p> <h3>What should you be doing at this time?</h3>
	Monitor for western flower thrips, particularly in vineyards near drying grains. Manage according to the Pest Management Guidelines.
	Monitor leafhoppers, spider mites, and mealybugs weekly. <ul style="list-style-type: none"> <li>• Keep records (<i>example form available online</i>).</li> <li>• Manage if needed according to the Pest Management Guidelines.</li> </ul>
	Examine leaves and shoots for Botrytis bunch rot and powdery mildew. Manage if needed according to the Pest Management Guidelines.
	If European fruit lecanium scale has been a problem in the past, monitor for egg hatch to time treatment.
	Continue to check omnivorous leafroller pheromone traps weekly. Keep records ( <i>example form available online</i> ).
	Continue monitoring pheromone traps for vine mealybug. <ul style="list-style-type: none"> <li>• If males are caught or honeydew, sooty mold, or ants are found, look for nymphs/females on surrounding vines.</li> <li>• Keep records (<i>example form available online</i>).</li> <li>• If grape or vine mealybug nymphs/females are found on the vine, manage according to the Pest Management Guidelines.</li> </ul>
	Remove basal leaves and lateral shoots in the fruit zone beginning around berry set to minimize summer rot, Botrytis bunch rot, and leafhopper populations, and to maximize spray application coverage. <ul style="list-style-type: none"> <li>• Time leaf pull before first-generation grape leafhoppers become adults.</li> <li>• Remove only the leaves on the shaded side of the canopy on non-divided trellis systems to prevent heat damage and sunburn of sensitive varieties (Thompson Seedless, Redglobe).</li> </ul> <p>Treat for Botrytis before rain according to the Pest Management Guidelines.</p>

<b>✓ Done</b>	<h2 style="margin: 0;">Bloom to veraison</h2> <p style="margin: 0;">(San Joaquin Valley, early May to July; Coachella Valley, April)</p> <p style="margin: 0;"><b>What should you be doing at this time?</b></p>
	<p>Monitor caterpillars if they have been a problem in the past:</p> <ul style="list-style-type: none"> <li>• Omnivorous leafroller</li> <li>• Grape leaffolder</li> <li>• Western grapeleaf skeletonizer</li> </ul> <p>Keep records (<i>example form available online</i>).</p>
	<p>Monitor sticky traps for glassy-winged sharpshooters. Keep records (<i>example form available online</i>).</p>
	<p>Other pests or pest damage you may see:</p> <ul style="list-style-type: none"> <li>• Grape thrips</li> <li>• Grasshopper</li> <li>• Whitefly</li> <li>• Black widow spiders</li> <li>• Red-headed and green sharpshooters</li> <li>• False chinch bug</li> </ul>

<b>✓ Done</b>	<h2 style="margin: 0;">Veraison</h2> <p style="margin: 0;">(San Joaquin Valley, June to July; Coachella Valley, May)</p> <p style="margin: 0;"><b>What should you be doing at this time?</b></p>
	<p>Monitor leafhoppers, spider mites, and mealybugs weekly. Keep records (<i>example form available online</i>). Manage if needed according to the Pest Management Guidelines.</p>
	<p>Continue checking pheromone traps weekly for omnivorous leafroller. Keep records (<i>example form available online</i>).</p>
	<p>Inspect vines weekly for grape mealybug and vine mealybug. Educate field crew to identify and mark vine infestations for treatment. Manage if needed according to the Pest Management Guidelines.</p>
	<p>Monitor sticky traps for glassy-winged sharpshooter. Keep records (<i>example form available online</i>).</p>
	<p>Mark locations of vines with poor growth for future confirmation and management of abiotic disorders or pests:</p> <ul style="list-style-type: none"> <li>• Pierce's disease</li> <li>• Phylloxera</li> <li>• Nematodes</li> </ul>
	<p>Monitor for Botrytis bunch rot, powdery mildew, and summer bunch rot. Hedge canopy to increase air movement and reduce humidity in the fruit zone. Manage if needed according to the Pest Management Guidelines.</p>
	<p>Monitor caterpillars if they have been a problem in the past:</p> <ul style="list-style-type: none"> <li>• Omnivorous leafroller</li> <li>• Grape leaffolder</li> <li>• Western grapeleaf skeletonizer</li> </ul> <p>Keep records (<i>example form available online</i>).</p>
	<p>If necessary manage birds with netting or scare devices as fruit ripens.</p>
	<p>Remove weeds that have escaped treatment before they set seed.</p>
	<p>Consider the use of plastic vine covers for late harvest varieties, which are susceptible Botrytis bunch rot after heavy rain.</p>



<b>✓ Done</b>	<h2>Veraison</h2> <p>(San Joaquin Valley, June to July; Coachella Valley, May)</p> <p><b>What should you be doing at this time?</b></p>
	<p>Other pests, pest damage or diseases you may see:</p> <ul style="list-style-type: none"> <li>• Whitefly</li> <li>• European fruit lecanium scale</li> <li>• Grasshoppers, katydids</li> <li>• Red-headed and green sharpshooters</li> <li>• Vinegar flies</li> <li>• Esca</li> </ul>

<b>✓ Done</b>	<h2>Harvest</h2> <p>(San Joaquin Valley, late June to early November; Coachella Valley, mid-May to early July)</p> <p><b>What should you be doing at this time?</b></p>
	Check fruit at harvest to assess the effectiveness of the current year's IPM program and to determine the needs of next year's program. Note blocks in the vineyard that had problems.
	Check sticky traps for glassy-winged sharpshooter. Keep records ( <i>example form available online</i> ).
	If necessary, continue managing birds with netting or scare devices.
	Continue monitoring for vine mealybug on fruit and foliage; educate harvest crews to recognize infestations and to report if found.

<b>✓ Done</b>	<h2>Postharvest</h2> <p><b>What should you be doing at this time?</b></p>
	<p>Continue monitoring for vine mealybug on fruit and foliage.</p> <p>Treat if needed according to the Pest Management Guidelines.</p> <p>If vine mealybug is present, steam-sanitize equipment before moving to uninfested areas.</p>
	<p>In the San Joaquin Valley look for European fruit lecanium scale on leaves.</p> <p>Treat if needed just before leaf drop, according to the Pest Management Guidelines.</p>
	<p>Continue to mark and remove vines infested with diseases such as:</p> <ul style="list-style-type: none"> <li>• Pierce's disease</li> </ul>
	<p>Carry out sanitation activities and vine surgery for trunk diseases well before the first fall rain event:</p> <ul style="list-style-type: none"> <li>• Botryosphaeria dieback</li> <li>• Eutypa dieback</li> <li>• Esca</li> </ul>
	Continue to monitor for western grapeleaf skeletonizer on early harvested varieties.
	In the Coachella Valley, sample for nematodes in October if not already done in spring.
	Check sticky traps for glassy-winged sharpshooters.
	<p>Other pests you may see:</p> <ul style="list-style-type: none"> <li>• Grape thrips</li> <li>• Red-headed and green sharpshooters</li> </ul>

<b>✓ Done</b>	<h2 style="margin: 0;">Dormancy</h2> <p><b>What should you be doing at this time?</b></p>
	In the San Joaquin Valley, sample for nematodes from November to February.
	<p>Carry out preventative practices for trunk diseases:</p> <ul style="list-style-type: none"> <li>• Use delayed pruning or double pruning in February or later.</li> <li>• Use applications of pruning-wound protectants after pruning and before rain in November through January.</li> </ul>
	<p>Carry out dormant-season sanitation activities:</p> <ul style="list-style-type: none"> <li>• Destroy prunings of older infested wood to reduce pest sources.</li> <li>• Remove dried grape clusters on vines and disc weeds and clusters where orange tortrix or omnivorous leafroller is a problem.</li> <li>• In vineyards with a history of branch and twig borers, examine old pruning scars and dead parts of vines for brown frass and wood dust.</li> <li>• If you have vine mealybug, steam sanitize equipment before moving to uninfested area of the vineyard.</li> </ul>
	<p>Survey weeds to plan a weed management strategy.</p> <ul style="list-style-type: none"> <li>• Pay close attention to weeds that may present a special problem or management challenge.</li> <li>• Record your observations (<i>example form available online</i>).</li> <li>• Use records to make herbicide selections in vineyards where sprays are planned.</li> </ul>

<b>✓ Done</b>	<h2 style="margin: 0;">Pesticide application checklist</h2> <p>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</p>
	<b>✓ Choose a pesticide from the Pest Management Guidelines for the target pest, considering:</b>
	<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> </ul>
	<ul style="list-style-type: none"> <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> </ul>
	<ul style="list-style-type: none"> <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> </ul>
	<ul style="list-style-type: none"> <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> </ul>
	<ul style="list-style-type: none"> <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>
	<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.
	<p>Avoid spraying during these conditions to avoid off-site movement of pesticides.</p> <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>

✓ Done	Pesticide application checklist
	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>✓ Done</b>	<b>Pesticide application checklist</b>
	<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.
	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.
	<b>✓ Consider practices that reduce air quality problems.</b>
	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.

<http://www.ipm.ucanr.edu/PMG/selectnewpest.grapes.html>.

For more about mitigating the effects of pesticides, see the Mitigation page: <http://www.ipm.ucanr.edu/mitigation/>.

# Wine and Raisin Grape Year-Round IPM Program

(Reviewed 7/15)

## ANNUAL CHECKLIST

These practices are recommended for a monitoring-based IPM program that reduces environmental quality problems related to pesticide use. Track your progress through the year using this form.

Each time a pesticide application is considered, review the Pesticide Application Checklist at the bottom of this form for information on how to minimize environmental quality problems. This program covers the major pests of wine and raisin grapes. Details on carrying out each practice, information on additional pests, and additional copies of this form are available from the UC IPM Pest Management Guidelines: Grape at <http://www.ipm.ucanr.edu/PMG>.

This year-round program applies only to wine and raisin grapes. For table grapes, see the TABLE GRAPE YEAR-ROUND IPM PROGRAM.

✓ Done	Delayed-dormancy What should you be doing at this time?
	<p>On a warm day, monitor vines and spurs for:</p> <ul style="list-style-type: none"> <li>• Mealybugs</li> <li>• Ants associated with mealybugs and European fruit lecanium scale</li> <li>• Orange overwintering spider mites</li> <li>• Cutworm</li> </ul> <p>Keep records. Treat if needed according to the Pest Management Guidelines.</p>
	<p>In coastal areas, check orange tortrix pheromone traps that were deployed during the dormant period. Keep records.</p>
	<p>Just before budbreak, deploy omnivorous leafroller pheromone traps. Check traps twice weekly until a biofix date is established; thereafter, check traps weekly. Keep records.</p>
	<p>Monitor for sharpshooters:</p> <ul style="list-style-type: none"> <li>• Glassy-winged sharpshooter.</li> </ul> <p>In coastal regions near riparian and landscape areas check traps for:</p> <ul style="list-style-type: none"> <li>• Blue-green sharpshooter.</li> </ul> <p>Change traps weekly. Keep records.</p>
	<p>Vineyard floor management before bud break:</p> <ul style="list-style-type: none"> <li>• Control weeds with mowing, cultivation, or herbicides</li> <li>• Mow tall cover crop</li> </ul>
	<p>Other pests or pest damage you may see.</p> <ul style="list-style-type: none"> <li>• Rodents</li> <li>• Branch and twig borer</li> <li>• Click beetles</li> <li>• Bud beetles</li> <li>• Dead spurs from trunk diseases</li> </ul>

✓ Done	Budbreak What should you be doing at this time?
	<p>On a warm day, monitor vines and spurs for:</p> <ul style="list-style-type: none"> <li>• <i>Pseudococcus</i> and vine mealybugs</li> <li>• Ants associated with mealybugs and European fruit lecanium scale</li> <li>• Orange overwintering spider mites</li> <li>• Cutworm</li> <li>• Thrips</li> </ul> <p>Keep records. Treat if needed according to the Pest Management Guidelines.</p>
	<p>Check pheromone traps for:</p> <ul style="list-style-type: none"> <li>• Omnivorous leafroller</li> <li>• Orange tortrix in coastal areas</li> </ul> <p>Keep records.</p>
	<p>Monitor leaf wetness. Track powdery mildew ascospore release and mildew risk index. Treat if needed according to the Pest Management Guidelines.</p>
	<p>Consider treating for phomopsis cane and leaf spot if rain continues after budbreak.</p>
	<p>Remove vines that have spring symptoms of Pierce's disease.</p>
	<p>Monitor for sharpshooters:</p> <ul style="list-style-type: none"> <li>• Glassy-winged sharpshooter.</li> </ul> <p>In coastal regions near riparian and landscape areas check traps for:</p> <ul style="list-style-type: none"> <li>• Blue-green sharpshooter.</li> </ul> <p>Change traps weekly. Keep records.</p>

✓ Done	Rapid shoot growth What should you be doing at this time?
	<p>Look for thrips if cold weather persists.</p>
	<p>Look for spider mites and their natural enemies weekly on first-emerging leaves. Map areas of concern for bloom monitoring.</p>
	<p>Monitor leafhoppers weekly starting a month after budbreak or whenever first nymphs appear. Keep records.</p>
	<p>Continue checking pheromone traps for:</p> <ul style="list-style-type: none"> <li>• Omnivorous leafroller</li> <li>• Orange tortrix in coastal areas</li> </ul> <p>Keep records.</p>
	<p>In southern San Joaquin Valley, deploy vine mealybug pheromone traps around April 1 and check every two weeks.</p> <ul style="list-style-type: none"> <li>• If males are caught or honeydew, sooty mold, or ants are found, look for nymph/female infestations on surrounding vines.</li> <li>• Keep records.</li> <li>• Treat if needed according to the Pest Management Guidelines.</li> </ul>

✓ Done	Rapid shoot growth What should you be doing at this time?
	<p>Monitor caterpillars if they have been a problem in the past:</p> <ul style="list-style-type: none"> <li>• Western grapeleaf skeletonizer</li> <li>• Grape leaffolder</li> <li>• Orange tortrix in coastal vineyards</li> <li>• Omnivorous leafroller</li> </ul> <p>Map areas of concern for bloom monitoring.</p>
	<p>If European fruit lecanium scale has been a problem in the past, monitor female development on old wood.</p>
	<p>Manage grey and Argentine ants if mealybugs and scale are a problem.</p>
	<p>Monitor for sharpshooters:</p> <ul style="list-style-type: none"> <li>• Glassy-winged sharpshooter.</li> </ul> <p>In coastal regions near riparian and landscape areas check traps for:</p> <ul style="list-style-type: none"> <li>• Blue-green sharpshooter.</li> </ul> <p>Change traps weekly. Keep records.</p>
	<p>Monitor for flagging. If you see a flag, distinguish between <i>Botrytis</i> shoot blight and branch and twig borer.</p>
	<p>Monitor leaf wetness. Track powdery mildew ascospore release and mildew risk index. Treat if needed according to the Pest Management Guidelines.</p>
	<p>Survey weeds to plan a weed management strategy.</p> <ul style="list-style-type: none"> <li>• Control weeds that escaped a dormant season treatment, using postemergence herbicides or cultivation. Record which weeds escaped for future herbicide treatment decisions.</li> </ul>
	<p>Other pests or pest damage you may see:</p> <ul style="list-style-type: none"> <li>• Eutypa dieback</li> <li>• Phomopsis cane and leaf spot</li> </ul>

✓ Done	Bloom to veraison What should you be doing at this time?
	<p>Monitor leafhopper and spider mites weekly. Keep records. Treat if needed according to the Pest Management Guidelines.</p>
	<p>Monitor for <i>Botrytis</i> and powdery mildew by inspecting leaves and shoots.</p>
	<p>If European fruit lecanium scale has been a problem in the past, monitor for egg hatch to time treatment.</p>
	<p>Check pheromone traps for:</p> <ul style="list-style-type: none"> <li>• Omnivorous leafroller</li> <li>• Orange tortrix (in coastal areas)</li> </ul> <p>Keep records.</p>
	<p>In areas other than southern San Joaquin Valley, put up vine mealybug pheromone traps. In all areas, check traps every two weeks.</p> <ul style="list-style-type: none"> <li>• If males are caught or honeydew, sooty mold, or ants are found, look for sessile nymph/female infestations on surrounding vines.</li> <li>• Keep records.</li> <li>• Treat if needed according to the Pest Management Guidelines.</li> </ul>
	<p>Monitor Pseudococcus mealybugs by looking for honeydew, sooty mold, and ant activity.</p> <ul style="list-style-type: none"> <li>• Keep records.</li> </ul>

✓ Done	Bloom to veraison What should you be doing at this time?
	<ul style="list-style-type: none"> <li>• If you see crawlers, treat if needed according to the Pest Management Guidelines.</li> </ul>
	<p>To reduce possible summer rot, Botrytis, and leafhoppers, remove basal leaves or basal lateral shoots beginning around berry set.</p> <ul style="list-style-type: none"> <li>• Time leaf pull before first-generation grape leafhoppers become adults.</li> <li>• Treat for Botrytis prior to rain, if leaves are not removed.</li> </ul>
	<p>Monitor caterpillars if they have been a problem in the past:</p> <ul style="list-style-type: none"> <li>• Omnivorous leafroller</li> <li>• Orange tortrix</li> <li>• Grape leafroller</li> <li>• Western grapeleaf skeletonizer</li> </ul> <p>Keep records.</p>
	<p>Monitor for sharpshooters:</p> <ul style="list-style-type: none"> <li>• Glassy-winged sharpshooter</li> </ul> <p>In coastal regions near riparian and landscape areas check for:</p> <ul style="list-style-type: none"> <li>• Blue-green sharpshooter</li> </ul> <p>Change sticky traps weekly. Keep records on a monitoring form.</p>
	<p>Extra care must be taken when applying systemic herbicides, such as glyphosate near or after veraison.</p>
	<p>Other pests or pest damage you may see;</p> <ul style="list-style-type: none"> <li>• Grasshopper</li> <li>• Whitefly</li> </ul>

✓ Done	Veraison What should you be doing at this time?
	<p>Monitor leafhoppers and spider mites weekly. Keep records. Treat if needed according to the Pest Management Guidelines.</p>
	<p>Check pheromone traps for:</p> <ul style="list-style-type: none"> <li>• Omnivorous leafroller</li> <li>• Orange tortrix in coastal areas</li> </ul> <p>Keep records.</p>
	<p>Check vine mealybug pheromone traps.</p> <ul style="list-style-type: none"> <li>• If males are found, or if honeydew, sooty mold, or ant activity is found, look for sessile nymph/female infestations on surrounding vines.</li> <li>• Educate field crew to flag cluster infestations for treatment.</li> <li>• Treat if needed according to the Pest Management Guidelines.</li> </ul>
	<p>Monitor grape and obscure mealybugs. Keep records. If you see crawlers, treat if needed according to the Pest Management Guidelines.</p>
	<p>Monitor for glassy-winged sharpshooter. Check traps weekly. Keep records.</p>
	<p>Look for vine symptoms of Pierce's disease. Or for virus like symptoms of early fall color and/or poor fruit maturity.</p>
	<p>If rain occurs shortly after veraison, monitor for <i>Botrytis</i>.</p>
	<p>Monitor caterpillars if they have been a problem in the past:</p> <ul style="list-style-type: none"> <li>• Omnivorous leafroller</li> </ul>



✓ Done	<h2>Veraison</h2> <p>What should you be doing at this time?</p>
	<ul style="list-style-type: none"> <li>• Orange tortrix</li> <li>• Grape leaffolder</li> <li>• Western grapeleaf skeletonizer</li> </ul> <p>Keep records.</p>
	Inspect roots of weakened vines for galls or phylloxera.
	If necessary manage birds with netting or scare devices as fruit ripens.
	<p>Other pests or pest damage you may see.</p> <ul style="list-style-type: none"> <li>• Whitefly</li> <li>• European fruit lecanium scale</li> <li>• Grasshoppers/katydids</li> <li>• Esca</li> </ul>

✓ Done	<h2>Harvest</h2> <p>What should you be doing at this time?</p>
	Be aware that high populations of adult leafhoppers may interfere with hand harvesting.
	<p>Monitor for grape, obscure, and vine mealybugs.</p> <ul style="list-style-type: none"> <li>• Look for cluster infestations and mark on a map.</li> <li>• Educate harvest crew to flag cluster infestations of vine mealybug for treatment.</li> <li>• Treat vine mealybug if needed according to the Pest Management Guidelines.</li> </ul>
	If you have vine mealybug, steam sanitize equipment before moving to an uninfested area of the vineyard.
	For Pierce's disease, flag vines with symptoms for removal. Also for virus symptoms. Mark vines for spring monitoring/removal depending on incidence.
	If necessary, continue managing birds with netting or scare devices.
	Treat for <i>Botrytis</i> prior to any anticipated rain.
	Sample soil and roots for nematodes; inspect roots for galls and phylloxera.
	Monitor glassy-winged sharpshooter. Check traps weekly and keep records.

✓ Done	<b>Postharvest</b> <b>What should you be doing at this time?</b>
	If necessary, treat for vine mealybug immediately after harvest according to the Pest Management Guidelines.
	To reduce risk of transferring vine mealybug, do not place winery pomace in the vineyard; compost pomace or cover piles securely with clear plastic.
	Look for symptoms of Pierce's disease on vines and flag for removal. Also for virus-infected vines.
	Look for European fruit lecanium scale on leaves; treat according to the Pest Management Guidelines.
	If you desire a cover crop, seed after harvest. Cover should be planted when regular irrigation is used or rain is expected. If early rain is followed by a dry period, germinated seeds may die without further irrigation.
	Record weeds present in the vineyard. Determine if herbicide applications are warranted. Contact herbicides may be more desirable at this time. Extra care must be taken when using systemic herbicides (glyphosate). Drift may result in damage to new foliage developing in spring.
	Carry out sanitation activities and vine surgery for trunk diseases well before the first rain event: <ul style="list-style-type: none"> <li>• Botryosphaeria dieback</li> <li>• Eutypa dieback</li> <li>• Esca</li> </ul>

✓ Done	Dormancy What should you be doing at this time?
	<p>Carry out preventative practices for trunk diseases</p> <ul style="list-style-type: none"> <li>• Use delayed pruning or double pruning in February or later.</li> <li>• Use applications of pruning-wound protectants after pruning and before rain in November through January.</li> </ul>
	<p>In coastal areas, set out orange tortrix pheromone traps by December.</p> <ul style="list-style-type: none"> <li>• Check traps twice weekly until a biofix date is established; thereafter, check traps weekly.</li> <li>• Keep records.</li> </ul>
	<p>If present, treat for Phomopsis cane and leaf spot before rainfall.</p>
	<p>Sample for nematodes in January or February.</p>
	<p>Carry out dormant-season sanitation activities:</p> <ul style="list-style-type: none"> <li>• Destroy prunings of older infested wood to reduce pest sources.</li> <li>• Remove dried grape clusters on vines and disc weeds and clusters where orange tortrix or omnivorous leafroller is a problem.</li> <li>• In vineyards with a history of branch and twig borers, examine old pruning scars and dead parts of vines for brown frass and wood dust.</li> <li>• If you have vine mealybug, steam sanitize equipment before moving to an uninfested area of the vineyard.</li> </ul>
	<p>Survey weeds to plan a weed management strategy. If herbicides are used:</p> <ul style="list-style-type: none"> <li>• Use the late-winter survey form to record your observations and make pre- and postemergence herbicide selection decisions.</li> <li>• Remove leaves and debris under the vine before applying herbicides.</li> <li>• Do not make preemergence herbicide applications if heavy rains are expected soon after application. However, applications should be made when a rain event of 0.25-0.50 inches is expected within 2-3 weeks.</li> <li>• If possible, make preemergence herbicide applications after dormant activities, such as pruning, are completed to reduce soil movement.</li> </ul>

✓ Done	Pesticide application checklist
	<p>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</p>
	<p><b>✓ Choose a pesticide from the Pest Management Guidelines for the target pest, considering:</b></p>
	<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> </ul>
	<ul style="list-style-type: none"> <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> </ul>
	<ul style="list-style-type: none"> <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> </ul>
	<ul style="list-style-type: none"> <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> </ul>
	<ul style="list-style-type: none"> <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>
	<p><b>✓ Before an application</b></p>

✓ Done	Pesticide application checklist
	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.
	<p>Avoid spraying during these conditions to avoid off-site movement of pesticides.</p> <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>✓ Done</b>	<b>Pesticide application checklist</b>
	<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.
	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.
	<b>✓ Consider practices that reduce air quality problems.</b>
	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.

<http://www.ipm.ucanr.edu/PMG/selectnewpest.grapes.html>.

For more about mitigating the effects of pesticides, see the Mitigation page: <http://www.ipm.ucanr.edu/mitigation/>.

## *General Information*

*(Section reviewed 7/15)*

# DELAYED-DORMANT AND BUDBREAK MONITORING (Wine and Raisin Grapes) (7/15)

Monitor vines, spurs and canes once during the delayed dormant season and once at bud break to check for cutworms, mealybugs, ants, thrips, and mites.

Use monitoring form with detailed treatment threshold information (*example form (PDF) available online*).

### HOW TO SAMPLE

1. On a warm day (65°F or above), monitor 20 vines by looking at 5 randomly selected vines per quadrant of the vineyard. For the best estimate of pest distribution, monitor fewer vines in more locations. Be sure to include those areas, however, where you have noticed pests in the past.
2. Monitor vines following the guidelines below. For spur monitoring choose a spur on the basal portion of a cordon closest to the crown.
3. Record your observations on a monitoring form.

### PROCEDURE AND TREATMENT THRESHOLDS

Pests	Monitoring procedures	Treatment threshold
Cutworms	<ul style="list-style-type: none"> <li>• Examine 5 buds for damage (hollowed buds).</li> <li>• If damage is present, look for cutworms under bark, on cordons, trunk, and at soil level.</li> </ul>	Don't treat if less than 4% of the buds per location are damaged.
<i>Pseudococcus</i> mealybugs (grape, obscure, longtailed)	<ul style="list-style-type: none"> <li>• Look for crawlers under loose bark at the spur tip or on canes.</li> <li>• Along Central Coast, also look for more mature obscure and longtailed mealybugs at base of spur, under bark.</li> </ul>	Treat if 1 out of 5 spurs is infested.
Vine mealybug	<ul style="list-style-type: none"> <li>• Look for nymphs and females under bark at graft union, in old pruning wounds in the trunk, and below the base of the spur (old remnant egg sacs may be found).</li> <li>• In sandy soils, look at soil level and at roots.</li> </ul>	Treat during the delayed dormant period and again at bloom if vine mealybug is present. For heavy infestations, consider removing bark before spraying trunk and cordons.
Ants	<ul style="list-style-type: none"> <li>• Look for ants. If found, look more closely for mealybugs or European fruit lecanium scale.</li> </ul>	Identify areas of concern for spring monitoring.
Mites	<ul style="list-style-type: none"> <li>• Look under loose bark on spur tip for orange overwintering form of Pacific or Willamette spider mite.</li> </ul>	Identify areas of concern for bloom monitoring.
Thrips	<ul style="list-style-type: none"> <li>• Open shoots or gently tap buds over white paper to check for thrips.</li> </ul>	Treatment may be necessary if damage increases and temperatures remain cool.

# DELAYED-DORMANT AND BUDBREAK MONITORING (Table Grapes) (7/15)

Monitor vines and spurs once during the delayed dormant season and once at budbreak to check for cutworms, mealybugs, ants, and mites. Spurs are one-year-old canes that were pruned back to 1 to 2 buds at pruning.

Use monitoring form with detailed treatment threshold information (*example form available online*).

## HOW TO SAMPLE

1. On a warm day (65°F or above), monitor 20 vines by looking at 5 randomly selected vines per quadrant of the vineyard. For the best estimate of pest distribution, monitor fewer vines in more locations. Be sure to include those areas, however, where you have noticed pests in the past.
2. Monitor vines following the guidelines below. For spur monitoring choose a spur on the basal portion of a cordon closest to the crown.
3. Record your observations on a monitoring form.

## PROCEDURE AND TREATMENT THRESHOLDS

Pests	Monitoring procedures	Treatment threshold
<b>Cutworms</b>	<ul style="list-style-type: none"> <li>• Examine 5 buds for damage (hollowed buds).</li> <li>• If damage is present, look for cutworms under bark, on cordons, trunk, and at soil level.</li> </ul>	Don't treat if less than 4% of the buds per location are damaged.
<b><i>Pseudococcus</i> mealybugs (grape, obscure, longtailed)</b>	<ul style="list-style-type: none"> <li>• Look for the presence of crawlers under the thin bark on spurs or canes.</li> </ul>	Treat if there is an average of 1 spur or cane with crawlers for every 10 sampled.
<b>Vine mealybug</b>	<ul style="list-style-type: none"> <li>• Look for nymphs and females under bark at graft union, in old pruning wounds in the trunk, and below the base of the spur (old remnant egg sacs may be found).</li> <li>• In sandy soils, look at soil level and at roots.</li> </ul>	Treat during the delayed dormant period and again at bloom if vine mealybug is present. For heavy infestations, consider removing bark before spraying trunk and cordons.
<b>Ants</b>	<ul style="list-style-type: none"> <li>• Look for ants.</li> <li>• If found, look more closely for mealybugs or European fruit lecanium scale.</li> </ul>	Identify areas of concern for spring monitoring.
<b>Spider mites</b>	<ul style="list-style-type: none"> <li>• Look under loose bark on spur tip for orange overwintering form of Pacific or Willamette spider mite.</li> </ul>	Identify areas of concern for bloom monitoring.

# PHEROMONE TRAPS (7/15)

Deploy pheromone traps in vineyards to monitor the flights of omnivorous leafroller or orange tortrix (coastal areas).

## GENERAL GUIDELINES FOR USING PHEROMONE TRAPS

- Place traps in each vineyard for which you need to make pest management decisions, using at least 2 traps per block.
- Distribute traps uniformly through the vineyard. Use the same trap locations each year. Place additional traps in hot spots.
- Hang traps in the shade inside the vines and at least 15 vines from the end of the rows.
- Check traps twice a week until the biofix is established; thereafter, check traps weekly.
- Remove trapped insects from the trap bottom after you count and record the trap catch on the pheromone trap and degree-day monitoring form (example form (PDF) available online).
- Replace trap bottoms monthly or when they become covered with debris.
- Follow the manufacturer’s recommendations for replacing pheromone lures. Store lures in a refrigerator or freezer.

## WHEN TO PUT OUT TRAPS

Pest	Where and when to set traps	Biofix
Omnivorous leafroller	Central Valley and other warm inland valley vineyards—just before budbreak	First night moths are caught consistently in traps
Orange tortrix	Coastal regions—late December	When low catches are observed between late January through early February and again in early June



## MONITORING INSECTS AND SPIDER MITES (7/15)

Begin monitoring weekly for mealybugs, leafhopper nymphs, and spider mites together during bloom. Divide the vineyard into quadrants. In each quadrant, randomly select 5 vines each at least a few vines in from the end of the row. Look for mealybugs, leafhoppers, and mites on each of the 20 vines.

Use monitoring form with detailed treatment threshold information (*example form available online*).

### Mealybug

- Early in the season, inspect basal leaves for grape, obscure, and longtailed mealybugs and under the bark of trunks for vine mealybug.
- Later in the season, inspect all plant parts for mealybugs.
- Make a record of any vine that is infested.

### Leafhoppers

- On each vine, choose one leaf at the 3rd or 4th node up from the basal node for first generation nymphs or young fully expanded leaves in the middle of the cane for 2nd or 3rd generation nymphs.
- Count and record the number of nymphs on each leaf using the monitoring form.
- Note whether they are grape leafhopper nymphs, variegated leafhopper nymphs, Virginia creeper leafhopper nymphs, or a mixed population of multiple species.
- Check the leaves for parasitized eggs (red, or with parasite emergence holes) and note their presence (+) or absence (-).
- Follow guidelines in the leafhopper section to determine whether treatment is required.

### Spider mites

- Early in the season, choose one leaf between the 2nd and 4th nodes on each of the 20 vines. Later in the season, choose the 4th expanded leaf from the growing tip.
- Use a 10–14X hand lens and look for mites and mite predators.
- Note if mites and mite predators are present (+) or absent (-) on the monitoring form.
- Follow guidelines in the webspinning spider mite section to determine whether treatment is necessary.

## MONITORING CATERPILLARS (7/15)

Grape leafroller and western grapeleaf skeletonizer feed on foliage and heavy populations can lead to defoliation. Omnivorous leafroller, orange tortrix, and light brown apple moth feed on leaves, flowers, and developing berries, but their primary damage is feeding on fruit which enables rot organisms to enter fruit.

### Rapid shoot growth

Early in rapid shoot growth, start monitoring for webbing on leaves caused by omnivorous leafroller, orange tortrix, or light brown apple moth to map out areas of concern for bloom monitoring. Unroll leaves with orange tortrix or light brown apple moth and look for leafroller larva, pupa, or parasite cocoons. Check for leaves skeletonized by western grapeleaf skeletonizer.

### Bloom

Plan to treat omnivorous leafroller, grape leafroller, and western grapeleaf skeletonizer (also, orange tortrix or light brown apple moth in coastal regions), if they have been a problem in the past or if there is no evidence of parasitism. If they haven't been a problem in the past, or if parasitism is present, be sure to monitor flower clusters or leaves for the caterpillars and damage they cause in wine/raisin grapes or in table grapes, as described below, to determine the need for treatment.

### After bloom

Monitor during the growing season in wine/raisin grapes or in table grapes, by examining fruit clusters for omnivorous leafroller, orange tortrix, and light brown apple moth and leaves for grape leafroller and western grape leaf skeletonizer, following the guidelines below. Treatment after veraison for omnivorous leafroller, orange tortrix, and light brown apple moth is limited in effectiveness and not recommended. However, veraison monitoring for all these caterpillars will alert you to larval damage going into harvest and potential problems the following year.

### Harvest

At harvest, check fruit clusters for damage by omnivorous leafroller, orange tortrix, and light brown apple moth to assess this year's management program, natural enemy populations, and to plan for next year. Also assess grape leafroller damage in table grapes.

## HOW TO MONITOR

- Monitor 20 vines weekly by looking at 5 vines in each quadrant of the vineyard.
- On each vine, check for pests and the damage they cause by following the guidelines below.
- Record results on a monitoring form (*example form*(PDF) *available online*) and treat using the treatment thresholds below.

## PROCEDURE AND TREATMENT THRESHOLDS

Caterpillar	Procedure	Treatment threshold
Omnivorous leafroller	Examine 10 flower / fruit clusters in the center of each of 20 vines, for a total of 200 clusters. If you see webbing and frass, look for caterpillars. Note the number of clusters infested with omnivorous leafroller.	At bloom, treat if any larvae are found. After bloom, treat if 2 or more clusters are infested.
Orange tortrix <i>(Coastal regions only)</i>	From bloom until bunch closure, examine 10 flower / fruit clusters in the center of each of 20 vines, for a total of 200 clusters. If you see webbing and frass, look for caterpillars. Note the number of clusters infested with orange tortrix and the prevalence of parasite cocoons.	If you find an average of 0.5-1 larva / vine, treatment may be warranted if parasites are not present.
Grape leaffolder	Count the number of rolled leaves per vine. Unroll leaves and look for both healthy and parasitized grape leaffolder larvae.	Treatment may be warranted if population levels are increasing. Treat before larvae roll leaves.
Light brown apple moth	From bloom until bunch closure, examine 10 flower / fruit clusters in the center of each of 20 vines, for a total of 200 clusters. If you see webbing and frass, look for caterpillars. Caterpillars must be properly identified by the agricultural commissioner's office.	From bloom to bunch closure treat if any larvae found is identified as light brown apple moth.
Western grapeleaf skeletonizer	Check for skeletonized leaves. If present, look for caterpillars and evidence of granulosis virus. (See the western grapeleaf skeletonizer section for a description of virus infection.)	If larvae are found and no granulosis virus is evident, treat soon after bloom.

# RELATIVE TOXICITIES OF INSECTICIDES AND MITICIDES USED IN GRAPES TO NATURAL ENEMIES AND HONEY BEES (12/16)

Common name (Example 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>
abamectin (Agri-Mek)	6	moderate (mites, western grapeleaf skeletonizer)	M	L	M/H	I	moderate to predatory mites and affected insects
acetamiprid (Assail)	4A	broad (insects)	— <sup>7</sup>	— <sup>8</sup>	—	II	moderate
azadirachtin (Debug Turbo)	un	broad (insects, mites)	M	L/M	L/M	II	short
<i>Bacillus thuringiensis</i> ssp. <i>kurstaki</i>	11A	narrow (caterpillars)	L	L	L	III	none
bifenazate (Acramite)	20D	narrow (mites)	L	L	L	II	short
buprofezin (Applaud)	16	narrow (sucking insects, beetles)	L	H <sup>9</sup>	L	II	long
carbaryl (Sevin)	1A	broad (insects, mites)	M/H	H	H	I	long
chlorantraniliprole (Altacor)	28	narrow (primarily caterpillars)	L	L	L/M	III	short
clofentezine (Apollo)	10A	narrow (mites)	M	L	L	III	short
clothianidin (Belay)	4A	lygus, aphids	—	M/H	M/H	I	long
cryolite (Kryocide)	8C	narrow (foliage chewing insects)	L	L	L	III	short to none
cyflumetofen (Nealta)	25A	—	—	—	—	—	—
dinotefuran (Venom)	4A	narrow (sucking insects)	L	—	L	I	short
disodium tetraborate (Gourmet Liquid Ant Bait)	un	—	—	—	—	—	—
etoxazole (Zeal)	10B	narrow (mites)	H <sup>8</sup>	L	—	II	short
fenpropathrin (Danitol)	3A	broad (insects, mites)	H	H	H	I	—
fenpyroximate (Fujimite)	21A	narrow (mites, some insects)	H	L	L	III	long for predatory mites
flupyradifurone (Sivanto)	4D	narrow (sucking insects)	—	—	—	II	short
hexythiazox (Onager)	10A	narrow (mites)	L	L	L	II	short to moderate
imidacloprid (Admire Pro)	4A	narrow (sucking insects, cutworms)	—	L	—	I	—
indoxacarb (Avaunt)	22A	narrow (caterpillars, plant bugs)	L	L	L	I	moderate
insecticidal soap (M-Pede)	—	broad (insects, mites)	M	M	M	III	short to none
kaolin clay (Surround)	—	narrow (sucking insects)	—	—	—	III	—
malathion	1B	broad (insects, mites)	M	H	H	I	moderate
metaflumizone bait (Altrevin)	22B	—	—	—	—	III	—
methoxyfenozide (Intrepid)	18	narrow (caterpillars)	L	L	L	II	none
neem oil (Trilogy)	—	broad (soft-bodied insects)	L	L	L	II	short
narrow range oil (Omni Supreme)	—	broad (exposed insects, mites)	L	L	L	II	short to none
phosmet (Imidan)	1B	broad (insects, mites)	H	H	H	I	moderate to long
pyrethrin (Pyganic)	3A	broad (insects)	—	M	M	I	short
pyrethrin/piperonyl butoxide (Pyrenone)	3A/—	broad (insects)	—	—	—	I	short

pyriproxyfen (Esteem Ant Bait)	7C	narrow (scale, beetles)	L	H <sup>9</sup>	L	III	long
S-methoprene bait (Tango)	7A	—	—	—	—	III	—
spinetoram (Delegate)	5	narrow (caterpillars, thrips, whiteflies, aphids, scales, leafminers)	L/M	M <sup>10</sup>	M/H	II	moderate <sup>11</sup>
spinosad (Entrust, Success)	5	narrow (caterpillars, thrips)	L	M <sup>10</sup>	L/M	II	short
spirodiclofen (Envidor)	23	narrow (mites)	L	—	—	II	—
spirotetramat (Movento)	23	narrow (aphids, scale, psyllids, whiteflies)	L	L	L	II	short
thiamethoxam (Platinum)	4A	narrow (sucking insects)	— <sup>7</sup>	—	M	I	moderate
<b>H = high    M = moderate    L = low    — = no information    un = unknown or uncertain mode of action</b>							

- 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, *Galenromus 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/bee precaution/>).
- 6 Duration: *short* means hours to days; *moderate* means days to 2 weeks; and *long* means many weeks or months.
- 7 May cause flare-ups of spider mite populations.
- 8 Acute toxicity low but reproductive capacity is impacted.
- 9 Kills lady beetles.
- 10 Toxic against some natural enemies (predatory thrips, syrphid fly and lacewing larvae, beetles) when sprayed and up to 5-7 days after, especially for syrphid fly larvae.
- 11 Residual is moderate if solution is between pH of 7 to 8.

**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*, UC ANR Publication 3386.

# GENERAL PROPERTIES OF FUNGICIDES USED IN GRAPES (12/14)

Common name (Example trade name)	Chemical class	Activity	Mode of action (FRAC Group No.1)	Resistance potential	Comments
azoxystrobin (Abound)	QoI <sup>5</sup>	contact, systemic <sup>2</sup>	single-site (11)	high	
<i>Bacillus pumilis</i> (Sonata)	microbial	contact	various (44)	low	
<i>Bacillus subtilis</i> (Serenade)	microbial	contact	various (44)	low	
captan	phthalamide	contact	multi-site (M4)	low	highly toxic to honey bee larvae
copper	inorganic	contact	multi-site (M1)	low	
copper hydroxide	inorganic	contact	multi-site (M1)	low	
copper sulfate	inorganic	contact	multi-site (M1)	low	
cyflufenamid (Torino)	phenylacetamide	contact	unknown (U6)	high	
cyprodinil (Vanguard)	anilinopyrimidine	mostly contact, slightly systemic	single-site (9)	high	
cyprodinil / fludioxonil (Switch)	anilinopyrimidine and phenylpyrrole	contact, slightly systemic	single-site/ single-site (9 / 12)	low to medium	
difenoconazole / azoxystrobin (Quadris Top)	DMI <sup>3</sup> -triazole and QoI <sup>5</sup>	systemic (local)	single-site/ single-site (3 / 11)	medium to high	
difenoconazole / cyprodinil (Inspire Super)	DMI <sup>3</sup> and anilinopyrimidine	contact, systemic	single-site/ single-site (3 / 9)	medium	
fenhexamid (Elevate)	hydroxyanilide	contact	single-site (17)	high	
fluopyram / tebuconazole (Luna Experience)	SDHI <sup>6</sup> pyridinyl-ethyl-benzamide and DMI <sup>3</sup>	contact, systemic	single-site/ single-site (7 / 3)	medium	
fungicidal soap (M-Pede)	inorganic salt	contact	—	low	
iprodione (Rovral)	dicarboximide	systemic (local)	single-site (2)	medium	
kresoxim-methyl (Sovran)	QoI <sup>5</sup>	contact, systemic <sup>2</sup>	single-site (11)	high	
mancozeb (Dithane)	dithiocarbamate	contact	multi-site (M3)	low	
mefenoxam (Ridomil Gold)	phenylamide	contact, systemic	single-site (4)	high	
metrafenone (Vivando)	benzophenone	contact	unknown (U8)	high	
myclobutanil (Rally)	DMI <sup>3</sup> -triazole	systemic (local) <sup>2</sup>	single-site (3)	high	
oil (JMS stilet oil)	mineral oil	contact	various (NC)	low	
potassium bicarbonate (Armcarb, Kaligreen, Milstop)	inorganic salt	contact	various (NC)	low	
pyraclostrobin / boscalid (Pristine)	QoI <sup>5</sup> and SDHI <sup>6</sup>	contact, systemic <sup>2</sup>	single-site/ single-site (11 / 7)	high	
pyrimethanil (Scala)	anilinopyrimidine	mostly contact, slightly systemic	single-site (9)	high	
quinoxifen (Quintec)	aryloxyquinoline	contact	single-site (13)	medium	
sulfur	inorganic	contact	multi-site (M2)	low	highly toxic to native strains of western predatory mite ( <i>Galen-dromus occidentalis</i> ) and parasites.
tebuconazole (Elite)	DMI <sup>3</sup> -triazole	systemic (local) <sup>2</sup>	single-site (3)	high	

tetraconazole (Mettle)	DMI <sup>3</sup> -triazole	systemic (local)	single-site (3)	high
thiophanate-methyl (Topsin)	MBC <sup>7</sup>	systemic (local)	single-site (1)	very high
trifloxystrobin (Flint)	QoI <sup>5</sup>	contact, systemic <sup>2</sup>	single site (11)	high
triflumizole (Procure)	DMI <sup>3</sup> -imidazole	systemic (local) <sup>2</sup>	single-site (3)	high
ziram	dithiocarbamate	contact	multi-site (M3)	low

<sup>1</sup> 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.

<sup>2</sup> Generally considered to have systemic action based on performance data but has not been proven experimentally.

<sup>3</sup> DMI = demethylation (sterol) inhibitor

<sup>4</sup> SAR = systemic acquired resistance induced in host

<sup>5</sup> QoI = quinone outside inhibitor (strobilurin)

<sup>6</sup> SDHI = succinate dehydrogenase inhibitor

<sup>7</sup> MBC = methyl benzimidazole carbamate

— = unknown

NC = not classified

**Acknowledgment:** Adaskaveg et al., 2017. Efficacy and Timing of Fungicides, Bactericides, and Biologicals for Deciduous Tree Fruit, Nut Crops, and Grapevines. (PDF)

# FUNGICIDE EFFICACY (6/17)

## Conventional Chemistry

Fungicide	Resistance risk (FRAC#) <sup>1</sup>	Powdery mildew	Downy mildew	Rot		Phomopsis cane and leaf spot	Eutypa dieback	Bot Canker	Dead Arm ( <i>Phomopsis</i> sp.)
				Botrytis bunch rot	Summer rot				
Abound	high (11) <sup>2</sup>	++++	++++	+	---	+++	NR	---	---
Flint <sup>3</sup>	high (11) <sup>2</sup>	++++	+++	++	++	++	NR	---	---
Inspire Super	medium (3/9)	++++	---	++++	++	---	NR	NR	NR
Kenja	high (7)	++++	NR	NR	NR	NR	NR	NR	NR
Luna Experience	medium (3/7)	++++	---	++++	++	---	NR	NR	NR
Luna Tranquility**	medium (7/9)	++++	---	+++	++	---	NR	NR	NR
Merivon (wine+raisin)	medium (7/11)	++++	---	++++	++	---	NR	NR	NR
Mettle	high (3)	++++	---	---	+	---	+++	---	---
Orius, Tebucon, Toledo, Tebuconazole, Elite, (Tebuzol)**	high (3)	++++	---	++	++	---	NR	---	---
Pristine	medium (7/11) <sup>2</sup>	++++	++++	++++	+++	+++	NR	---	---
Procure	high (3)	++++	---	---	---	---	NR	---	---
Quadris Top	high (3/11)	++++	+	++	++	++	NR	---	---
Quintec	high (13)	++++	---	---	---	---	NR	---	---
Rally	high (3)	++++	---	---	---	---	+++	++	++
Rally+Topsin-M <sup>5</sup>	high (1+3)	++++	---	---	---	++++	++++ <sup>6</sup>	++++	++++
Revus Top	medium (3/40)	++++	++++	++	++	++	NR	---	---
Rhyme	high (3)	++++	---	---	---	---	NR	---	---
Rubigan**, Vintage**	high (3)	++++	---	---	---	---	NR	---	---
Sovran	high (11) <sup>2</sup>	++++	++++	++	++	++++	---	NR	++++
Sulfur	low (M2)	++++	---	---	---	---	NR	---	---
Topsin-M, T-Methyl, Incognito	high (1) <sup>2</sup>	++++	---	++	++	+	++++	++++	++
Torino	high (U6)	++++	---	---	---	---	---	---	---
Vivando	high (U8)	++++	---	---	---	---	---	---	---
Luna Privilege	High (7)	+++	---	+++	+	---	++	---	---
Bayleton**	high (3)	++	---	---	---	---	NR	---	---
Copper	low (M1)	++	+++	++	+++	---	---	---	---
Elevate	high (17) <sup>2</sup>	++	---	++++	++	---	NR	---	---
Ph-D	medium (19)	++	---	+++	+++	ND	NR	---	---
Scala	high (9) <sup>2</sup>	++	---	++++	++	---	NR	---	---
Switch	low (9/12)	++	---	++++	+++	---	---	---	---
Vanguard	high (9) <sup>2</sup>	++	---	++++	++	---	NR	---	---
Botran	medium (14)	---	---	+++	---	---	---	---	---
Captan	low (M4)	---	+	+++	+++	+++	NR	---	---
CaptEvote**	low (M4/17)	---	+	+++	+++	+	---	---	---



Dithane,Manzate, Penncozeb	low (M3)	---	---	++	---	+++	---	---	---
Presidio**	high (43)	----	++++	---	----	---	----	----	----
Revus	high (40)	---	++++	---	----	---	----	----	----
Ridomil Gold, (Mefenoxam**)	high (4)	----	++++	---	----	---	----	----	----
Rovral,Iprodione, Nevado	low (2)	---	---	+++	---	---	---	---	---
Ziram	low (M3)	----	++	+	+	+++	----	----	+++
Laguna	high (3)	ND	ND	ND	ND	ND	ND	ND	ND
Aprovia*	medium (7/11) <sup>2</sup>	NR	NR	NR	NR	NR	NR	NR	NR
Rovral + Oil <sup>4</sup>	low (2)	NR	---	++++	---	---	NR	---	---
Oso	medium (19)	NR	---	+++	+++	ND	NR	---	---

**Rating:** +++++ = excellent and consistent, +++ = good and reliable, ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, ---- = ineffective; ND = no data and NR = not recommended.

\* Registration pending in California.

\*\* Not registered, label withdrawn or inactive in California.

\*\*\* Registered only on wine grapes in California.

## Soft Chemistry (Biological and Natural Products)

Fungicide	Resistance risk (FRAC#) <sup>1</sup>	Bunch rot				Phomopsis cane and leaf spot	Eutypa dieback	Bot Canker	Dead Arm (Phomopsis sp.)
		Powdery mildew	Downy mildew	Botrytis	Summer				
Cinnacure	low	+++	---	---	---	---	---	---	---
Elexa**	low	+++	---	---	---	---	---	---	---
Fracture	low	+++	---	++	---	---	---	---	---
JMS Stylet oil <sup>4</sup>	low	+++	---	+++	++	---	NR	---	---
Kaligreen	low	+++	---	---	---	---	---	---	---
Milstop	low	+++	---	---	---	---	---	---	---
Purespray	low	+++	---	---	---	---	---	---	---
Regalia	low	+++	----	---	---	---	----	---	---
Serenade	low (44)	+++	---	++	+	---	---	---	---
Sonata	low	+++	---	++	NR	---	---	---	---
Taegro**	low	+++	---	++	+	---	---	---	---
Vintre	low	+++	---	---	---	---	---	---	---
Actinovate	low	++	----	---	---	---	---	---	---
Employ*	low	++	----	---	---	---	---	---	---
HiPeak*	low	++	----	---	----	----	----	---	---
Prev-am <sup>*4</sup>	low	++	----	---	----	----	++	---	---
Sporan	low	++	----	---	----	----	---	---	---
Timorex* <sup>4</sup>	low	++	----	---	----	----	---	---	---
VigorCal*	low	++	----	---	----	----	---	---	---
VigorK*	low	++	----	---	----	----	---	---	---
Double Nickel	low	+	----	+	NR	----	---	---	---
Sporatec	low	+	----	---	----	----	---	---	---
B-Lock*	low	---	---	---	----	----	++++	++	NR
Vitiseal	low	---	---	---	----	----	++++	---	---
Botector	low	ND	---	+	----	----	---	---	---

**Rating:** +++++ = excellent and consistent, +++ = good and reliable under low to medium disease pressure (high disease pressure will result in reduced efficacy with a rating of +/+++), ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, ---- = ineffective; and NR = not recommended.

\* Registration pending in California.

\*\* Not registered, label withdrawn or inactive in California.

- <sup>1</sup> 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.
- <sup>2</sup> To reduce the risk of resistance development, start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.
- <sup>3</sup> Causes severe phytotoxicity on Concord grape.
- <sup>4</sup> Phytotoxic if used within 2 weeks of Captan or sulfur.
- <sup>5</sup> Tank mixture applied post-pruning (dormant or delayed dormant).
- <sup>6</sup> Apply at two-week intervals during rain events.

*Acknowledgment: Adaskaveg et al., 2017. Efficacy and Timing of Fungicides, Bactericides, and Biologicals for Deciduous Tree Fruit, Nut Crops, and Grapevines. (PDF)*

## TREATMENT TIMINGS FOR KEY DISEASES (6/17)

Note: not all indicated timings may be necessary for disease control.

Disease	Dormant	Budbreak	Full bloom	Pre-close	Veraison	Preharvest/ Postharvest
<b>Botryosphaeria canker (bot canker)</b>	+++	—	—	—	—	—
<b>Botrytis bunch rot</b>	+++ <sup>2</sup>	—	+++ <sup>1</sup>	+++ <sup>1</sup>	+++ <sup>1</sup>	+++ <sup>1</sup>
<b>Brown spot</b>	—	—	—	+++	+++	+++
<b>Dead arm</b>	+++	+++	—	—	—	—
<b>Downy mildew</b>	—	+++	+++	—	—	—
<b>Esca (black measles)</b>	+++ <sup>2</sup>	—	—	—	—	—
<b>Eutypa Dieback</b>	+++	—	—	—	—	—
<b>Phomopsis</b>	+++	+++	—	—	—	—
<b>Powdery mildew</b>	+++ <sup>2</sup>	+++ <sup>3</sup>	+++ <sup>3</sup>	+++ <sup>4</sup>	—	—
<b>Summer bunch rot (sour rot)</b>	—	—	—	—	+++ <sup>1</sup>	+++ <sup>5</sup>

Rating: +++ = most effective, ++ = moderately effective, + = least effective, — = ineffective

<sup>1</sup> Apply only if rain is forecast.

<sup>2</sup> Use 10 gal lime sulfur per acre in at least 100 gal water.

<sup>3</sup> Apply budbreak and full bloom treatments every year.

<sup>4</sup> Apply as needed (a disease risk assessment model is available to help determine need for spray).

<sup>5</sup> Preharvest treatments for postharvest decay control.

*Acknowledgment: Adaskaveg et al., 2017. Efficacy and Timing of Fungicides, Bactericides, and Biologicals for Deciduous Tree Fruit, Nut Crops, and Grapevines. (PDF)*

# FUNGICIDE RESISTANCE MANAGEMENT (6/17)

**Note:** not all indicated timings may be necessary for disease control (*see Treatment Timings For Key Diseases*). If treatments are needed based on weather or environmental monitoring models, suggested fungicide groups are listed for each timing.

## HOW TO USE THIS TABLE:

- Identify the disease(s) that need(s) to be managed. Know the disease history of the orchard, especially from the previous season.
- Select one of the suggested FRAC mode-of-action group numbers. *Numbers separated by slashes are pre-mixtures, whereas numbers grouped by pluses are tank mixtures.* If several diseases need to be managed, select a group that is effective against all diseases. Refer to **General Properties of Fungicides** to determine which fungicides belong to each FRAC group. Group numbers are listed in numerical order within the suggested disease management program below.
- Rotate groups for each application within a season and, if possible, use each group only once per season, except for multi-site mode-of-action materials (e.g., M2) or natural products or biological controls (NP/BC).

Disease	Dormant	Bud break	Full bloom	Pre-close	Veraison	Preharvest
Botryosphaeria canker	NP <sup>6</sup> (lime sulfur) <sup>3</sup>	—	—	—	—	—
Botrytis	—	—	3/7, 3/9 7/11 <sup>2</sup> , 9, 9/12, 17 19, M4	3/7, 3/9 7/11 <sup>2</sup> 9, 9/12, 17 19	3/7, 3/9 7/11 <sup>2</sup> , 9, 9/12, 17 19	3/7, 3/9 7/11 9, 9/12 17 19
Downy mildew	—	NP, 4, 40, 43	4,40,43	—	—	—
Esca	NP <sup>6</sup> (lime sulfur) <sup>3</sup>	—	—	—	—	—
Eutypa	NP <sup>6</sup> (B-Lock), 1	—	—	—	—	—
Powdery mildew <sup>4,5</sup>	NP <sup>6</sup> (lime sulfur) Oil	M2 Oil	3/7, 3/9 7/11 13 17+11 19 U8	3, 3/7, 3/9 7/11 11, 13, U8 BC <sup>6</sup> NP <sup>6</sup> M4	3, 3/7, 3/9 11 13, 19 M4 U8	—
Phomopsis cane and leafspot	—	2 11 M4/M3	—	—	—	—
Summer bunch rot (sour rot)	—	—	—	3/9, 7/11 9, 9/12 Oil, M1	3/9, 7/11 9, 9/12 M1	3/9, 7/11 <sup>7</sup> 9 <sup>7</sup> , 9/12 M1 <sup>7</sup>

<sup>1</sup> 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/>). Group numbers are listed in numerical order within the suggested disease management program. Fungicides with a different group number are suitable to alternate in a resistance management program. Refer to the fungicide efficacy table for fungicides belonging to each FRAC group.

<sup>2</sup> Apply only if rain is forecasted. When using one class do not follow with the same class.

- <sup>3</sup> Use 10 gallons lime sulfur per acre in at least 100 gallons water. Use liquid lime sulfur in dormant applications and wettable sulfur at and after prebloom.
- <sup>4</sup> Apply bud break and full bloom treatments every year.
- <sup>5</sup> Apply as needed (a disease risk assessment model is available to help determine need for spray).
- <sup>6</sup> NP/BC = Natural Products/Biological Controls such as B-Lock, Sonata, Serenade, Kaligreen, Cinnacure, etc.
- <sup>7</sup> Apply when insect and bird damage present or when rainfall is forecasted.

*Acknowledgment: Adaskaveg et al., 2017. Efficacy and Timing of Fungicides, Bactericides, and Biologicals for Deciduous Tree Fruit, Nut Crops, and Grapevines. (PDF)*

## PATHOGEN TESTING SERVICE FOR GRAPES (7/15)

The University of California's Foundation Plant Services offers pathogen testing on a fee-for-service basis for 16 different pathogens. Testing is performed using Polymerase Chain Reaction, which is one of the most sensitive methods for pathogen detection currently available. Testing is available for the following viral and bacterial pathogens of grapevines:

- Grapevine leafroll-associated virus (1–5)
- Grapevine vitivirus (A, B, & D)
- Rupestris stem pitting-associated virus
- Grapevine fan leaf virus
- Grapevine fleck virus
- Tomato ring spot virus
- Arabis mosaic virus
- Pierce's disease (*Xylella fastidiosa*)
- Phytoplasmas
- Grapevine rootstock stem lesion-associated virus (formerly know as Redglobe virus)

For more information call the Foundation Plant Services at (530) 752-3590 or view the Web site at <http://fpms.ucdavis.edu>.

## *Insects and Mites*

(Section reviewed 7/15)

### ANTS (7/15)

**Scientific Names:** Argentine ant: *Linepithema humile*  
 Gray ant: *Formica aerata* and *Formica perpilosa*  
 Pavement ant: *Tetramorium caespitum*  
 Southern fire ant: *Solenopsis xyloni*  
 Thief ant: *Solenopsis molesta*

### DESCRIPTION OF THE PESTS

The most prevalent of the ant species in coastal vineyards, the Argentine ant, which feeds on sugars, is about 0.13 inch (3 mm) long, uniformly deep brown to light black and does not bite or sting. It has one petiole node (hump) between the thorax and the gaster (swollen part of abdomen right behind the petiole). Worker ants travel in characteristic trails on vines, trellis wires, the ground, and drip irrigation laterals. They forage during all daylight hours.

Ant populations peak in midsummer and early fall. Their nests are very shallow, usually within 2 inches of the soil surface.

In the San Joaquin and Coachella valleys, the most prevalent ants are native gray ants, which are also referred to as field ants. Gray ants feed primarily on sugars. These ants measure up to 0.3 inch (7.5 mm) and, like the Argentine ant, have one petiole node (hump). Gray ants nest in the topsoil or under rocks and debris, move in an irregular jerky manner, and generally do not travel in trails or sting. *Formica aerata* is more common in the San Joaquin Valley, whereas *Formica perpilosa* occurs primarily in the Coachella Valley.

The pavement ant feeds primarily on protein-based foods such as seeds. It is 0.13 inch (2–3 mm) long and has a dull, blackish brown body that is covered with coarse hairs. The head and thorax have many parallel furrows. Pavement ants have two nodes between the thorax and the gaster. They move in a slow deliberate motion and prefer to nest in sandy or loam soils.

The southern fire ant, also called the California or native fire ant, feeds primarily on protein. It is light reddish brown with a black abdomen. The entire body is covered with golden hairs and has two nodes between the thorax and the gaster. Workers range in size from 0.1 to 0.18 inch (2.5–4.5 mm). They do not usually travel in conspicuous trails and will swarm over the ground when disturbed. This ant will sting when provoked. Southern fire ants build nests of loose mounds or craters near bases of vines around wetted areas and do not aggregate in colonies as large as those of the Argentine ant. They forage in the morning and early evening and are underground during hot periods.

Thief ants are extremely small ants (1–1.5 mm) with yellowish, shiny bodies and feed on sugars. They are pests of grapes primarily in the Coachella Valley, but can also be found in the San Joaquin Valley and in coastal areas.

An illustrated key that covers common ant species (except gray ants) may be of value when identifying ants in vineyards and can be found online at <http://www.ipm.ucdavis.edu/TOOLS/ANTKEY/index.html>.

### DAMAGE

Ants can be extremely disruptive to IPM programs, especially Argentine and native gray ants. These ants feed on honeydew excreted by the European fruit lecanium scale and mealybugs. As part of this relationship, they also protect these honeydew-producing insects from predators and parasites, thus disrupting biological control.

### MANAGEMENT

Ants may be more of a problem in vineyards with cover crops; the exception appears to be a vetch cover crop, because it supplies ants with adequate amounts of nectar and keeps them from moving into vines. Manage ants when they are interfering with biological control of pests. Cultural practices and sprays can be used in an integrated program.

**Cultural Control**

Tilling the soil for weed control will also disturb the nesting sites of ants and help to reduce their populations. Use of a French plow in the vine row will disrupt ant colonies.

Planting a cover crop of common vetch (*Vicia sativa*) can help to keep gray field ants (*Formica* sp.) off the vines. Common vetch has an abundance of nectaries that attract the ants away from the honeydew-producing insects. In studies it was planted in a 80:20 mixture with 20% Merced rye so that it could establish in late fall and winter in order to attract the ants during spring and early summer. The addition of rye to the mixture helps to provide structure and support in the cover crop for the vetch. A heavy seeding rate (120 lb/acre) helps to ensure a good stand. The effect of other nectary-bearing cover crops on attracting ants has not been evaluated. (Research using cover crops to attract Argentine ants, *Linepithema humile*, has not been conducted.)

**Organically Acceptable Methods**

Organically acceptable management tools are the cultural controls. For sugar-feeding ants, Gourmet ant bait is approved for organic production.

**Monitoring and Treatment Decisions**

Monitor the vineyard in spring when honeydew-producing insects such as scale and mealybugs appear as outlined in DELAYED-DORMANT AND BUDBREAK MONITORING (wine and raisin grapes or table grapes) and record observations on a monitoring form (*example form available online*). Check the abdomen of ants descending the trunks to see if they are swollen and translucent; this helps identify them as honeydew-collecting species. Periodically inspect for ants on arms, cordons, and canes.

**Insecticides**

Baits are the preferred chemical method for ant control whenever feasible. Effective bait insecticides have slow-acting toxicants that worker ants collect and feed to other ants, including nest-building immatures and queens. For the most effective and economical control, treat when ants are active in early spring following winter rains and again in late August.

To determine which bait to use, identify your primary ant species; fire ants are predominantly protein feeders whereas Argentine ant and most gray ants are sugar feeders.

**Corncob grit and oil baits**

Solid baits utilize treated corncob grits mixed with soybean oil as the food attractant plus an insecticide. These are effective for the primarily protein-feeding fire ants. Light degrades toxicants, therefore apply baits early in the morning or late in the day when ants are active and will take the bait into the nest. Generally, corncob grit type baits are broadcast over the acreage that needs to be treated. However, spot application of baits at the location of the ant nest is preferred over widely spreading the bait because it concentrates the food where the ants are.

**Sugar-water-based baits**

Liquid baits use a toxicant mixed in sugar water, which disguises the toxicants as well as helps attract the ants. These baits are most useful for the liquid sugar-feeding Argentine and native gray ants. Evaporation of the bait can cause the concentration of the toxicant to increase to a level in the bait that becomes repellant to ants. All liquid baits must be used in an EPA-approved bait station.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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REVISED: 7/15

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

**LIQUID BAITS – SUGAR-FEEDING ANT SPECIES**

*(Must be used in approved bait station such as KM Ant Pro or constructed from an approved design.)*

A. DISODIUM TETRABORATE# (Gourmet Liquid Ant Bait) MODE-OF-ACTION GROUP NUMBER: un		NA	NA
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Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
B. S-METHOPRENE (Tango) MODE-OF-ACTION GROUP NUMBER: 7A		4	0

**SOLID BAITS – PROTEIN-FEEDING ANT SPECIES**

*(Apply with a broadcast spreader.)*

A. ABAMECTIN (Clinch bait 0.011%) MODE-OF-ACTION GROUP NUMBER: 6 COMMENTS: Use allowed under a Special Local Needs (SLN) registration for fire ants only within Fresno, Kern, Madera, Riverside, San Bernardino, and Tulare counties. A corncob grit and soy oil bait. Effective primarily against fire ants because they are attracted to the soy oil. Apply when fire ants are most active during the year (early summer and fall) and when they are most active during the day (early evening and early morning when soil temperature is above 60°F). Treatments are most effective if applied 2 days after an irrigation, when ant activity is at a maximum. Do not irrigate again until at least 24 hours after application. Do not apply if rainfall is anticipated within 4 to 6 hours after application. While Clinch can be broadcast using properly calibrated ground equipment to assure proper dosage and uniform distribution, spot applications at the location of the ant nest are preferred. Consider re-treating after 3 to 4 months. Do not apply onto blooming crops or weeds where bees are foraging. Certain formulations emit high amounts of volatile organic compounds (VOCs); use low-VOC formulations. <b>Regulations affect use for the San Joaquin Valley from May 1 to October 31, 2019.</b>	1 lb/acre	12	28
B. PYRIPROXYFEN (Esteem Ant Bait 0.5%) MODE-OF-ACTION GROUP NUMBER: 7C COMMENTS: A corncob grit and soy oil bait. Effective only against fire ants because they are attracted to the soy oil. Apply when fire ants are most active during the year (especially early summer and fall) and when they are most active during the day (early evening and early morning when soil temperature is above 60°F). Treatments are most effective if applied 2 days after an irrigation, when ant activity is at a maximum. Do not irrigate again until at least 24 hours after application. Do not apply if rainfall is anticipated within 4 to 6 hours after application. While this bait can be broadcast using properly calibrated ground equipment to assure proper dosage and uniform distribution, spot applications at the location of the ant nest are preferred. Consider re-treating after 3 to 4 months. Do not apply onto blooming crops or weeds where bees are foraging.	1.5–2 lb/acre	12	1
C. METAFLUMIZONE (Aftrevin 0.063%) MODE-OF-ACTION GROUP NUMBER: 22B COMMENTS: A corncob grit and soy oil bait. Effective only against fire ants because they are attracted to the soy oil. Apply when fire ants are most active during the year (especially early summer and fall) and when they are most active during the day (early evening and early morning when soil temperature is above 60°F). Treatments are most effective if applied 2 days after irrigation, when ant activity is at a maximum. Do not irrigate again until at least 24 hours after application. Do not apply if rainfall is anticipated within 4 to 6 hours after application. While this bait can be broadcast using properly calibrated ground equipment to assure proper dosage and uniform distribution, spot applications at the location of the ant nest are preferred. Consider re-treating after 3 to 4 months.	1.5 lb/acre	12	5



Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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**			
‡			
*			
1			

# BLACK VINE WEEVIL (7/15)

**Scientific Name:** *Otiorhynchus sulcatus*

## DESCRIPTION OF THE PEST

The black vine weevil is primarily a pest in central coast vineyards. The adult is a hard-shelled black beetle about 0.5 inch long with small patches of white scales on the forewings. A long and broad snout, typical of weevils, projects from the front of the head. In coastal areas adult emergence generally starts in early April and continues through May. About 2 to 3 weeks after they emerge, females begin laying eggs and continue for 6 to 8 weeks. Eggs hatch into white grubs (larvae) that feed on roots. Larvae feed for about 10 months before pupating in the soil during late winter.

## DAMAGE

Adults are nocturnal, feeding on buds, foliage, flowers, and the cluster rachis. Significant bud damage can occur on late budding varieties. Foliar feeding is characterized by notching along leaf margins. Larvae feed underground on roots but do not appear to damage the vines.

## MANAGEMENT

Weevils move from under loose trunk bark and the soil up to the vine canopy and back, so management measures target the vine trunk and the soil surface surrounding the trunk. Among cover crops, creeping red fescue supports black vine weevil larvae populations while oats, vetch, and alfalfa do not.

Adult emergence is monitored with a corrugated cardboard trap. Strip loose bark from a vine and wrap an 8- to 10-inch wide corrugated cardboard "tree wrap" around a trunk, cinching it in the middle with a plastic tie to hold it in place. Weevils will hide in the wrap's corrugations during the day. From mid- to late March, inspect the corrugations twice weekly to detect for first emergence. Thereafter, inspect weekly. This technique has shown that generally adult activity between the soil and vine peaks in mid- to late May and is complete by early July.

Black vine weevil is generally not treated; however, if chlorpyrifos (Lorsban) is used for ant control, it also will deter this insect.

# BLACK WIDOW SPIDER (7/15)

**Scientific Name:** *Lactrodectus hesperus*

## DESCRIPTION OF THE PEST

The typical adult female black widow has a shiny black body, slender black legs, and a red or orange mark in the shape of an hourglass on the underside of the large, round abdomen. The body, excluding legs is 5/16 to 5/8 inches long.

The adult male black widow is one-half to two-thirds the length of the female, has a smaller abdomen, and is seldom recognized as a black widow. The topside of its abdomen is greenish gray with a pattern of cream-colored areas and one light-colored band going lengthwise down the middle. The hourglass mark on the underside of the abdomen typically is yellow or yellow-orange and broad in the middle. The legs are banded with alternating light and dark areas.

Like males, young female black widow spiders are patterned on the top side. In the early stages they resemble males, but gradually acquire the typical female coloration with each molt. In intermediate stages they have tan or cream-colored, olive gray, and orange markings on the topside of the abdomen, a yellowish orange hourglass mark on the underside and banded legs.

The egg sacs are mostly spherical, about 1/2 inch long and 5/8 inch in diameter, creamy yellow to light tan in color, opaque, and tough and paperlike on the surface. A female may produce several egg sacs during her lifetime, which can be 2 years. Tiny, young black widows, which are nearly white in color, emerge from the egg sac and remain close together during the first days after emergence, often preying on each other. Soon afterwards, the spiderlings disperse to new locations by 'ballooning' on light silken thread and infest new areas. Webbing produced by black widow spiders is very strong compared to other spider webbing.

## DAMAGE

Generally spiders play a beneficial predatory role in a vineyard and are not thought of as pests. However, in the southern San Joaquin Valley (Kern and Tulare counties) and the Coachella Valley, black widow spiders can be a problem in table grape vineyards because of quarantine issues in crops to be exported to other countries and because of the public's fear of black widows.

## MANAGEMENT

If a mealybug treatment is not planned, an in-season treatment for caterpillars with fenprothrin (Danitol) will control black widows; full coverage is important. Because there are protected areas in the vineyard where insecticide coverage is poor (e.g., cement irrigation pipe stands, trellis poles, and cross-supports), an in-season application may be required to keep these spiders out of the grape cluster. Fenprothrin (Danitol) is effective, but spiders often seek cover before sprayers can reach them.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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REVISED: 7/15

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

### GROWING SEASON

A.	FENPROPATHRIN* (Danitol 2.4EC) MODE-OF-ACTION GROUP NUMBER: 3A COMMENTS: Direct the spray towards fruit clusters. Coverage is very important. Use sufficient water to get the insecticide throughout the vine. To protect honey bees, apply only during late evening, night, or early morning when bees are not present. Disruptive to other beneficial insects.	5.33–10.66 oz	24	21
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\*\* Apply with enough water to provide complete coverage.

- ‡ 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 R.E.I. exceeds the P.H.I. 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/>.

# BRANCH AND TWIG BORER (7/15)

**Scientific Name:** *Melalgus* (= *Polycaon*) *confertus*

## DESCRIPTION OF THE PEST

The branch and twig borer, also known as the grape cane borer, occurs throughout California. Adult borers are dark brown beetles, cylindrical in shape with a pronotum that is wider near the head than the posterior end. Females are about 0.7 inch long; adult males are smaller, about 0.3 to 0.4 inch long. Larvae have white bodies that are typically curved in a C-shape and enlarged at the anterior end; the head is brown. Branch and twig borers have one generation per year. Adult emergence starts in March and continues through April. Larvae spend up to 10 months in tunnels they excavate.

## DAMAGE

Both adults and larvae injure grapevines. Larvae bore into wood at dead or dying parts of vines, often in old pruning scars. Adults burrow into fruiting canes at the base of the bud or shoot, or they burrow into the crotch formed by the shoot and spur. Feeding is often deep enough to completely conceal the adult in the hole. Feeding at the base of shoots on spurs will cause shoots to wilt (flagging) and fall. This pest is most serious in cane-pruned vineyards where feeding on canes can cause them to break when shoots reach a length of 10 to 12 inches, if a strong wind occurs. Shoot wilting can also be caused by *Botrytis*.

## MANAGEMENT

Establishment of branch and twig borer in a vineyard may be attributed to one or two factors: (1) proximity to habitat suitable to the insect, such as riparian or woodland areas, old orchards, or unmaintained vineyards, and (2) failure to destroy or adequately remove dead or damaged parts of vines that may have resulted from disease (such as *Eutypa* and Pierce's disease) or cultural practices such as T-budding, lowering the vine head, or mechanical pruning.

Chemical control is normally not necessary if good cultural controls are practiced. April treatment of carbaryl for cutworms offers some measurable control of adult borers but may cause mite outbreaks later in the season.

### Biological Control

The many species of general predators found under the bark of grapevines may assist in maintaining lower populations. Treatments with commercial formulations of the entomopathogenic nematode *Steinernema carpocapsae*, which can move through frass tubes to infect larvae, may be of some benefit.

### Cultural Control

The best way to manage branch and twig borer in vineyards is to prevent invasion and establishment of the beetles through cultural methods. Wood and brush piles of any kind of tree or shrub should be completely removed from the vineyard or burned before emergence of adult beetles in March. Remove dead or dying portions of vines and destroy them with other prunings. Do not leave grapevine prunings in the vicinity of the vineyard. All prunings must be removed from berms on the vine rows and destroyed to optimize sanitation. If mechanical cane chipping or cutting is used for pruning disposal, the residue should be incorporated into the soil or composted before adult emergence. Good vine health is important for reducing sites of borer establishment in vineyards.

### Organically Acceptable Methods

Biological and cultural controls are organically acceptable, including the use of beneficial nematodes.

### Monitoring and Treatment Decisions

Look for shoot wilting (flagging) and drying leaves when you monitor your vineyard during the period of rapid shoot growth. In coastal regions, adults continue to emerge through April. Examine the base of these shoots for a 0.4 inch diameter hole. If no holes are present, another possibility is a *Botrytis* infection. Cut the shoot in half and look for brown discoloration.

After pruning, examine old pruning scars and dead parts of vines for brown frass and fine wood dust filling the holes that were made by borer larvae. Borer holes are detected more easily during the dormant season. No control action thresholds have been established. It is unlikely that borer injury in cordon-pruned vineyards would ever justify chemical treatment if good vineyard pruning and sanitation is practiced. Cane-pruned vineyards with a history of borer injury may require treatment.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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REVISED: 7/15

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

A.	CARBARYL* (Sevin XLR Plus) MODE-OF-ACTION GROUP NUMBER: 1A COMMENTS: May cause mite outbreaks; do not use where mites are a chronic problem. Extremely toxic to honey bees. To protect honey bees, apply only during late evening, night, or early morning when bees are not present. Do not spray directly nor allow drift onto blooming crops or weeds where bees are foraging.	1–2 lb	144 (6 days)	7
B.	STEINERNEMA CARPOCAPSAE# COMMENTS: Nematodes are perishable, so store them under cool, dark conditions. Use hand sprayer to aim spray at infested cordons. Most effective when applied during January and February.	Label rates	NA	NA

\*\* Apply with enough water to provide complete coverage.

‡ 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 R.E.I. exceeds the P.H.I. 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/>.

# Acceptable for use on organically grown produce.

NA Not applicable.

## CUTWORMS (7/15)

**Scientific Names:** Variegated cutworm: *Peridroma saucia*  
 Spotted cutworm: *Xestia (Amathes) c-nigrum*  
 Brassy cutworm: *Orthodes rufula* and other species

### DESCRIPTION OF THE PESTS

Cutworms are inconspicuously marked, dull-colored caterpillars ranging from 0.6 to 2.0 inch (1.5–5 cm) in length. Positive identification is important as behavioral differences affect control actions.

Mature **variegated cutworm** larvae are 1.5 to 2.0 inch (3.8–5 cm) long with smooth skin. Body color varies from pale gray to dark mottled brown intermixed with red and yellow dots along the dorsum.

Mature **spotted cutworms** are about 1.3 inch (3.5 cm) long and are a dull gray brown. A row of dark or black triangular markings are found on each side of the dorsal body surface.

Mature **brassy cutworms** are 1.0 to 1.2 inch (2.5–3 cm) long and are reddish or brassy in appearance. Of the cutworm species that attack grapes, brassy cutworm is the only one with hairs protruding from the compound eye area. A hand lens is needed to detect these hairs.

Variegated cutworm is the predominant species in the San Joaquin Valley and North Coast, while spotted cutworm is predominant in the Central Coast counties. In the North Coast, the variegated cutworm normally returns to the ground during the day but may also remain under the bark of the vine. In the San Joaquin Valley variegated cutworm larvae do not return to the soil but rather move under the bark. Spotted cutworms routinely remain under grapevine bark in all production areas.

### DAMAGE

Feeding on grapevines occurs from bud swell to when shoots are several inches long. Injured buds may fail to develop. Grapevines can compensate for early-season damage to buds or shoots to some extent by the growth of secondary buds. The fruitfulness of secondary buds, however, varies according to variety, and some varieties such as Thompson Seedless and Chardonnay have unfruitful or significantly less fruitful secondary buds respectively. In these varieties, destruction of primary buds can be expected to reduce the number of clusters in proportion to the number of buds destroyed.

### MANAGEMENT

Historical records of cutworm infestations or damage are useful in developing monitoring strategies for individual vineyards because cutworm problems are normally spotty or localized. Many varieties of grapes can tolerate a significant amount of damage without any economic loss. No chemicals are highly effective in controlling cutworms, so frequently treatments may not be economically justified.

#### Biological Control

Natural enemies of cutworms include predaceous or parasitic insects, mammals, parasitic nematodes, pathogens, birds, and reptiles. The hymenopteran (wasp) parasites, including ichneumonids, chalcids, braconids, and sphecids, are the most important group of cutworm natural enemies. Predaceous beetles (often found under bark) and tachinid flies are also factors in biological control.

#### Cultural Control

Cultural practices have not been demonstrated to successfully control cutworms; however, some practices do affect their population abundance. Weed removal in late summer or fall may be beneficial in disrupting cutworm life cycles. Plowing or discing of weeds just before or soon after bud swell is not recommended where cutworms are a problem, because it can cause movement of cutworms to the grapevines. Furrow and flood irrigation can be manipulated to bring cutworm larvae to the soil surface, exposing them to adverse weather and predators.

#### Organically Acceptable Methods

Biological and cultural controls and the Entrust formulation of spinosad are organically acceptable methods.

#### Monitoring and Treatment Decisions

Begin to monitor bud feeding by cutworms during bud swell in early spring. Cutworms can be monitored along with other pests following the procedures discussed in DELAYED-DORMANT AND BUDBREAK

MONITORING (wine/raisin grapes or table grapes). Because cutworm infestations are clumped, many vines must be examined to detect an infestation. In spring cutworms leave the soil and climb up the vines. During the day they hid under loose bark towards the base of the vine and come out to feed at night. Randomly select five locations in the vineyard to observe, concentrating on areas known to be chronically infested. Check 4 vines within each location for damaged buds (total 20 vines). On each vine examine 5 buds for damage (total 25 buds per location).

In cool growing regions with a long period between bud swell and shoot growth, monitoring may be needed over a 2- to 3-week period. Record results on a monitoring form (*example form available online*).

The number of damaged buds that can be tolerated depends on variety. If secondary buds are highly fruitful, little yield loss will result even when a large proportion of buds are damaged. If less than 4% of the buds are damaged, treatment may be unnecessary. Treating an entire vineyard is seldom necessary because infestations are usually localized; consider spot treatments. Cutworm feeding after shoots are about 6 inches long does not result in significant injury.

To make sure cutworms are causing the damage, return to damaged vines at night to look for cutworm larvae. Other species of insects (grape bud beetle, click beetles, branch and twig borers, orange tortrix larvae) also cause similar injury.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
REVISED: 7/15			
<i>The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide’s properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.</i>			
A. SPINETORAM (Delegate WG) MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: A stomach poison; most effective when ingested. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	3–5 oz	4	7
B. CARBARYL* (Sevin XLR Plus) MODE-OF-ACTION GROUP NUMBER: 1A COMMENTS: Disruptive to predators of mites and parasites of leafhoppers; do not use where mites are a chronic problem. Extremely toxic to honey bees. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	1–2 lb	12	7
C. INDOXACARB (Avaunt) MODE-OF-ACTION GROUP NUMBER: 22A COMMENTS: To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	3.5–6.0 oz	12	7
D. SPINOSAD (Entrust)# (Success) MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: Apply when eggs first hatch to target the young larvae. A stomach poison; most effective when ingested. Heavy infestations require a second application in 4 or 5 days. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	1.25–2.5 oz 4–8 fl oz	4 4	7 7



- \*\* Apply with enough water to provide complete coverage.
- ‡ 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 R.E.I. exceeds the P.H.I. 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/>.

# DROSOPHILA FLIES (7/15)

**Scientific Names:** *Drosophila melanogaster*, *D. simulans*, and other species

## DESCRIPTION OF THE PESTS

Various species of *Drosophila* are known as vinegar or pomace flies. In vineyards more than 95% are *D. melanogaster* and *D. simulans*. Adults are small, yellowish flies and are commonly attracted to fermenting fruit of all kinds. Populations build up as the fruit harvest season progresses. The 0.25-inch-long maggot-shaped larva can be found in cull and damaged fruit in the vineyards. Oblong pupae occur wherever larvae are found and have a forked breathing tube at one end. The life cycle in summer is only 7 to 8 days, with the adult laying 700 to 800 eggs in a 20- to 30-day life span.

The spotted wing drosophila, *D. suzukii*, is a new exotic pest of California and has been reported to infest undamaged, soft-skinned fruits such as cherry, raspberry, blackberry, strawberry, and blueberry. The adult male spotted wing drosophila has a dark spot on the front edge near the tip of each forewing; the adult female looks the same as other *Drosophila sp.* commonly found in vineyards except that it has a large and serrated ovipositor. See MALE/FEMALE IDENTIFICATION CARD for more information on identification. Under laboratory conditions the spotted wing drosophila can be forced to infest grape berries, but under field conditions this has not been seen in California.

## DAMAGE

*D. melanogaster* and *D. simulans* are a problem of damaged or cracked fruit. Eggs are laid in damaged or exposed fleshy tissue and larvae feed on the berries. The primary damage by this pest, however, is the sour rot organisms that it vectors from bunch to bunch in the vineyard.

## MANAGEMENT

The key to controlling drosophila flies is to reduce the incidence of summer bunch rot. Good fertilizer and irrigation management and use of gibberellins (Thompson Seedless only) may reduce the number of tight bunches, thus decreasing the incidence of bunch rot. Good sanitation practices in storage or processing plants are helpful in reducing populations of this pest. Pyrethrin and spinosyn insecticides can be used prior to and after harvest, but are not effective for long-term control as they only provide short-residual suppression of adults. In table grapes, note the presence of drosophila flies at harvest as an indicator of bunch rot diseases.

## Monitoring and Treatment Decisions

No monitoring guidelines have been developed for *Drosophila spp.* in grapes. However, research conducted in cherries and other crops has shown that bucket style traps, containing apple cider vinegar or a yeast bait can capture spotted winged drosophila and other *Drosophila sp.* Do not use apple-cider-flavored distilled vinegar. The most successful traps are described in more detail in the 2014 Recommendations for Sweet Cherry (PDF).

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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REVISED: 7/15

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

### POSTHARVEST

A.	PYRETHRIN/PIPERONYL BUTOXIDE MODE-OF-ACTION GROUP NUMBER: 3A/— COMMENTS: Spray containers with 1 pt/150 gal water and as needed. Apply to fruit in field, storage, or processing plants.	Label rates	12	0
B.	PYRETHRIN# (Pyganic EC5.0II) MODE-OF-ACTION GROUP NUMBER: 3A COMMENTS: To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	4.5–17 fl oz	12	0

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
REVISED: 7/15			
C. SPINETORAM (Delegate WG) MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: A stomach poison; most effective when ingested. Do not apply more than 19.5 oz/acre per crop per year or make applications less than 4 days apart. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	3–5 oz	4	7
D. SPINOSAD (Entrust)# (Success) MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: Do not apply more than 7.5 oz/acre per crop per year. Labeled for the control of spotted wing drosophila. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	1.25–2.5 oz 4–8 fl oz	4 4	7 7

\*\* Apply with enough water to provide complete coverage.

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/>.

‡ 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 R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.

NA Not applicable.

# EUROPEAN FRUIT LECANIUM SCALE (7/15)

**Scientific Name:** *Parthenolecanium corni*

## DESCRIPTION OF THE PEST

European fruit lecanium is a scale insect that is also known as the brown apricot scale. The adult female's domed shell is shiny brown and about 0.4 inch in diameter. Adult females are mostly found on 1- to 3-year-old wood on the underside of woody canes, cordons, and spurs where they remain for the rest of their lives. Females reproduce parthenogenetically (without mating), and eggs are laid in spring (beginning in April) beneath the female's body. Crawlers hatch from May through most of June. They move to the shoots and leaves of the current season's growth and molt to second instars from June to July.

In the North Coast a portion of the second-instar population continues development and becomes adults that produce a second generation. The crawlers of the second generation may be found on leaf petioles and shoots in August. Beginning in September, second-instar nymphs from both the first and second generation migrate back to 1- to 3-year-old wood. They overwinter under the bark in the second-instar stage. Early in spring, the second instars molt to the third-instar stage and then quickly develop into mature females that begin laying eggs in April and May. There is usually only one generation each year, but a portion of the population in the North Coast will have two generations. The second generation has not been observed in other grape-growing regions.

## DAMAGE

European fruit lecanium scale produces honeydew as it feeds. Sooty mold may grow on the honeydew, causing blackened areas on leaves and fruit. When European fruit lecanium occurs in abundance, it may stunt vine growth.

## MANAGEMENT

Parasites and predators often keep populations below damaging levels. Only when populations increase to great numbers should insecticide applications be considered.

Honeydew-seeking ants must be controlled to allow natural enemies of scale to aid in its control. This is best accomplished either with tillage or by treating the ants with an insecticide. See the section on ANTS for additional information on their control.

### Biological Control

European fruit lecanium is attacked by several species of parasites, including *Aphytis* spp., *Coccophagus* spp., *Encarsia* spp., and *Metaphycus luteolus*. Important parasites in the North Coast region are *Metaphycus insidiosus*, *Coccophagus lycimnia*, and *Blastothrix longipennis*. Frequently, second-instar scales may be heavily parasitized early in spring before budbreak. In addition, many common predators help control this scale. These include lady beetles (*Chilocorus orbis*, *Hyperaspis* spp., *Rhyzobius lophanthae*), lacewings, the predaceous sap beetle (*Cybocephalus californicus*) and predatory seed bugs (*Phytocoris* spp.).

### Organically Acceptable Methods

Organically acceptable methods of controlling European fruit lecanium include biological control and oil sprays.

### Monitoring and Treatment Decisions

Monitor closely throughout the year and make a map of infested areas in the vineyard. Monitor 1- to 3-year-old wood in early March for the presence of parasitism of second-instar scale nymphs. Place the scales in gelatin capsules (available from pharmacies) and hold the capsules at room temperature for 2-4 weeks to detect parasite emergence, or look for round exit holes on the scale bodies. You can also monitor female development on old wood. Monitor for crawler emergence in May by placing double-sided sticky tape around 1-year-old wood near the females, or by turning over the females and looking for crawlers.

The crawler stage is the stage most susceptible to chemical treatment, especially when using summer oil sprays. Crawlers emerge for a period of about 6 weeks, starting in mid-May. Treatment levels for scale have not been established. Determine the need for treatment of European fruit lecanium by evaluating records of honeydew from the previous season. Time treatment by monitoring for egg hatch in May; turn 10 females upside down and note if crawlers are present among the eggs. Look for mature females under cordons.

When using summer oil sprays, make two applications; apply the first treatment when 50% of the females show egg hatch (i.e., there are some crawlers below them), repeat monitoring again in 2 weeks and apply the second treatment when 90% of the females show crawlers. Alternatively, treat with imidacloprid when 90% of the females show crawlers. High temperatures in the summer months may reduce scale numbers. If numbers are high in September and grapes have been harvested, apply a treatment of oil before mid-October. In late season varieties or cool regions where harvest is late, an oil treatment may not be effective if the second instars have already moved under the bark for the winter.

When monitoring late in the dormant season, watch for ants. If ants are present, look closely for mealybugs and lecanium scale as outlined in DELAYED-DORMANT AND BUDBREAK MONITORING (wine/raisin grapes or table grapes) and record your results on a monitoring form (*example form available online*).

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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REVISED: 7/15

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

**SUMMER**

A.	NARROW RANGE OIL# (Omni Supreme and others) MODE OF ACTION: Contact including smothering and barrier effects. COMMENTS: Apply at 50% and again at 90% egg hatch. Be sure that vines are well watered and do not apply at least 10 days before and after a sulfur application to avoid phytotoxicity. Works by contact activity only so good coverage is essential. Check with certifier to determine which products are organically acceptable.	Label rates	See label	See label
B.	NEEM OIL# (Trilogy) MODE OF ACTION: Unknown. A botanical insecticide. COMMENTS: Make two applications: one at 50% and one at 90% egg hatch.	1–2%	4	0
C.	IMIDACLOPRID (Admire Pro - Soil) (Admire Pro - Foliar) MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: Treat in mid- to late May. Most effective in drip-irrigated vineyards with sandy soils that are not on deficit irrigation. Efficacy may be reduced in high clay soils. If two applications are required because of coarse soils or where the longest period of protection is required, make the second application 21 to 45 days after the bloom application. Apply a total of 7 to 14 fl oz/acre; the full rate of 14 oz/acre is recommended where vigorous vine growth is expected or in warmer growing areas such as the San Joaquin or Sacramento valleys. To protect honey bees, apply foliar sprays only during late evening, night, or early morning when bees are not present.	7–14 fl oz 1.0–1.4 fl oz	12 12	30 0

**POSTHARVEST**

A.	NARROW RANGE OIL# (Omni Supreme and others) MODE OF ACTION: Contact including smothering and barrier effects. COMMENTS: Be sure that vines are well watered and do not apply at least 10 days before and after a sulfur application to avoid phytotoxicity. Works by contact activity only so good coverage is essential. Check with certifier to determine which products are organically acceptable.	Label rates	See label	See label
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\*\* Apply with enough water to provide complete coverage.

‡ 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 R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.

# Acceptable for use on organically grown produce.

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

## FALSE CHINCH BUG (7/15)

**Scientific Name:** *Nysius raphanus*

### DESCRIPTION OF THE PEST

False chinch bug breeds in great numbers in grass or weedy areas, especially on London rocket, and may migrate into vineyards in search for green growth when these areas dry up or are plowed under. Adults are gray and about 0.12 inch long. Nymphs are gray with reddish brown abdomens. When they migrate, they are mainly in the wingless stage, and consequently they migrate by walking. A number of winged adults are also present, but instead of flying they march along with wingless immatures.

### DAMAGE

Large numbers of nymphs and adults migrating into the vineyard in the spring, may suck plant juices and inject a toxin that causes vines to wilt and turn brown. Because of the great number of bugs involved and their toxic injections, all the leaves on border vines can be killed in a few hours. September and October migrations are also possible.

### MANAGEMENT

False chinch bugs are only a sporadic problem, but occasionally cause rapid and serious damage to young vines.

#### Cultural Control

If false chinch bugs have been a problem in past years, disc under stands of London rocket and other host weeds about 3 weeks before budbreak in grapevines. Do not delay discing until after budbreak, for it may result in a heavy movement of bugs from the weeds to the vines.

#### Organically Acceptable Methods

Cultural controls are organically acceptable.

#### Monitoring and Treatment Decisions

If discing weeds was not done, and high populations of false chinch bugs are found on weeds at budswell or after budbreak, a treatment may be necessary. If nymphs are found moving onto vines, spot treat both vines and adjacent weeds. Bugs migrate mainly in one direction and the wilted vines along the edge of the vineyard will show the line along which they are moving. The insecticides listed below, when applied to the soil in a 30-inch band, can form a barrier to prevent further migration.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
REVISED: 7/15			
<i>The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.</i>			
A. FENPROPATHRIN* (Danitol 2.4EC) MODE-OF-ACTION GROUP NUMBER: 3A COMMENTS: See label for additional requirements regarding hand labor. To protect honey bees, apply only during late evening, night, or early morning when bees are not present. Disruptive to other beneficial insects.	10.66–21.33 fl oz	24	21
B. MALATHION 8 Spray MODE-OF-ACTION GROUP NUMBER: 1B COMMENTS: To protect honey bees, apply only during late evening when bees are not present. R.E.I. is 72 hours for girdling and tying; 24 hours for other activities.	1.88 pt	See comments	3

\*\* Apply with enough water to provide complete coverage.

‡ 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 R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.

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

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# GRAPE BUD BEETLE (7/15)

**Scientific Name:** *Glyptoscelis squamulata*

## DESCRIPTION OF THE PEST

The grape bud beetle is a major pest in the Coachella Valley. It can be found in the Central Valley but is rarely if ever a pest problem there. The adults are a light gray color. Both sexes are about 0.25 to 0.4 inch (6–10 mm) long and 0.2 to 0.25 inch (5–6 mm) wide. There is one generation per year and larval stages are spent in the soil. Adults begin emerging from the soil in mid-January; peak emergence occurs around mid-March each year. Emergence time is not affected by aboveground temperatures.

## DAMAGE

Adult beetles cause crop loss by feeding on opening buds and eating the bud center, which contains the immature leaves and flower cluster primordia. Once the new shoots are 1 to 1.5 inches long, feeding damage is negligible.

## MANAGEMENT

An important part of managing grape bud beetle is keeping accurate yearly records of infested vineyards. These beetles usually occur in localized areas of a vineyard year after year. Because grape bud beetles are not equally distributed, survey all parts of a vineyard.

### Monitoring and Treatment Decisions

Adults come out of daytime hiding places about 1 hour after sundown. Beetles can be monitored with a flashlight. An ultra-violet lamp is preferred because the beetles naturally fluoresce a bright silvery blue when under UV light.

Treatment decisions for adults are complex. For example, unusually warm weather can push the buds out rapidly, or cold weather may delay budbreak and provide longer exposure of buds to beetle feeding. A variable portion of buds of all varieties never open in the Coachella Valley.

During budbreak, treatment is suggested when there are one to three beetles per vine and bud damage is noticeable in Thompson Seedless vineyards. Treatment is suggested during budbreak in Beauty Seedless, Perlette, Flame Seedless, and Cardinal vineyards when there are one to two beetles per vine and bud damage is noticeable.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
REVISED: 7/15			
<i>The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide’s properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.</i>			
A. PHOSMET (Imidan 70W) MODE-OF-ACTION GROUP NUMBER: 1B COMMENTS: To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	1.33 lb	336 (14 days)	See label

\*\* Apply with enough water to provide complete coverage.

‡ 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 R.E.I. exceeds the P.H.I. 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 more information, see the Web site at <http://www.irac-online.org/>.

# GRAPE LEAFFOLDER (7/15)

**Scientific Name:** *Desmia funeralis*

## DESCRIPTION OF THE PEST

Moths of the grape leaffolder are almost black, with two white spots on the forewings and two white stripes across the abdomen. Larvae are translucent but appear greenish because ingested leaf tissue shows through the body wall. Small black spots, located above the second pair of legs, are present on later instar larvae. This helps distinguish them from omnivorous leafroller.

Grape leaffolders have three generations a year (about April-May, June 15-July 15, and August). After overwintering as pupae, moths emerge in April or May and lay flat, elliptical eggs singly on either the upper or lower surface of the leaf. Many are deposited against the leaf veins on the underside of the leaf. After hatching, larvae feed between two leaves webbed together for about two weeks. Then each pale green, translucent larva rolls a leaf edge and feeds from the inside on the leaf edge. Larvae turn darker green as a result of this leaf feeding. If disturbed, larvae wriggle vigorously and drop to the ground without a silken thread. Mature larvae construct a separate leaf envelope on the edge of a leaf in which they pupate.

## DAMAGE

Grape leaffolder can reduce leaf surface by constructing leaf rolls and by leaf feeding. Twenty percent leaf reduction can be tolerated 1 month after fruit set in the San Joaquin Valley. Even more leaf damage can be tolerated later. However, third-generation damage can be severe enough to cause complete defoliation, which leads to sunburned berries, soft fruit, and direct berry feeding by leaffolder larvae.

## MANAGEMENT

Parasites play an important role in keeping grape leaffolder below a level that will cause damage. There seems to be no correlation between the past season's population and the current season's first generation nor with the population density that may develop later. Treatment of the first generation is rarely needed. However, inspect and judge each brood as to its potential to cause economic damage.

### Biological Control

Several parasites attack grape leaffolder. Among the most common is the larval parasite *Bracon cushmani*. After stinging and paralyzing leaffolder larvae, female *B. cushmani* lay from one to several eggs on the body of leaffolder larvae. *Bracon cushmani* larvae feed externally and, after completing their development, pupate next to the consumed host. Parasitism by this parasite frequently reduces second and third generation populations to below economic levels. In addition to *B. cushmani*, several other hymenopteran parasites and at least two species of flies parasitize leaffolder. Generalist predators such as lacewings and spiders also attack grape leaffolder larvae.

### Organically Acceptable Methods

Biological control and sprays of *Bacillus thuringiensis* and the Entrust formulation of spinosad are organically acceptable methods.

### Monitoring and Treatment Decisions

Grape leaffolder can be monitored along with other pests following the procedures in MONITORING CATERPILLARS. If grape leaffolders are present in the vineyard before bloom or have been a problem in the past and no parasitism was observed in the previous season, plan to treat at bloom. Otherwise, monitor for the characteristic group feeding of young larvae between leaves. As larvae begin making rolls, examine the vineyard every 2 to 3 days to detect a greater than expected increase. Record results on a monitoring form (*example form available online*).

Unroll leaves to check for parasitism. Populations tend to be spotty, and defoliation of a few vines used for raisin or wine grapes can probably be tolerated; however, table grapes should probably be treated. If treatment is warranted, treat as soon as a few rolls are noticed from the generation being treated because small larvae are more easily killed than older instars. Usually treatments applied for grapeleaf skeletonizer and omnivorous leafroller will also control grape leaffolder.

At harvest check table grapes for grape leaffolder damage to assess your management program and prepare for next year.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
REVISED: 7/15			
<i>The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.</i>			
A. CRYOLITE (Kryocide)	6–8 lb	12	30
(Prokil Cryolite 96)	6–8 lb	12	30
MODE-OF-ACTION GROUP NUMBER: 8C			
COMMENTS: Wine, table, and raisin: two applications maximum. Ground application only. If used on wine grapes or grapes that may be sold to a winery for export, observe their application restrictions. Cryolite is a stomach poison that must be ingested by the leaffolder to be effective so good coverage is essential. The best application timing is before leaf rolling begins. Do not apply more than 20 lb/acre per year.			
B. METHOXYFENOZIDE (Intrepid 2F)	10–16 fl oz	4	30
MODE-OF-ACTION GROUP NUMBER: 18			
COMMENTS: An insect growth regulator that affects lepidopterous larvae only. Must be ingested; most effective when applied to young caterpillars.			
C. CHLORANTRANILIPROLE (RYNAXYPYR) (Altacor)	2.0–4.5 oz	4	14
MODE-OF-ACTION GROUP NUMBER: 28			
D. SPINOSAD (Entrust)#	1.25–2.5 oz	4	7
(Success)	4–8 fl oz	4	7
MODE-OF-ACTION GROUP NUMBER: 5			
COMMENTS: Apply when eggs first hatch to target the young larvae. A stomach poison; most effective when ingested. Heavy infestations require a second application in 4 or 5 days. To protect honey bees, apply only during late evening, night, or early morning when bees are not present. Do not spray directly nor allow drift onto blooming crops or weeds where bees are foraging.			
E. SPINETORAM (Delegate WG)	3–5 fl oz	4	7
MODE-OF-ACTION GROUP NUMBER: 5			
COMMENTS: A stomach poison; most effective when ingested. To protect honey bees, apply only during late evening, night, or early morning when bees are not present. Do not spray directly nor allow drift onto blooming crops or weeds where bees are foraging.			
F. <i>BACILLUS THURINGIENSIS</i> ssp. <i>KURSTAKI</i> # (various products)	Label rates	4	0
MODE-OF-ACTION GROUP NUMBER: 11A			
COMMENTS: Only effective against young larvae. A stomach poison that must be ingested by the leaffolder to be effective. Good coverage is essential. Has a short residual so is most effective when applied 3 or 4 days before leaf rolling by the main brood.			

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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REVISED: 7/15

- \*\* Apply with enough water to provide complete coverage.
- ‡ 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 R.E.I. exceeds the P.H.I. 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 organo-phosphates have a Group number of 1B; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode-of-action group numbers (“un”=unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee). For more information, see the Web site: <http://www.irac-online.org/>.

# GRAPE PHYLLOXERA (7/15)

**Scientific Name:** *Daktulosphaira vitifoliae*

## DESCRIPTION OF THE PEST

Grape phylloxera is a tiny aphidlike insect that feeds on roots of *Vitis vinifera* grape and certain rootstocks, stunting growth of vines or killing them. This pest prefers heavy clay soils that are found in the cooler grape-growing regions of the state such as Napa, Sonoma, Lake, Mendocino, and Monterey counties, as well as the Sacramento Delta and the foothills. Although grape phylloxera is present in the heavier soils of the San Joaquin Valley, damage may not be as severe. It is not a pest on sandy soils.

The majority of grape phylloxera adults are wingless females. They are generally oval shaped, but those that lay eggs are pear shaped. They are small (0.04 inch long and 0.02 inch wide) and vary in color from yellow, yellowish green, olive green, to light brown, brown, or orange. Newly deposited eggs are yellow, oval, and about twice as long as wide. Nymphs resemble adults except they are smaller.

Grape phylloxera overwinter as small nymphs on roots. In spring when soil temperatures exceed 60°F, they start feeding and growing. First instar nymphs are active crawlers and may move from plant to plant in the ground, on the soil surface, or by blowing in the wind. They may also be moved between vineyards on cuttings, boots, or equipment. Established phylloxera feed externally in groups on roots. In fall when soil temperatures fall below 60°F, all life stages die except the small nymphs. There are three to five generations each year.

Occasionally, winged phylloxera are seen in *V. vinifera* vineyards, but they are believed to be sterile under California conditions.

## DAMAGE

Grape phylloxera damage the root systems of grapevines by feeding on the root, either on growing rootlets, which then swell and turn yellowish, or on mature hardened roots where the swellings are often hard to see. Necrotic spots (areas of dead tissue) develop at the feeding sites on the roots. The necrotic spots are a result of secondary fungal infections that can girdle roots, killing large sections of the root system. Such root injury causes vines to become stunted and produce less fruit.

Severity of infestation will differ with the vigor of the grapevine as well as with soil texture and drainage. Leaf-galling forms of phylloxera that are common in eastern states are extremely rare in California vineyards.

## MANAGEMENT

Resistant rootstocks are the only completely effective means for phylloxera control in the most severely affected areas. A pesticide treatment will not eradicate phylloxera populations; the chemical cannot easily penetrate the heavy soils that this pest prefers. Also, effectiveness of a treatment is difficult to evaluate because although many phylloxera may be killed, populations may rebound rapidly and resume feeding on the vines. Because it may take years of insecticide treatments to reverse severe damage, treatments to prevent damage may be a better strategy than curative treatments.

### Biological Control

Little information on biological control of grape phylloxera is available; environmental and root conditions are more important than natural enemies.

### Cultural Control

Avoid rootstocks that have *V. vinifera* parentage because virulent biotypes of phylloxera can be selected and may eventually damage these rootstocks (the biotype B damage of the rootstock AXR#1 in many counties in California is an example of this type of problem). It is necessary to use rootstocks that have strong resistance and no *V. vinifera* parentage for durable protection against phylloxera. Contact your UCCE farm advisor for the most recent information on local rootstock trials and suggestions on the best rootstock for specific agronomic conditions. When planting a new vineyard use only clean propagating material and do not hold clean material in infested areas before planting. Young resistant rootstock vines will support low phylloxera populations and may be stunted if replanting occurs in heavily infested soils. Contact your UCCE farm advisor for suggestions on replanting procedures.

In the hot Central Valley, phylloxera damage may be reduced by good water management, fertilization, and other cultural practices that help limit plant stress.

**Organically Acceptable Methods**

Resistant rootstocks are an organically acceptable management tool for this pest.

**Monitoring and Treatment Decisions**

Initial infestations of grape phylloxera appear as a few weakened vines. These insects are difficult to detect in an apparently healthy vineyard. Therefore, monitor vines at harvest in an area of the vineyard that has consistently displayed weaker growth, especially vines at the edges of the weak areas. Grape phylloxera are more readily identified on vines growing in poor soils because their impact is greater on these vines than on vigorously growing vines.

In North Coast vineyards infested vines may initially exhibit potassium deficiency symptoms. The infested area expands concentrically at a rate of two- to fourfold a year. Satellite infestations frequently establish downwind from larger infested areas. When searching for phylloxera, be aware that populations die out on declining vines. Therefore, concentrate monitoring efforts on the periphery of declining areas where damage symptoms are still minimal. Dig near the trunk of vines under the drip emitter and look for whitish yellow, hooked feeder roots that are galled. Examine the galls with a hand lens for the presence of phylloxera.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
REVISED: 7/15			
<i>The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.</i>			
A. SPIROTETRAMAT (Movento) MODE-OF-ACTION GROUP NUMBER: 23 COMMENTS: Multiple applications over several years reduces phylloxera numbers. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	8 oz	24	7
B. IMIDACLOPRID (Admire Pro - Soil) MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: Multiple applications over several years reduces phylloxera numbers. Soil moisture is important for effectiveness; follow label instructions carefully. Do not exceed 0.5 lb imidacloprid / acre per year. Remove weeds from vine row before application.	14 fl oz	12	30
C. CLOTHIANIDIN (Belay - Soil) MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: Apply to soil. Multiple applications over several years reduces phylloxera numbers. Soil moisture is important for effectiveness; follow label instructions carefully.	6–12 fl oz	12	30
D. DINOTEFURAN (Venom - Soil) MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: Apply to soil. Multiple applications over several years reduces phylloxera numbers. Soil moisture is important for effectiveness; follow label instructions carefully.	6 oz	12	28
E. THIAMETHOXAM (Platinum) MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: Multiple applications over several years reduces phylloxera numbers. Soil moisture is important for effectiveness; follow label instructions carefully.	17 oz	12	60

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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- \*\* Apply with enough water to provide complete coverage.
- ‡ 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 R.E.I. exceeds the P.H.I. 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/>.

## LEADCABLE BORER (7/15)

**Scientific Name:** *Scobicia declivis*

### DESCRIPTION OF THE PEST

Leadcable borer is a cylindrical black beetle, 0.25 to 0.35 inch long, that emerges from round holes in trunks or cordons of damaged vines and from dead wood during spring and early summer. The head of the leadcable borer is mostly concealed from above by a hoodlike pronotum. Larvae are 0.35 inch long and cream colored with a small, dark head. The larvae are C-shaped and may be found feeding in tunnels on the vine. This beetle is not a common pest of grape, but has been observed in San Joaquin County and North Coast vineyards. It has also been reported to infest oak wine barrels and corks.

### DAMAGE

Adults bore into wood to prepare egg tunnels. Leadcable borer larvae feed in trunk or cordon wood for up to 9 months during development, creating frass-filled tunnels that can weaken vine structure. They can reinfest the wood from which they emerge. Distribution of infested vines is typically localized within vineyards.

### MANAGEMENT

The best method of control is good sanitation. Remove prunings and dead wood from the vineyard and destroy by burning or by thoroughly discing or flailing before adults emerge in spring. Remove dead or damaged wood from vines. Leadcable borer can become a chronic problem in infested vineyards and may take several years to control by cultural means. Leadcable borer adults may be controlled by insecticides applied for worms and other species when adult beetles are present. Chemical control is not effective against larvae inside the wood.



## LEAFHOPPERS (4/19)

**Scientific Names:** Western grape leafhopper: *Erythroneura elegantula*  
 Variegated leafhopper: *Erythroneura variabilis*  
 Virginia creeper leafhopper: *Erythroneura ziczac*

### DESCRIPTION OF THE PESTS

The grape leafhopper is a pest of grapes north of the Tehachapi Mountains, especially in the San Joaquin, Sacramento, and North Coast valleys. It is also a problem in warmer, interior Central Coastal valleys. The variegated leafhopper is the major pest of grapes in southern California and in the Central Valley as far north as San Joaquin County. Variegated leafhopper is also found in Napa County, although grape leafhopper tends to be more common. Virginia creeper leafhopper has been sporadically detected in vineyards in northern Sacramento Valley, northern Sierra foothill counties, and in Lake and Mendocino counties.

Leafhoppers overwinter as adults and are found in spring on basal grape leaves and weeds.

#### Grape leafhopper

The adult grape leafhopper is about 0.12 inch (3 mm) long and light to pale yellow with distinct dark brown and reddish markings. Eggs are laid singly in epidermal tissue on the underside of leaves and appear as a bean-shaped, blisterlike protuberance that is slightly less than 0.04 inch (1 mm) long. Eggs of the first brood are laid in April and May on basal leaves. Nymphs are white with six pale yellow spots on the thorax and clear eyes.

#### Variegated leafhopper

Although similar in size to the grape leafhopper, the variegated leafhopper is darker in color and distinctly mottled brown, green, and white with a reddish tinge. The nymphs are almost transparent when first emerged, becoming orange-brown to yellow-brown. Eggs are laid singly in the epidermal tissue of both upper and lower leaf surfaces. Eggs, 0.03 inch (0.8 mm) long, are inserted adjacent or within leaf veins and are imbedded deeply within the leaf tissue. This latter characteristic reduces the effectiveness of egg parasites against the variegated leafhopper.

#### Virginia creeper leafhopper

Adults have reddish-brown zigzag markings on the wings and reddish-brown eyes. Bean-shaped eggs are usually laid in groups of two to seven, but they can be laid singly as well. The female covers the eggs with a bluish-gray deposit. Young nymphs are pale yellow and have reddish-brown eyes, second and third stage nymphs have two pairs of orange spots on the thorax. Mature nymphs (fourth and fifth stage) have two pairs of dark reddish-brown spots on the thorax.

### DAMAGE

Nymphs and adults of all three species remove the contents of leaf cells, leaving behind empty cells that appear as pale yellow spots or stippling. If populations are high, the entire leaf may be pale yellow or white. Loss of leaf efficiency and leaf drop can occur when leafhopper densities are extremely high. This can result in fruit sunburn and may delay fruit ripening, especially in young vines. If there is a significant reduction in the overall photosynthetic capacity of the vine, young or stressed vines may have less shoot growth the following season.

The accumulation of small droplets of excrement on berries and the associated growth of sooty mold results in berry spotting that is a concern in table grapes. Adult leafhoppers are also a nuisance to workers when populations are high at harvest time. Their excrement appears as minute, sticky clumps that darken with age.

### MANAGEMENT

Although leafhoppers infest most vineyards in California, they may not require chemical treatment because vines can tolerate fairly high populations without harm, and predators and parasites may be able to maintain leafhopper populations below tolerance levels. However, in coastal regions and the Central Valley, grape leafhopper populations may occasionally reach damaging levels and require treatment. If chemical control of leafhopper nymphs is necessary, if possible, delay application until the second (summer) brood to allow for egg parasitism to reduce populations. When Virginia creeper leafhopper is detected in a new region, their natural enemies might not be present to reduce populations and treating the first nymphal generation may be needed, especially in organic vineyards.

## Biological Control

Many natural enemies help to provide control of leafhopper populations. The egg parasites, *Anagrus erythroneuræ* and *A. daanei*, are the most common *Anagrus* spp. found in California vineyards during part of the season. These parasites may be more abundant in vineyards that are adjacent to prune, plum, and almond orchards, and near riparian areas where other leafhoppers, which overwinter in the egg stage, reside. *Anagrus* spp. can parasitize these eggs and survive the winter. After a leafhopper egg is parasitized it becomes visibly red. Unfortunately, these parasites are not as effective at controlling variegated leafhopper eggs as they are on those of the grape leafhopper. Eggs of Virginia creeper leafhopper are parasitized by *A. tretiakovæ* and *A. daanei* in Washington State and British Columbia. Studies are underway to determine their presence and impact on California's Virginia creeper leafhopper populations. Sulfur sprays applied for fungal control may be toxic to *Anagrus* spp.

General predators of leafhoppers include spiders, green lacewings (*Chrysopa* spp.), minute pirate bugs (*Orius* spp.), lady beetles (*Hippodamia* spp.), black hunter thrips, and predaceous mites. The predaceous mite, *Anystis agilis*, is an important predator of first instar nymphs especially in the North Coast. Although many growers have experimented with releases of lacewings for leafhoppers, control of economic populations has not been achieved in university field trials.

## Cultural Control

Removing basal leaves or lateral shoots during berry set and the 2-week period following (before adult leafhoppers emerge), as recommended for Botrytis bunch rot management, will normally reduce peak leafhopper populations during the season by 30-50%. This coupled with *Anagrus* activity may preclude the need for insecticide treatment even when leafhoppers exceed the thresholds below. Time leaf removal to coincide with first generation nymphal development up to and including the 5th instar but just before adults are present. Also, leaf removal will improve coverage and efficacy of pesticides. In warmer growing areas, be careful not to remove excessive numbers of leaves, which can lead to sunburned fruit. Preventing overly vigorous vine growth will also help suppress leafhoppers.

If the vineyard is accessible before budbreak and erosion is not a risk, remove weeds in vineyards and surrounding areas before vines start to grow in spring to reduce adult leafhopper populations that might disperse to new grape foliage.

## Organically Acceptable Methods

Biological and cultural control methods, including basal leaf removal, assist in control. Narrow range oils, neem oil, insecticidal soaps, PyGanic, or kaolin clay may give partial control when nymphs are small. Soaps may spot table grapes and should only be used before bloom on this crop.

## Monitoring and Treatment Decisions

About 4 weeks after budbreak, or whenever nymphs first appear, begin sampling for leafhoppers. Randomly select 20 vines in each block of the vineyard, each at least a few vines in from the end of the row.

### How to monitor:

- *First-generation nymphs*—On each vine, choose one leaf at the 3rd or 4th node up from the basal node.
- *Second- and third-generation nymphs*—Choose young but fully expanded leaves in middle of canes.
- Count nymphs on underside of each leaf. Note which leafhopper species' are present.
- Check the leaves for red, parasitized eggs or eggs with emergence holes.
- Record observations on a monitoring form (*example form available online*<).

Continue monitoring weekly until harvest. Starting at bloom, combine leafhopper monitoring with monitoring for spider mites and mealybugs. See MONITORING INSECTS AND SPIDER MITES.

## Treatment Thresholds

Treatment thresholds vary according to leafhopper generation and species; whether grapes are being grown for table, wine, or raisin use; canopy size; region; and degree of parasitization. A level of 10-30% parasitism on eggs of the first generation may result in economic control of the grape leafhopper during the second and third generations. However, if the leafhopper population is made up primarily of the variegated leafhopper or the Virginia creeper leafhopper, economic control by *Anagrus* spp. parasites may be less likely, although a combination of parasite and predator activity can be effective. Use the general guidelines below to help determine treatment needs. If treatment is necessary, removing basal leaves will allow better spray coverage and thus improve pesticide efficacy.

**Wine and Raisin Thompson Seedless Grapes**

For the first generation, treatment is not necessary if 20 or fewer nymphs per leaf are found. If *Anagrus* is active on eggs of the first generation, it is best not to treat unless leafhopper numbers are well above 20 per leaf. Also helpful is the removal of basal leaves before adults of the first generation appear, as described under CULTURAL CONTROL, to allow better spray coverage and thus improve efficacy of the pesticide. If you have to treat, wait until more than half the nymphs are in the third instar; this allows sufficient time for most eggs to have hatched.

For the second or third generation on wine and raisin Thompson Seedless grapes, the treatment threshold is 15 to 20 nymphs per leaf. Generally lower populations do not need treatment. However, coastal wine grapes with a low incidence of parasitism and small canopies may have a threshold of 10 to 20 nymphs per leaf. Vigorously growing vines can support higher populations.

**Table Grapes**

Treatment level is lower for table grapes because they need better fruit protection. For the first generation, treat if more than 15 leafhopper nymphs per leaf are found. In the second and third generations, early varieties (Flame Seedless) should not exceed 10 nymphs per leaf; midseason varieties (Thompson) 5 to 10 nymphs per leaf; and late varieties (Emperor) 5 to 8 nymphs per leaf. Large populations of adult leafhoppers in the fall are very annoying to workers who are hand-harvesting grapes. A treatment just before harvest may be warranted if adult populations are high.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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*The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide’s properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.*

A. IMIDACLOPRID (Admire Pro - Soil)	7–14 fl oz	12	30
(Admire Pro - Foliar)	1.0–1.4 fl oz	12	0
COMMENTS: Apply a total of 7 to 14 fl oz/acre in one or two drip irrigation applications. Two applications 21 to 45 days apart are recommended on coarse soils or where the longest periods of protection is required. Make the first application between budbreak and pea-berry stage. A total of 14 fl oz/acre is recommended where vigorous vine growth is expected or in warmer growing areas such as the Coachella, San Joaquin, or Sacramento valleys. Soil moisture is important for effectiveness; follow label instructions carefully. To protect honey bees, apply foliar sprays only during late evening, night, or early morning when bees are not present.			
B. FLUPYRADIFURONE (Sivanto 200SL - Soil)	21–28 fl oz	See label	30
(Sivanto 200SL - Foliar)	7–10.5 fl oz	See label	0
MODE-OF-ACTION GROUP NUMBER: 4D COMMENTS: Product efficacy is based on foliar trials; while the product label allows soil applications, efficacy as a soil treatment has not been confirmed in University trials.			
C. CLOTHIANIDIN (Belay - Soil)	12 fl oz	12	30
(Belay - Foliar)	2–4 fl oz	12	0
MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: Foliar and soil applied. Soil moisture is important for effectiveness; follow label instructions carefully. To protect honey bees, apply foliar sprays only during late evening, night, or early morning when bees are not present.			
D. DINOTEFURAN (Venom - Soil)	5–6 oz	12	28
(Venom - Foliar)	1–3 oz	12	1
MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: To protect honey bees, apply foliar sprays only during late evening, night, or early morning when bees are not present.			
E. BUPROFEZIN (Applaud)	9–12 oz	12	7

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
MODE-OF-ACTION GROUP NUMBER: 16 COMMENTS: An insect growth regulator; kills predatory beetles. Good coverage is essential. Use allowed under FIFRA section 2(ee) recommendation.			
F. ACETAMIPRID (Assail 70WP) MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	1.1 oz	12	3
G. THIAMETHOXAM (Platinum) MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: Soil moisture is important for effectiveness; follow label instructions carefully.	8–17 oz	12	60
H. PYRETHRIN/PIPERONYL BUTOXIDE (Pyrenone) MODE-OF-ACTION GROUP NUMBER: 3A/— COMMENTS: Spray containers with 1 pt per 150 gal water and as needed. Apply alone or in combination with a narrow range oil. Use in combination with a narrow range oil when treating first generation leafhoppers, except on table grapes. Do not use oil on later generations. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	Label rate	12	0
I. PYRETHRIN (Pyganic EC5.0II)# MODE-OF-ACTION GROUP NUMBER: 3A COMMENTS: To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	4.5–17 fl oz	12	0
J. AZADIRACTIN (Debug Turbo)# MODE-OF-ACTION GROUP NUMBER: un	16–32 fl oz	4	—
K. INSECTICIDAL SOAPS or NARROW RANGE OIL# (various products) MODE OF ACTION: Contact insecticide with smothering and barrier effects. COMMENTS: Partially effective on low leafhopper numbers if applied when nymphs are small. Research shows soap works better when combined with a low rate of oil. Care must be taken as both soap and oil can spot the waxy bloom on the berry. Do not apply sulfur within 10 days of an oil spray.	Label rates	See label	See label
L. KAOLIN CLAY (Surround WP)# MODE OF ACTION: Unknown. An inorganic insecticide. COMMENTS: An organically acceptable alternative for wine grapes.	25–50 lb	4	0

\*\* Apply with enough water to provide complete coverage.

‡ 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 R.E.I. exceeds the P.H.I. 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.

— No information

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

# LIGHT BROWN APPLE MOTH (7/15)

**Scientific Name:** *Epiphyas postvittana*

## DESCRIPTION OF THE PEST

Light brown apple moth, also known as LBAM, is an exotic pest native to Australia that has been detected in coastal California from Los Angeles to Sonoma counties. Because it is a quarantined pest with special requirements regarding movement, inspection and treatment of regulated plant materials, consult the CDFA Web site ([http://www.cdca.ca.gov/phpps/PDEP/lbam/lbam\\_main.html](http://www.cdca.ca.gov/phpps/PDEP/lbam/lbam_main.html)) or a county agricultural commissioner's office for compliance information.

In both appearance and behavior, the light brown apple moth is similar to other leafroller species in the tortricid family that occur in grapevines. The mature larval stages are pale-to-medium green with a light yellow-tan head. The first segment behind the head (prothoracic shield) is greenish brown with no dark markings. Full-grown larvae are about ½ to ¾ inch (10 to 18 mm) long. However, larvae cannot be reliably identified using morphological characters. Take captured, suspect larvae (preferably alive) to the county agricultural commissioner's office for proper identification.

The most efficient and reliable method for trapping male adults is with the use of light brown apple moth pheromone traps. There are many native tortricids that can be confused with this pest. Tortricid moths hold their wings over their abdomens in a bell shape when at rest and have protruding mouthparts that resemble a snout. Many moths have oblique markings on the wings. If you find a tortricid moth in a light brown apple moth pheromone trap, take it to your county agricultural commissioner's office for positive identification.

Depending on the climate, this pest may have from 2 to 4 generations a year. In its native range it does not survive well at high temperatures, but it does thrive in cooler areas with mild summers, moderate rainfall, and moderate-to-high humidity. Overwintering larvae do not have a winter resting stage (diapause). During the winter second- to fourth-stage larvae can be found on vegetation surrounding vineyards, on weeds or in grape mummies on the vine. Larvae may survive for up to 2 months in the winter without feeding.

Adult moths emerge after 1 to 3 weeks of pupation and mate soon after emergence. They stay sheltered in the foliage during the day, resting on leaf undersides. Females begin to lay eggs 2 to 3 days after emerging, depositing them at night on the upper side of leaves. On grapevines, eggs are normally found on fully developed leaves near the edge of the leaf blade. The eggs are typically laid in masses of 20 to 50 (but may contain up to 170 eggs), slightly overlapping each other like fish scales. Egg masses are covered with a greenish transparent coating when newly laid, but the eggs become darker as the embryo develops. Larvae emerge after 1 to 2 weeks and disperse widely on the vine. In spring the first stage larvae move to shoot tips where they web together developing leaves to form nests. The larvae feed within these shelters. Larvae may enter fruit clusters as early as bloomtime. They produce webbing along the cluster stem tying flower parts together and feed on developing berries in a manner similar to omnivorous leafroller and orange tortrix.

## DAMAGE

Overwintering larvae may feed on buds; injured buds may fail to develop further. During bloom, larvae may feed on flower clusters. After veraison, feeding damage to the berries may allow rot organisms to infect fruit.

## MANAGEMENT

Research on light brown apple moth management strategies in California has been slowed by presently imposed quarantine restrictions. Therefore, research results from other locations (Australia and New Zealand) form the basis for management guidelines, but these should be evaluated under California conditions when possible. It is probable that management strategies for this pest will be modified as local research projects proceed.

Removing mummified fruit and overwintering sites under the vines can reduce populations of these leafrollers. Well-timed spray treatments with a selective insecticide may be warranted if moths are caught in pheromone traps placed inside the vineyard and light brown apple moth larvae are seen feeding on grape clusters.

## Biological Control

General insect predators and several species of spiders may influence these leafroller populations by feeding on eggs or larvae. High mortality has been reported during the initial dispersal of the newly hatched larvae. Several parasitic wasps, *Meteorus* sp. in particular, have been recorded parasitizing light brown apple moth in California.

**Cultural Control**

Appropriate sanitation practices during the dormant season can help prevent a buildup of these leafrollers. Mow broad-leaved weeds in and around the vineyard before bud break. Remove mummified clusters when pruning and place them in the row middles to be chopped.

**Organically Acceptable Methods**

Cultural control and sprays of *Bacillus thuringiensis* and the Entrust formulation of spinosad are acceptable for use on organically certified crops.

**Monitoring and Treatment Decisions**

Pheromone lures are commercially available and may be used to monitor the presence of these moths in the vineyard.

In early spring, monitor shoots for webbing of leaves and larvae inside their nests. Follow the monitoring procedures in MONITORING CATERPILLARS, which have been developed for other vineyard leafrollers. Look for rolled leaves that appear glued to shoots. Beginning at bloom, monitor bunches for webbing and larvae. If insecticide applications are warranted, they must be applied before bunch closure.

Common name (Example trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
REVISED: 7/15			
<i>The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide’s properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.</i>			
<b>BLOOM TO BUNCH CLOSURE</b>			
A. METHOXYFENOZIDE (Intrepid 2F) MODE-OF-ACTION GROUP NUMBER: 18 COMMENTS: Do not apply more than 48 fl oz/ acre per season	10–16 fl oz	4	30
B. <i>BACILLUS THURINGIENSIS</i> ssp. <i>KURSTAKI</i> (various products) MODE-OF-ACTION GROUP NUMBER: 11A COMMENTS: Most effective on young larvae.	Label rates	4	0
C. SPINOSAD (Entrust)# (Success) MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: Do not apply more than 7.5 oz of Entrust or 29 fl oz of Success per acre per crop or make more than 6 applications per year. Do not make applications less than 5 days apart. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	1.25–2 oz 4–6 fl oz	4 4	7 7
D. CHLORANTRANILIPROLE (RYNAXYPYR) (Altacor) MODE-OF-ACTION GROUP NUMBER: 28	2.0–4.5 oz	4	14
E. SPINETORAM (Delegate WG) MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: A stomach poison; most effective when ingested. To protect honey bees, apply only during late evening, night, or early morning when bees are not present. Do not apply more than 19.5 oz/ acre per crop per year or make applications less than 4 days apart.	3–5 oz	4	7

‡ 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 R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.

# Acceptable for use on organically grown produce.

- 1 Rotate chemicals with a different mode-of-action Group number, and do not use products with the same mode-of-action Group number more than twice per season to help prevent 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/>.

## MEALYBUGS (*PSEUDOCOCCUS*) (7/15)

**Scientific Names:** Grape mealybug: *Pseudococcus maritimus*  
 Obscure mealybug: *Pseudococcus viburni*  
 Longtailed mealybug: *Pseudococcus longispinus*

### DESCRIPTION OF THE PESTS

Three species of mealybugs in the genus *Pseudococcus* may infest vineyards: the grape, obscure, and longtailed mealybugs. The primary species of concern in North Coast and San Joaquin Valley vineyards are the grape and obscure mealybugs. In Central Coast vineyards, obscure and longtailed mealybugs can cause damage. In the Coachella Valley, longtailed mealybug may occur. Vine mealybug, *Planococcus ficus*, is covered in a separate section of this publication.

#### Life Cycles

Grape and obscure mealybugs lay yellow to orange eggs within an egg sac; longtailed mealybugs give birth to live crawlers. Crawlers of all three species are yellow to orange-brown in color. The grape mealybug has two generations each year and overwinters as an egg or crawler in or near a white, cottony egg sac under loose bark and in the cordons or upper portions of the trunk. In spring most grape mealybug crawlers move toward the base of spurs, or under the loose bark of canes, and then onto expanding green shoots, reaching maturity in mid-May to early June. Most females return to old wood to lay eggs that hatch from mid-June to July. First generation crawlers then move out to the green portions of the vine to feed on fruit and foliage in late June or early July; mostly immatures are seen through July. Adult females will appear in late summer and early fall. Some females will oviposit in the fruit clusters but the majority of the females return to the old wood to lay the overwintering eggs.

Obscure and longtailed mealybugs do not diapause over the winter and have multiple overlapping generations with all life stages present on the vines year round. Obscure mealybug overwinters under the bark of the trunk, cordons, and spurs (the same as grape mealybug). In late spring some obscure mealybugs begin to feed on leaves, but the majority of the population remains hidden under the bark or in the tight clusters.

#### Appearance

Adults of all three *Pseudococcus* species are about 0.2 inch long, flat, oval shaped, and have a white waxy covering with wax filaments sticking out from circumference of the body. Longer filaments from the posterior end make these mealybugs appear to have "tails." These filaments are longer than those on the vine mealybug, a newly introduced species that is covered in a separate section.

The grape mealybug and the obscure mealybug closely resemble each other. One method of distinguishing them in the field is to gently probe a female with a sharp point (without puncturing the body) to elicit the release of a defensive excretion. If the color of the fluid excreted is reddish orange, then it is most likely grape mealybug; if it is clear, it is most likely obscure mealybug. Another distinguishing characteristic is based on the different life cycles of the two species: grape mealybug diapauses in winter and has two generations a year that do not overlap. Consequently, if only one or two life stages of a mealybug are present at a given time, it is most likely a grape mealybug because obscure mealybug does not diapause and thus all life stages are present throughout the year.

Longtailed mealybug is similar in appearance to the other two species but has much longer waxy filaments on the posterior end (they are as long or longer than the body of the adult female). Longtailed mealybugs are only a problem in Central Coast vineyards.

### DAMAGE

In recent years there have been increases in the number of grape mealybug infestations in the San Joaquin Valley and North Coast and an increase in the incidence of obscure and longtailed mealybugs in Central Coast vineyards. Susceptibility to mealybug damage varies by variety. It is worse on varieties that produce clusters close to the base of the shoot because the fruit often touches old wood. Mealybugs damage grapes by contaminating clusters with cottony egg sacs, larvae, adults, and honeydew. Often the honeydew is covered with a black sooty mold. All three species can transmit grape viruses.

### MANAGEMENT

Detecting and marking mealybug infestations during harvest is a key to monitoring populations the following season. Once established, parasites and predators can help keep populations down, but an infestation may slowly



spread unless controlled with insecticides. Leaving areas of the vineyard untreated is an effective technique to increase predator and parasitoid populations, however, under heavy population pressure, this may not be feasible. When treating mealybugs, leave at least one out of every 10 acres untreated to provide a refuge for natural enemies, or treat with an insecticide that is not toxic to parasites, see RELATIVE TOXICITIES TABLE.

Honeydew-seeking ants must be controlled in order to allow natural enemies of mealybugs to aid in mealybug control. Controlling ants may sufficiently allow parasites and predators to control mealybugs. Ant control is best accomplished either with tillage, cover crops of common vetch, or ant baits. See the section on ANTS for additional information on control.

### Biological Control

Many natural enemies play a part in the biological control of mealybugs. At least five species of parasitic wasps attack grape mealybugs in California. Little research on these parasites has been conducted, but it is assumed they play a prominent role in regulating populations. The impact of the different species varies from time to time and place to place. Grape mealybugs that are parasitized by two tiny wasps, *Acerophagus notativentris* and *Pseudophycus angelicus*, have multiple emergence holes that are easily seen with a hand lens. Ants must be controlled to keep them from interfering with these natural enemies. Two parasitic wasps, *Pseudophycus flavidulus* and *Leptomastix epona*, have been imported for release against obscure mealybugs but are not commercially available. To ensure survival of parasites, do not use disruptive insecticides during the growing season.

The most effective mealybug predators are lady beetles such as the mealybug destroyer, *Cryptolaemus montrouzieri* and *Hyperaspis* sp., which can be found in coastal regions. Cecidomyiid flies prey on mealybug eggs and small larvae. These predators plus lacewings, minute pirate bugs, and spiders are important in keeping mealybug populations in check.

### Cultural Control

If gray field ants (*Formica* spp.) are tending grape mealybug and protecting them from parasites, studies show that planting a cover crop of common vetch (*Vicia sativa*) can help reduce the number of ants present on the vines. Common vetch has an abundance of extra floral nectaries that attract the ants away from grape mealybug, thus exposing the mealybugs to parasites. In research studies, common vetch was fall seeded in a 80:20 mixture with 20% Merced rye. The cover crop established itself in late fall and winter so that by early spring it was ready to attract the ants. A heavy seeding rate (120 lb/acre) helps to ensure a good stand. The effect of other nectary-bearing cover crops on attracting ants has not been evaluated. (Research using cover crops to attract Argentine ants, *Linepithema humile*, has not been conducted.)

Training vines so that clusters hang freely and do not touch the wood can also be an effective strategy to reduce grape mealybug infestations.

### Monitoring and Treatment Decisions

Monitor mealybugs closely throughout the year. Detection and mapping of populations at harvest is important for monitoring populations the following season. If the vineyard had an infestation at harvest, monitor for mealybugs in late February to early March the following year. (This monitoring can be combined with scouting for other pests as described in DELAYED-DORMANT AND BUDBREAK MONITORING (wine/raisin grapes or table grapes)). Peel back the thin bark on spurs in the current season's prunings or loose bark on canes and look for the presence of grape mealybug crawlers.

To monitor adult activity, grape mealybug pheromone lures are available and are used in red delta traps to monitor for males. There are two grape mealybug male flights per year. Monitoring the spring flight of grape mealybug males can be used to predict the emergence of crawlers of the summer brood and to time control measures. Infestations may be spotted in both summer and winter by looking for the presence of honeydew and sooty mold. Also, look for ants on the vines because their presence is a good indication of a mealybug infestation. If ant activity is high, however, the amount of honeydew on the plant may be minimal because the ants harvest it.

Be sure to monitor parasitism by collecting mealybugs and holding them in gelatin capsules (available from pharmacies) at room temperature for 2 to 4 weeks to detect parasite emergence. If parasitism is found, leaving untreated areas of the vineyard can provide refuges in which the parasites can survive.

If monitoring indicates a small population, a single treatment in the delayed dormant period or spring may adequately control populations. For high infestation levels, treat in the early spring and in the summer. Crawlers

and young nymphs are the stages most susceptible to insecticides. Properly timed delay dormant/spring applications target these life stages.

Grape mealybug has two generations a year, with crawlers present from delayed dormancy to early spring and again in summer (June or July). *Obscure and longtailed mealybugs* do not diapause in winter and, therefore, all life stages can be present in the vines. The most effective treatment timing for these two species is in spring.

#### ***Delayed dormant and early spring treatments***

For wine and raisin grapes, if an average of one spur or cane of every five sampled (i.e. 20% or more) has crawlers, a treatment is warranted. If the insect growth regulator buprofezin is used, it should be applied when the majority of the population is in the crawler stage and before shoots are 6" long. For table grapes, the threshold is an average of one spur or cane of every 10 sampled (10% or more). Applications are best made as dilute sprays applied by a ground rig.

#### ***Spring treatments***

If an insect growth regulator was not previously used, be sure to monitor in April for immatures under the bark in cordons and spurs. Monitor for mealybugs along with other pests as outlined in MONITORING INSECTS AND SPIDER MITES. If a treatment is needed and a soil-applied neonicotinoid is chosen, select a product that is most effective on the soil type in the vineyard. Specifically, imidacloprid and clothianidin are more effective on light-textured soils, whereas thiamethoxam and dinotefuran are most efficacious on heavy soils.

#### ***Summer monitoring and treatments***

In late May/early June, examine the base of spurs for mature grape mealybug females and/or ant movement on the vine.

- Choose 20 vines from different areas of the vineyard.
- Inspect 1 spur per vine to determine how many of the 20 vines are infested. Note that ant movement and honeydew are signs of mealybug presence.
- Record each vine that has a spur with grape mealybug on a monitoring form (*example form available online*).
- Treatment may be warranted if 20% or more of the spurs on wine and raisin vines are infested with female grape mealybug; the threshold for table grapes is 4%.
- Be sure to monitor parasitism by collecting mealybugs and holding them in gelatin capsules at room temperature for 2 to 4 weeks to detect parasite emergence. If parasitism is found, untreated areas of the vineyard can provide refuges for parasites.

#### ***Cluster monitoring***

Clusters that touch old wood can also be monitored during the period from June 15 to July 15. If no crawlers are detected in the clusters, little or no infestation is present. If a single treatment is applied in summer, make a foliar application in June, 1 to 2 weeks after egg hatch. Be sure to make summer treatments when mealybugs are small and vulnerable; once they are more than half-grown, foliar treatments may not be effective.

For raisin and wine grapes, dilute applications can be made, however after veraison on table grapes make concentrate foliar applications to avoid berry spotting. It is important to note that once mealybugs have moved into the clusters and after bunches in wine grape varieties have closed, foliar treatments are not effective. *Educate field workers or harvest crew to recognize mealybug cluster infestations and flag the vines for treatment.*

#### **Postharvest Treatments**

Postharvest treatments are not effective against *Pseudococcus* mealybugs because the majority of the population is in the egg stage under the bark and not vulnerable to foliar treatments at this time.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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*The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.*

**EARLY SPRING (UP TO 6-INCH SHOOT GROWTH)**

- |  |          |    |    |
|--|----------|----|----|
| A. BUPROFEZIN<br>(Applaud)   | 12–24 oz | 12 | 30 |
| MODE-OF-ACTION GROUP NUMBER: 16  |          |    |    |
| COMMENTS: An insect growth regulator. Buprofezin targets early stage nymphs on the vine that are exposed and still moving around before they settle under the bark to feed. Apply when shoots have 6 inch of growth. Good coverage is essential. Tank mixes are not recommended. Do not apply more than 24 oz per season. Buprofezin may be harm the mealybug destroyer ( <i>Cryptolaemus montrouzieri</i> ) when applied during the summer. |          |    |    |

**LATE SPRING**

- |   |               |    |    |
|---|---------------|----|----|
| A. SPIROTETRAMAT<br>(Movento)   | 6–8 fl oz     | 24 | 7  |
| MODE-OF-ACTION GROUP NUMBER: 23   |               |    |    |
| COMMENTS: A foliar insecticide that is absorbed by the leaves and moves systemically in the phloem and xylem. Use with a non-ionic surfactant. Sufficient leaf canopy must be present for uptake and translocation. It takes about 4 weeks after treatment to see the full effect. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.  |               |    |    |
| B. IMIDACLOPRID<br>(Admire Pro - Soil)  | 7–14 fl oz    | 12 | 30 |
| (Admire Pro - Foliar)   | 1.0–1.4 fl oz | 12 | 0  |
| MODE-OF-ACTION GROUP NUMBER: 4A   |               |    |    |
| COMMENTS: Efficacy of soil-applied neonicotinoids depends on soil texture. Imidacloprid binds readily to certain soil particles, has low water solubility, and long persistence (months). These characteristics allow it to be very effective in light soils, but ineffective in heavy soils. When the soil is rewetted and plant roots are actively absorbing water, the insecticide is also absorbed by roots. Best when applied in a drip irrigation system; otherwise, French plow the soil, apply as a ground spray, and immediately irrigate. Apply 7 to 14 fl oz/ acre in one or two drip irrigation applications. On coarse soils or where the longest period of protection is required, make two applications. Make the first application from bloom through the pea-sized berry stage and the second 21 to 45 days later, keeping in mind the preharvest interval. The full rate of 14 oz/ acre is recommended where vigorous vine growth is expected or in warmer growing areas such as the San Joaquin or Sacramento valleys or where mealybug numbers are high. Do not exceed 0.5 lb a.i. of imidacloprid/ acre per year. Adequate soil moisture is important at the time of application; follow label instructions carefully. To protect honey bees, apply foliar sprays only during late evening, night, or early morning when bees are not present. |               |    |    |
| C. CLOTHIANIDIN<br>(Belay - Soil)   | 6–12 fl oz    | 12 | 30 |
| (Belay - Foliar)  | 6 fl oz       | 12 | 0  |
| MODE-OF-ACTION GROUP NUMBER: 4A   |               |    |    |
| COMMENTS: Efficacy of soil-applied neonicotinoids depends on soil texture. Clothianidin has low water solubility, medium capacity to bind onto soil particles, and moderate to long persistence (weeks to months). Studies indicate it is effective in light soils. Adequate soil moisture is important at the time of application; follow label instructions carefully. To protect honey bees, apply foliar sprays only during late evening, night, or early morning when bees are not present.  |               |    |    |
| D. DINOTEFURAN<br>(Venom - Soil)  | 6 oz          | 12 | 28 |
| (Venom - Foliar)  | 1–3 oz        | 12 | 1  |
| MODE-OF-ACTION GROUP NUMBER: 4A   |               |    |    |
| COMMENTS: Efficacy of soil-applied neonicotinoids depends on soil texture. Dinotefuran has very high water solubility, low capacity to bind onto soil particles, and short to moderate persistence (days to weeks). Studies indicate it is moderately effective in heavy soils. Adequate soil moisture is important at the time of application; follow label instructions carefully. To protect honey bees, apply foliar sprays only during late evening, night, or early morning when bees are not present.  |               |    |    |

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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E. THIAMETHOXAM (Platinum)	17 oz	12	60
MODE-OF-ACTION GROUP NUMBER: 4A			
COMMENTS: Efficacy of soil-applied neonicotinoids depends on soil texture. Thiamethoxam has high water solubility, medium capacity to bind onto soil particles, and short to medium persistence (days to weeks). Studies indicate this is the most effective neonicotinoid for heavy soils. Adequate soil moisture is important at the time of application; follow label instructions carefully.			

**SUMMER**

**Note:** Make applications before mealybugs move into clusters and before bunches in wine grape varieties have closed.

A. BUPROFEZIN (Applaud)	12-24 oz	12	30
MODE-OF-ACTION GROUP NUMBER: 16			
COMMENTS: An insect growth regulator. Buprofezin targets early stage nymphs on the vine that are exposed and still moving around before they settle under the bark to feed. Apply when summer brood crawlers are present. Good coverage is essential. Tank mixes are not recommended. Do not apply more than 24 oz per season. Buprofezin may harm the mealybug destroyer ( <i>Cryptolaemus montrouzieri</i> ) when applied during the summer.			

\*\* Apply with enough water to provide complete coverage.

‡ 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 R.E.I. exceeds the P.H.I. 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/>.

# OMNIVOROUS LEAFROLLER (7/15)

**Scientific Name:** *Platynota stultana*

## DESCRIPTION OF THE PEST

The adult omnivorous leafroller is bell-shaped with blackish gray snoutlike mouthparts that protrude forward from the head. Forewings are dark rusty brown with tan tips. Size varies from 0.38 to 0.5 inch long. Omnivorous leafroller overwinters in the larval stage in grape mummies, vineyard weeds, and other trash in the vineyard. In spring, larvae complete their development and moths emerge and lay shinglelike egg masses on grape leaves. After about 5 days these eggs hatch, and larvae web two young leaves together to form a nest in which they feed. Unlike the grape leafroller, it does not roll leaves; instead, it ties leaves together and feeds inside. Later, nests can be found in flower clusters (May) and bunches (June-Sept.), as well as on leaves and in shoot tips.

Omnivorous leafroller larvae are often confused with grape leafrollers. Omnivorous leafrollers can have either a black or brown head capsule, depending on the instar. Mature larvae range in color from cream to brownish green with whitish slightly convex tubercles on the top of the abdomen. The grape leafroller does not have whitish tubercles. In addition, omnivorous leafroller larvae usually drop to the ground on a thread when disturbed, rather than dropping directly, as is the case with the grape leafroller.

Generally, there are four flight periods each year with a partial fifth in warmer years. Adult flights generally occur in spring (Feb-April), late May, mid-July, and late August or early September. The first of five larval instars appears a short time after a flight starts.

## DAMAGE

The omnivorous leafroller can cause serious damage in California's Central Valley and coastal vineyards. Although it does feed on leaves, flowers, and developing berries, the most significant damage occurs after veraison when feeding allows rot organisms to enter fruit at the damage sites.

## MANAGEMENT

Populations are usually small in spring and early summer but may increase greatly later in summer and cause severe berry rot problems. The increase may be a result of migration triggered by the drying out of weed plant hosts. Consequently, cultural control is an important component in managing this pest. Spring treatments are recommended if the vineyard has a history of problems with this pest. Otherwise chemical treatments are necessary only when monitoring indicates a need.

### Biological Control

More than 10 species of parasites have been recorded from omnivorous leafroller larvae. However, seldom does mortality from these parasites exceed 10%. Predators such as lacewings, minute pirate bugs and spiders feed on young omnivorous leafroller larvae.

### Cultural Control

During the dormant season control vineyard weeds and prune out old fruit mummies and destroy by flailing or shredding. French plow and disc clusters and weeds to bury overwintering larvae living on weeds in ground duff and dried berries. Early harvest can also prevent infestation by fourth generation larvae. Removing basal leaves will also improve coverage and efficacy of cryolite, *Bacillus thuringiensis*, and other pesticides. In warmer growing areas, be careful not to remove excessive numbers of leaves, which can lead to sunburned fruit.

### Organically Acceptable Methods

Cultural and biological controls and sprays of *Bacillus thuringiensis* and the Entrust formulation of spinosad are acceptable on organically certified grapes.

### Monitoring and Treatment Decisions

Treat for omnivorous leafroller at bloom if the vineyard has a history of this pest or if a serious infestation occurred in the previous season. Otherwise, monitor to determine the need for treatment. Monitor along with other caterpillars as outlined in MONITORING CATERPILLARS; record results on a monitoring form (*example form available online*).

Acceptable damage levels at harvest are about 1-2% for raisin grapes and less for wine and table grape varieties. Trying to reduce damage any further than this threshold would probably not be cost effective.

Thorough coverage with spray applications is extremely important to protect the berries. Such coverage is difficult in tight bunches so make a major effort to control this pest before bunch closure. Improved coverage and efficacy of pesticides can be obtained by removing basal leaves, see CULTURAL CONTROL. In Central Valley and other warm inland valley vineyards, use pheromone traps, degree-day models, and monitoring to assess omnivorous leafroller populations.

**Pheromone traps**

Place pheromone traps in the vineyard just before budbreak, and check traps twice a week. Information obtained from trap catches is used to establish a biofix, which is an identifiable point in the life cycle of this pest. For omnivorous leafroller, the biofix is the first night moths are consistently caught in traps. Continue to monitor with pheromone traps through fruit set, until berries are pea-sized, to track adult flights of subsequent generations. For information on placing and monitoring traps in a vineyard, see PHEROMONE TRAPS.

**Degree-days**

Once biofix is reached, begin accumulating degree-days from the biofix using a lower threshold of 48°F and an upper threshold of 87°F. (For assistance in calculating degree-days, see Degree-days" on the UC IPM Web site). When 500 degree-days have accumulated, egg hatch starts, and it is time to sample clusters.

**Monitoring**

At bloom, monitor 200 flower clusters (10 clusters in the middle of 20 vines) to determine if omnivorous leafroller is present. If you find any omnivorous leafrollers or damage, treat.

Following bloom, if there is a cover-crop or abundant weeds, use a sweep-net to sample for larvae or thoroughly inspect the weeds. If larvae are found in the weeds but not in the grape clusters, start sampling clusters intensively for second-generation larvae at 300 degree-days after the 2nd flight biofix (minimum of once a week and sample 200 clusters). Treatments are warranted if more than 1% of the clusters have omnivorous leafroller larvae or nests. Because of the additional foliage at this time (late June-early July), apply second generation treatments at a slow speed (max. 3 mph) to achieve adequate coverage of the clusters.

If surrounding crops harbor omnivorous leafroller moths, a 3rd generation treatment might be necessary. Monitor table grapes at harvest for omnivorous leafroller damage to assess this year's management program and to plan for next year.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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REVISED: 7/15

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

**FIRST GENERATION**

A. CRYOLITE (Kryocide)	6–8 lb	12	30
(Prokil Cryolite 96)	6–8 lb	12	30
MODE-OF-ACTION GROUP NUMBER: 8C			
COMMENTS: Wine, table, and raisin: two applications maximum. Ground application only. If used on wine grapes or grapes that may be sold to a winery for export, observe their restrictions on postbloom applications. Early-season treatment effectively reduces numbers and does not cause outbreaks of pest mites and leafhoppers. Can provide season-long control of low-to-moderate numbers. Good coverage of clusters is critical. Cryolite is a stomach poison that must be ingested to be effective.			
B. METHOXYFENOZIDE (Intrepid 2F)	10–16 fl oz	4	30
MODE-OF-ACTION GROUP NUMBER: 18			
COMMENTS: Do not apply more than 48 fl oz/ acre per season. Early-season treatment effectively reduces numbers and does not cause outbreaks of pest mites and leafhoppers.			

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
C. CHLORANTRANILIPROLE (RYNAXYPYR) (Altacor) MODE-OF-ACTION GROUP NUMBER: 28	2.0–4.5 oz	4	14
D. SPINOSAD (Entrust)# (Success) MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: Apply when eggs first hatch to target young larvae. A stomach poison; most effective when ingested. Heavy infestations may require a second application in 4 or 5 days. Early-season treatment effectively reduces numbers and does not cause outbreaks of pest mites and leafhoppers. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	1.25–2.5 oz 4–8 fl oz	4 4	7 7
E. SPINETORAM (Delegate WG) MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: A stomach poison; most effective when ingested. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	3–5 fl oz	4	7
F. <i>BACILLUS THURINGIENSIS</i> ssp. <i>KURSTAKI</i> # (various products) MODE-OF-ACTION GROUP NUMBER: 11A COMMENTS: Only effective against young larvae. A stomach poison that must be ingested by the leafroller to be effective; good coverage is essential. Has a short residual so is most effective when applied 3 or 4 days before leafrolling by the main brood.	Label rates	4	0

**SECOND/THIRD GENERATION**

A. METHOXYFENOZIDE (Intrepid 2F) MODE-OF-ACTION GROUP NUMBER: 18 COMMENTS: Do not apply more than 48 fl oz/ acre per season.	10–16 fl oz	4	30
B. CHLORANTRANILIPROLE (RYNAXYPYR) (Altacor) MODE-OF-ACTION GROUP NUMBER: 28	2.0–4.5 oz	4	14
C. SPINOSAD (Entrust)# (Success) MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: Apply when eggs first hatch to target young larvae. A stomach poison; most effective when ingested. Heavy infestations may require a second application in 4 or 5 days. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	1.25–2.5 oz 4–8 fl oz	4 4	7 7
D. SPINETORAM (Delegate WG) MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: A stomach poison; most effective when ingested. To protect honey bees, apply only during late evening, night, and very early morning when bees are not present.	3–5 fl oz	4	7
E. <i>BACILLUS THURINGIENSIS</i> ssp. <i>KURSTAKI</i> # (various products) MODE-OF-ACTION GROUP NUMBER: 11A COMMENTS: Two applications 10 to 14 days apart on low-to-moderate levels of summer broods is effective if the first brood was treated. Only effective against young larvae. Is not harmful to predatory mites.		Label rates	4 0

\*\* Apply with enough water to provide complete coverage.

‡ 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 R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.

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

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
# 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 <a href="http://www.irac-online.org/">http://www.irac-online.org/</a> .			



# ORANGE TORTRIX (7/15)

**Scientific Name:** *Argyrotaenia franciscana* (= *A. citrana*)

## DESCRIPTION OF THE PEST

Although orange tortrix is found in other areas it is generally considered a pest of grapes in the coastal areas and valleys where there is a marine influence for part of the day. At rest the orange tortrix adult is bell shaped and about 0.5 inch (12 mm) long. The female is orange-brown and generally has a faint V-shaped marking located midwing. The male is similar to the female except that it has darker markings. Eggs are laid in overlapping masses. The straw-colored caterpillars have a tan head and prothoracic shield. They are about 0.5 inch (12 mm) long when mature and very active. If disturbed, they wriggle sideways or backwards and either drop to the ground or hang by a silken thread. There are three overlapping generations per year and all developmental stages of this pest can be present throughout the growing season.

The garden tortrix, *Ptycholoma peritana*, frequently appears in orange tortrix traps and can be distinguished from orange tortrix by the dark brown diagonal stripe on the forewings that create a chevron pattern when the moth is at rest. The chevron pattern on the garden tortrix is darker than that of the orange tortrix. Garden tortrix also has a light-colored margin on the edge of the chevron, which orange tortrix lacks.

## DAMAGE

Orange tortrix causes the same kind of damage as the omnivorous leafroller in inland areas. Overwintering larvae feed on any soft, exposed vine tissue, weeds, and in grape mummies on the vine. Early spring feeding may occur on developing buds. During rapid shoot growth larvae feed within webbed leaves near the shoot tip. Larvae enter the clusters as early as bloom time and make nests of webbing among the berries. Besides injury to leaves and berry stems, their feeding on berries allows entry of bunch rot disease organisms.

## MANAGEMENT

If orange tortrix is a problem, encourage biological control by the judicious use of insecticides, clean up the vineyard during the dormant period as described under cultural control and, if treatments are necessary, spot treat when possible, and ensure thorough coverage of vines.

### Biological Control

In coastal vineyards the dominant parasite of orange tortrix is *Exochus nigripalpus subobscurus*. The adult *Exochus* wasp is about 0.25 inch (6 mm) long, with a black head and body and yellow legs. This internal larval parasite emerges after the larva pupates and can be detected by the presence of round emergence holes on the pupal case. Moderate to heavy parasitism in late spring has resulted in season-long biological control in coastal vineyards. There are indications that coyote brush grown near vineyards in the Salinas Valley will increase parasitism by this parasite by allowing the parasite to overwinter on orange tortrix and other hosts found in the coyote brush. At least three other wasp species and one parasitic fly are known to attack orange tortrix.

Spiders are often found in orange tortrix nests and undoubtedly feed on larvae.

### Cultural Control

Clean up the vineyard during the dormant period. During winter, larvae are often found in weeds such as mallow (cheeseweed), curly dock, mustards, filaree, lupine, and California poppy. Vineyard cover crops of oats and barley are also attractive to this pest. Remove dried grape clusters on vines, and disc weeds and clusters on the ground. Do this work at least a month before shoots begin to develop in spring. Damage can often be prevented by harvesting as early as possible.

### Organically Acceptable Methods

Cultural and biological controls and sprays of *Bacillus thuringiensis* and the Entrust formulation of spinosad are organically acceptable management tools.

### Monitoring and Treatment Decisions

Check vineyard areas that have a history of infestation or where infestation is suspected. See MONITORING CATERPILLARS section for monitoring procedures. Check varieties with compact clusters, developing shoots, flowers, or fruit clusters. Examine 10 flower clusters in the center of each of 20 vines for a total of 200 clusters. Look for rolled leaves that are webbed to shoots. Also look for evidence of parasitism. Record results on a monitoring form (*example form available online*). Later in the season, look for orange tortrix larvae and webbing

inside fruit clusters. If you find an average of 0.5-1 larva/vine, treatment may be warranted if parasites are not present. If the infestation is not widespread, spot treatments can be used. Inside coverage of clusters is essential; treat both sides of the row.

**Pheromone traps**

Pheromone traps for this pest are available and are useful to follow flights and time subsequent treatments in coastal vineyards. Place pheromone traps in the vineyard in late December. Low-trap catches at the end of January to early February represent the beginning of adult emergence, which will give rise to the first generation. Be sure to distinguish orange tortrix from garden tortrix, which may also be caught in traps but is not a pest. Garden tortrix has a light-colored margin along the forward edge of the dark stripe that forms a chevron pattern when the wings are at rest and a dark, crescent-shaped spot on the distal edge of each forewing. Use the low trap catches in late January through early February as the biofix (identifiable point in the life cycle) to start accumulating degree-days; low trap catches represent the beginning of adult emergence. Monitoring with pheromone traps after biofix will provide more information about subsequent generations of orange tortrix in the vineyard. For information on placing and monitoring pheromone traps, see PHEROMONE TRAPS.

**Degree-days**

Use degree-day accumulation, with a lower threshold of 43°F and an upper threshold of 78°F, from the date of lowest moth catch to predict the subsequent stages of the insect's life cycle. (For assistance in calculating degree-days, see "Degree-days" on the UC IPM Web site at <http://www.ipm.ucdavis.edu>.) Allowing 1,000±50 degree-days to accumulate after the date of lowest trap catch in late January/early February and in early June will indicate the timing of applications for control of the first and second generations.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
REVISED: 7/15			
<i>The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.</i>			
<b>BERRY SET TO BUNCH CLOSURE</b>			
A. METHOXYFENOZIDE (Intrepid 2F) MODE-OF-ACTION GROUP NUMBER: 18 COMMENTS: Do not apply more than 48 fl oz/acre per season.	10–16 fl oz	4	30
B. CHLORANTRANILIPROLE (RYNAXYPYR) (Altacor) MODE-OF-ACTION GROUP NUMBER: 28	2.0–4.5 oz	4	14
C. SPINOSAD (Entrust)# (Success) MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: Apply when eggs first hatch to target the young larvae. A stomach poison; most effective when ingested. Heavy infestations require a second application in 4 or 5 days. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	1.5–2.5 oz 4–8 fl oz	4 4	7 7
D. SPINETORAM (Delegate WG) MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: A stomach poison; most effective when ingested. To protect honey bees, apply only during late evening, night, or early morning when bees are not present. Do not apply more than 19.5 oz/acre per crop per year or make applications less than 4 days apart.	3–5 fl oz	4	7

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
E. CRYOLITE (Kryocide) (Prokil Cryolite 96) MODE-OF-ACTION GROUP NUMBER: 8C COMMENTS: Wine, table, and raisins: 2 applications maximum. Ground application only. If used on wine grapes or grapes that may be sold to a winery for export, observe their restrictions on postbloom applications. Early-season treatment effectively reduces numbers and does not cause outbreaks of pest mites and leafhoppers. Can provide season-long control of low-to-moderate numbers. Good coverage of clusters is critical. Cryolite is a stomach poison that must be ingested to be effective.	6–8 lb 6–8 lb	12 12	30 30
F. <i>BACILLUS THURINGIENSIS</i> ssp. <i>KURSTAKI</i> # (various products) MODE-OF-ACTION GROUP NUMBER: 11A COMMENTS: Works best when 2 applications are applied 10 days apart in dry, warm weather during spring when shoots are less than 18 inches long and orange tortrix is found rolling leaves at the tip of shoots. Good coverage is critical. Not as effective later in season when larvae are in the fruit bunches. Not harmful to predatory mites.	Label rates	4	0

\*\* Apply with enough water to provide complete coverage.

‡ 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 R.E.I. exceeds the P.H.I. 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.irc-online.org/>.

## PACIFIC COAST WIREWORM (CLICK BEETLE) (7/15)

**Scientific Name:** *Limonius canus*

### DESCRIPTION OF THE PEST

Adults of the Pacific Coast wireworm are about 0.5 inch (13 mm) long, reddish brown to black, with a prothorax that has pointed posterior tips. They are commonly known as click beetles because, if held, they will bend their body backwards and then quickly straighten it to create an audible snap.

The larval stage of this insect lives in the soil and is commonly referred to as a wireworm. Wireworms have hard bodies that are slender, cylindrical yellowish to brown in color, and about 0.75 inch long when full grown. It takes about 3 to 4 years for the wireworm or click beetle to complete its life cycle. Most of the time is spent in the larval stage, but all stages may be present at once. In grapes, the larval stage is not considered a pest whereas the adult click beetle can be damaging.

### DAMAGE

The click beetle can feed on buds in spring. The injury to the bud looks essentially the same as that of the grape bud beetle. Unlike the grape bud beetle and the cutworm, the click beetle is a day feeder. Overwintering in the ground litter, it emerges in spring on warm days. Click beetles are often seen in large numbers resting on cover crops during the day. Even with these high populations in the vineyards, they seldom cause economic damage to grapes.

### MANAGEMENT

No material is registered for use on this pest; however, click beetles usually occur in conjunction with cutworm infestations and it has been observed that the spray materials used for cutworms also control click beetles.

## SHARPSHOOTERS (4/19)

**Scientific Names:** Blue-green sharpshooter: *Graphocephala atropunctata*  
 Glassy-winged sharpshooter: *Homalodisca vitripennis* (= *H. coagulata*)  
 Green sharpshooter: *Draeculacephala minerva*  
 Red-headed sharpshooter: *Xyphon* (= *Carneocephala*) *fulgida*

### DESCRIPTION OF THE PESTS

Sharpshooters are in the same insect family as leafhoppers (Cicadellidae).

#### Blue-green Sharpshooter

The blue-green sharpshooter has green to bright blue wings, head, and thorax, and yellow legs and abdomen, which are visible on the underside. It is about 0.4 inches long. In California they are found in coastal regions near riparian and landscaped areas.

The blue-green sharpshooter feeds, reproduces, and is often abundant on cultivated grape. It also feeds and reproduces on many other plants but prefers woody or perennial plants such as wild grape, blackberry, elderberry, and stinging nettle. Mugwort, which is a perennial, is a major breeding host. The blue-green sharpshooter is most common along stream banks or in ravines or canyons that have dense growth of trees, vines, and shrubs. It can also be abundant in ornamental landscaping. Because it feeds on succulent new growth in areas of abundant soil moisture and shade, it is seldom found in unshaded, dry locations but also finds plants in constant deep shade unattractive.

The blue-green sharpshooter has one generation a year in most of California and a second generation in some parts of the state. They overwinter in riparian vegetation. In late winter and early spring, adults become active, and a small percentage begin moving into nearby vineyards for feeding and egg laying starting just after budbreak. Their movement into vineyards increases as natural vegetation dries up. Eggs hatch from May through July. Some of the nymphs become adults by mid-June, and the number of young adults continues to increase through July and August. In August when grape foliage is less succulent, blue-green sharpshooters begin to move back to nearby natural habitats. Populations of blue-green sharpshooter are always larger in natural vegetation than in vineyards.

#### Glassy-winged Sharpshooter

The glassy-winged sharpshooter is a large insect compared to the other leafhoppers. Adults are about 0.5 inch long and are generally dark brown to black when viewed from the top or side. The abdomen is whitish or yellow. The head is brown to black and covered with numerous ivory to yellowish spots. These spots help distinguish glassy-winged sharpshooter from a close relative, smoke-tree sharpshooter (*H. lacerata*), which is native to the desert region of southern California and slightly smaller in size. The head of the smoke-tree sharpshooter is covered with wavy, light-colored lines, rather than spots. Immature stages (nymphs) of the glassy-winged sharpshooter are smaller than the adult, wingless, uniform olive-gray in color, and have prominent bulging eyes.

Females lay their eggs in masses of up to 28 in the lower leaf surface of young leaves that have recently expanded. When it is first laid, the egg mass appears as a greenish blister on the leaf. The female covers the leaf blister with a secretion that resembles white chalk, making it easy to see. Shortly after egg hatch, the leaf tissue that contained the egg mass begins to turn brown. The dead leaf tissue remains as a permanent brown scar.

Nymphs emerge in 10 to 14 days and proceed to feed on leaf petioles, small stems, and leaves while they progress through five molts before becoming winged adults. There are two generations a year.

Glassy-winged sharpshooter has become established in most of southern California and in the Central Valley from Bakersfield to Fresno. It occurs in unusually high numbers in citrus and avocado groves and on numerous kinds of plants in irrigated ornamental landscapes, riparian areas, and native woodlands.

#### Green Sharpshooter and Red-headed Sharpshooter

The green sharpshooter prefers lush dairy pastures, permanent grasses, and areas that are continually irrigated. They favor watergrass, bermudagrass, Italian rye, perennial rye, and fescue as host plants. Red-headed sharpshooters feed and breed only in areas where bermudagrass grows. Grapes are incidental hosts of these grass-feeding sharpshooters. In central California, insect movement is usually to the east (downwind at dusk) of pastures, weedy hay fields, or other grassy areas. The presence of neighboring hay fields or permanent pastures should be considered when planting a vineyard.

The green and red-headed sharpshooters have three generations per year. They overwinter as adults and lay eggs from late February to early March. The overwintering adults do not live long, thus it is probably the second generation that moves into the vineyard.

## DAMAGE

Sharpshooter feeding does not cause damage in grape; however, these insects vector the bacterium *Xylella fastidiosa*, which causes Pierce's disease in grapes. The blue-green sharpshooter is the most important vector of *Xylella fastidiosa* in coastal grape-growing areas; green, willow, and red-headed sharpshooters are also present. The glassy-winged sharpshooter is the primary vector in the Coachella Valley, Temecula, and southern San Joaquin Valley. In areas of the Central Valley where the glassy-winged sharpshooter is not present, the green and red-headed sharpshooters are the primary vectors.

When sharpshooters feed on vines, they inject the bacterium, which multiplies in the water-conducting system and causes water stress of the plant. Symptoms from early spring infections may become visible by fall of the year infected, but that is variety dependent. In vines infected the previous year, budbreak will be delayed or absent in spring, and leaf scorch appears by early summer and increases through fall, causing clusters to dry. Early-season infections (March-May) are more likely than late-summer infections to survive the following winter and become chronic. *Xylella fastidiosa* can kill vines 1 to 3 years after infection.

The glassy-winged sharpshooter feeds much lower on the shoot in summer than do the other sharpshooter vectors in California. It also feeds at the base of second-year canes, which may increase the number of late-season infections that survive the winter and become chronic infections. Feeding by this sharpshooter also occurs during winter on one- to two-year old vines, leading to transmission of the bacterium even during dormancy. If the inoculum enters the wood below where winter pruning cuts are made, the feeding can lead to chronic infections. Rather than the generally linear increase in Pierce's disease incidence over several years that has been experienced where other sharpshooters are the vectors, glassy-winged sharpshooter may exponentially increase the rate of vine-to-vine spread of Pierce's disease during a single season. Growers should try to reduce numbers of glassy-winged sharpshooter whenever they are present in vineyards.

## MANAGEMENT

Pierce's disease control is based entirely on preventing infection. Do not allow vectors to enter vineyards from areas adjacent to vineyards, especially during spring months. In vineyards subject to influxes of glassy-winged sharpshooter, immediately remove vines with Pierce's disease as soon as symptoms become apparent. Vineyards within 0.5 to 1 mile of citrus or avocado groves are at greatest risk.

Insecticide treatments aimed at controlling the vector in areas adjacent to the vineyard have reduced the incidence of Pierce's disease by reducing the numbers of sharpshooters immigrating into the vineyards in early spring. The degree of control, however, is not effective for very susceptible varieties such as Chardonnay and Pinot Noir or for vines less than 3 years old. If a vineyard is near an area with a history of Pierce's disease, use varieties that are less susceptible to this disease.

### Monitoring and Treatment Decisions for Blue-green and Glassy-winged Sharpshooters

The best time to start assessing the need for managing the blue-green or glassy-winged sharpshooters is at budbreak. Monitoring at this time will enable you to observe movement of sharpshooters into your vineyard from surrounding vegetation.

- Monitor for glassy-winged sharpshooter in all vineyards through late summer.
- Monitor blue-green sharpshooter in coastal vineyards and in vineyards with a history of problems until late May or 1 month after treatment.
- From May to July, make visual searches and sample with a sweep net in riparian areas or ornamental landscapes adjacent to the vineyard.

#### To monitor for sharpshooters:

- In late February just before budbreak, place several double-sided yellow sticky traps (at least 4x7 inches for blue-green sharpshooters and 9x11 for glassy-winged sharpshooter) in areas adjacent to vineyards that serve as habitat for sharpshooters, such as riparian areas and ornamental landscapes.
- In the vineyard place a minimum of 6 traps per block, 100-200 feet apart for blue-green sharpshooters. Be sure that some of the traps are placed 50 feet within the vineyard perimeter. For glassy-winged sharpshooter,

place one trap per 10 acres within 30 feet of the vineyard perimeter, especially on edges adjacent to alternate hosts such as citrus.

- Check traps once per week beginning at budbreak and more frequently after 2-3 days of warm weather. Continue to monitor traps for blue-green sharpshooters until late May or for a month after treatment. Monitor traps for glassy-winged sharpshooters throughout the season until daytime temperature remains below 65°F.
- Remove insects from the trap after counting and recording on a monitoring form (*example form available online*).
- Replace traps every 2 weeks or when they become excessively dirty or discolored and especially on edges adjoining other alternate glassy-winged sharpshooter hosts such as citrus.

*Treatment is warranted for blue-green sharpshooters if:*

- After successive warm days above 70°F, there is a sharp increase in the number of sharpshooters trapped.
- More than an average of 7 are caught per trap/week in riparian or ornamental habitats.
- Visual inspections reveal more than 1 sharpshooter/vine.

*Treatment is warranted for glassy-winged sharpshooters if:*

- They are present in the vineyard.

**Blue-green sharpshooters**

Treat vegetation along the edges of the vineyard where sharpshooters are observed. If sharpshooters have migrated into the vineyard and new shoot growth on grapevines is longer than a few inches, also treat the first 200 to 300 feet in from the edge of the vineyard. Replace traps after spraying and continue monitoring traps and vegetation. Respray if trap catches indicate another population increase. The goal is to eliminate more than 95% of the vector population.

Riparian vegetation management has proven to be effective in reducing the damaging spring populations of blue-green sharpshooters. Because these areas are ecologically sensitive and regulated by federal, state, and local legislation, the unauthorized removal of vegetation is prohibited or restricted. Vegetation management of these areas must be acceptable or beneficial for wildlife and water quality and maintain the integrity of the riparian habitat. For additional information, contact the California Department of Fish and Game for current regulations and guidelines. For more information, see the complete *Riparian Vegetation Management for Pierce’s Disease in North Coast California Vineyards* online at [http://nature.berkeley.edu/almeidalab/wp-content/uploads/2016/07/PD\\_Riparian\\_Vegetation\\_Manual.pdf](http://nature.berkeley.edu/almeidalab/wp-content/uploads/2016/07/PD_Riparian_Vegetation_Manual.pdf).

**Glassy-winged sharpshooter**

In addition to trap monitoring, do visual searching to monitor for eggs, nymphs, and adults. Combine the visual search with leafhopper and mite sampling. Management of glassy-winged sharpshooter in vineyards adjacent to other host crops is best if done on an areawide basis. This approach relies on monitoring agricultural crops, vineyards, and other plant species, and treatment of overwintering hosts. Apply insecticide treatment to vineyards if any glassy-winged sharpshooter life stage is discovered in a vineyard or if there is a potential for movement of this pest into the vineyard.

**Monitoring and Treatment Decisions for Green and Red-headed Sharpshooters**

In the Central Valley, insecticide treatments for these sharpshooters are of little value overall because overlapping generations result in the continuous presence of eggs inside protective leaf tissues of host plants from February through fall. Sprays are not effective against eggs. In alfalfa fields, orchards, or field-crop areas, the grass weeds growing in or at the margins of the crop support green sharpshooter populations, and red-headed sharpshooter populations are supported in areas with bermudagrass. Eliminate weedy grasses whenever possible. Monitor with a sweep net areas of grass weeds that are adjacent to the vineyard and cannot be eliminated. (Green and red-headed sharpshooters are not attracted to yellow sticky traps and must therefore be monitored with a sweep net.) An average catch of two or more sharpshooters per 50 sweeps in a total of 400 sweeps is cause for concern. About all that can be done is to try to purchase or lease adjacent properties and manage them so that sharpshooter populations do not build up.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
<i>The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.</i>			
A. IMIDACLOPRID (Admire Pro - Soil) (Admire Pro - Foliar) COMMENTS: Foliar imidacloprid kills sharpshooters fast but only for about 2 weeks. Soil-applied imidacloprid provides a slower kill but remains effective longer. To protect honey bees, apply foliar sprays only during late evening, night, or early morning when bees are not present.	7–14 fl oz 1.0–1.4 fl oz	12 12	30 0
B. FLUPYRADIFURONE (Sivanto 200SL - Soil) (Sivanto 200SL - Foliar) MODE-OF-ACTION GROUP NUMBER: 4D COMMENTS: Product efficacy is based on foliar trials; while the product label allows soil applications, efficacy as a soil treatment has not been confirmed in University trials.	21–28 fl oz 7–10.5 fl oz	See label See label	30 0
C. ACETAMIPRID (Assail 70WP) MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	1.1 oz	12	3
D. CLOTHIANIDIN (Belay - Soil) (Belay - Foliar) MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: Soil moisture is important for effective soil application; follow label instructions carefully. For foliar application, to protect honey bees, apply only during late evening, night, or early morning when bees are not present. Do not spray directly nor allow drift onto blooming crops or weeds where bees are foraging.	12 fl oz 4–6 fl oz	12 12	30 0
E. DINOTEFURAN (Venom - Soil) (Venom - Foliar) MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: Soil moisture is important for effectiveness; follow label instructions carefully. To protect honey bees, apply foliar sprays only during late evening, night, or early morning when bees are not present.	5–6 oz 1–3 oz	12 12	28 1
F. THIAMETHOXAM (Platinum) MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: Soil moisture is important for effectiveness; follow label instructions carefully.	8–17 oz	12	60
G. FENPROPATHRIN* (Danitol 2.4EC) MODE-OF-ACTION GROUP NUMBER: 3A COMMENTS: Do not apply in the San Joaquin Valley because mite outbreaks may occur. See label for additional requirements regarding hand labor. To protect honey bees, apply only during late evening, night, or early morning when bees are not present. Disruptive to beneficial insects.	10.67 fl oz	24	21
H. PYRETHRIN (Pyganic EC5.0II)# MODE-OF-ACTION GROUP NUMBER: 3A COMMENTS: To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	4.5–17 fl oz	12	0
I. KAOLIN CLAY (Surround WP)# MODE OF ACTION: Unknown. An inorganic insecticide. COMMENTS: Repels but does not kill sharpshooters. Apply at 7- to 21-day intervals if infestations occur; apply before infestation, if possible. Supplemental pest control methods may be needed for full control.	25–50 lb	4	0



Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
** Apply with enough water to provide complete coverage.			
‡ 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 R.E.I. exceeds the P.H.I. 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 <a href="http://www.iraonline.org/">http://www.iraonline.org/</a> .			

## THRIPS (7/15)

**Scientific Names:** Grape thrips: *Drepanothrips reuteri*  
Western flower thrips: *Frankliniella occidentalis* and others

### DESCRIPTION OF THE PESTS

Thrips are small insects, 0.04 inch long, with distinctive feathery wings. Color varies from yellow to brown in color. Grape thrips and western flower thrips are the most important species causing damage on grapes. Both species may be found in most grape-growing areas. Grape thrips populations usually reach their greatest numbers in July; this coincides with peak vine growth, and as vine growth slows, the numbers of thrips decreases. Western flower thrips populations peak in May, coinciding with grape bloom and the drying up of winter plant hosts.

### DAMAGE

Table grapes are susceptible to fruit damage caused by the western flower thrips. They create halo-spotting on the fruit when they oviposit in berries during bloom and up to fruit set or shortly thereafter. Both western flower thrips and grape thrips can scar berries with their feeding, which renders certain white varieties used for table grapes unmarketable. Thrips scarring is primarily a problem on Red Globe, Calmeria, Italia, and occasionally on Thompson Seedless. Fruit feeding discontinues in summer when both species feed on new vegetative growth.

In the North Coast, western flower thrips can feed in emerging shoots in early spring and stunt shoots and cause leaves to cup, especially during cool, rainy springs. Grape thrips may attack shoot tips in late spring or early summer although damage does not become apparent until the population has already decreased. While summer damage of leaves by thrips is common, it is not considered a problem for most varieties. However, a heavy grape thrips population can be a problem in Salvadors.

### MANAGEMENT

In general, thrips are a minor problem on wine and raisin grapes in California with the exception of large populations on emerging shoots in cool growing regions; however, table grapes are susceptible to thrips damage and may require treatment. For table grapes, make thrips management decisions based on pest population and damage in previous years and varietal susceptibility.

#### Biological Control

Little is known about natural control of thrips in vineyards but predators such as minute pirate bugs undoubtedly play a role in keeping populations in check.

#### Cultural Control

Avoid mowing cover crops infested with thrips at budbreak or before bloom because thrips may move to vines and cause shoot stunting.

#### Organically Acceptable Methods

Biological and cultural controls and sprays of the Entrust formulation of spinosad are acceptable in organically managed vineyards.

#### Monitoring and Treatment Decisions

On cool days after budbreak monitor for thrips. Open shoots or gently tap buds over white paper to check for thrips.

#### *Table grapes*

During the period of rapid shoot growth, inspect flowers or fruit clusters for adults or larvae, as well as the predatory minute pirate bug, by striking clusters three times over a white piece of cardboard. Normal population levels of western flower thrips range from 5 to 25 adults and 10-50 larvae per cluster. High levels exceed 150 adults and 300 larvae per cluster, but damaging population levels for grape thrips in clusters has not been determined. Bloom sprays may be necessary to prevent berry scarring in table grape vineyards.

At harvest look for damage caused by thrips to assess this year's management program and to plan for next year.

*Wine grapes*

From dormancy through budbreak, monitor for thrips along with other pests in wine/raisin grapes as outlined in DORMANT/DELAYED DORMANT AND BUDBREAK MONITORING. Inspect new shoots in spring, especially in cool regions, for shoot scarring and distorted leaves. In these areas treatment may be necessary if damage increases and cool temperatures persist. Record observations on a monitoring form (*example form available online*).

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
REVISED: 7/15			
<i>The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.</i>			
A. SPINETORAM (Delegate WG) MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: A stomach poison; most effective when ingested. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	3–5 oz	4	7
B. SPINOSAD (Entrust)# (Success) MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: Apply when eggs first hatch to target the young larvae. Heavy infestations require a second application in 4 or 5 days. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	1.25–2.5 oz 4–8 fl oz	4 4	7 7
C. FENPROPATHRIN* (Danitol 2.4EC) MODE-OF-ACTION GROUP NUMBER: 3A COMMENTS: To protect honey bees, apply only during late evening, night, or early morning when bees are not present. Disruptive to beneficial insects.	10.33–21.22 fl oz	24	21
D. NARROW RANGE OIL# (JMS Organic Stylet Oil) MODE OF ACTION: Contact including smothering and barrier effects. COMMENTS: Use for thrips control early in the season; do not use for flower thrips in table grapes. Apply early in the season from 1-inch shoot length until set. Will help prevent shoot damage in early spring but not effective for berry scarring. Commonly used when shoot growth is slowed by cool, spring temperatures. (Also controls mites and serves as a contact treatment for powdery mildew in spring.) Using ground equipment, spray for optimum coverage of leaf surfaces. Repeat sprays every 1 to 14 days. Late season applications may leave a residue on post-veraison berries. Do not apply with copper when fruit is present; do not apply within 10 days of sulfur. Read label carefully for other use restrictions.	1–2 gal	See label	See label

\*\* Apply with enough water to provide complete coverage.

‡ 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 R.E.I. exceeds the P.H.I. 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/>.

## VINE MEALYBUG (4/19)

**Scientific Name:** *Planococcus ficus*

### DESCRIPTION OF THE PEST

Vine mealybugs are small (adult females are about 1/8 inch in length), soft, oval, flat, distinctly segmented, and covered with a white, mealy wax that extends into spines (filaments along the body margin and the posterior end). The vine mealybug has a pinkish body that is visible through the powdery wax, and it is slightly smaller than the *Pseudococcus* mealybugs. The waxy filaments that protrude from the body of the vine mealybug are shorter than those on the *Pseudococcus* mealybugs, and the vine mealybug does not possess long tail filaments. The adult male is smaller than the female, has wings, and flies short distances to mate. There are three to seven generations a year.

All or most life stages of the vine mealybug can be present year-round on a vine depending on the grape-growing region. In the North Coast during winter months, the only life stages found are nymphs located under the bark predominately at the graft union, on trunk pruning wounds, and below the base of spurs. In other regions during the winter months, vine mealybug eggs, crawlers, nymphs, and adults are under the bark, within developing buds, and on roots.

As temperatures warm in spring, vine mealybug populations increase and become more visible as they move from the roots or trunk to the cordons and canopy. By late spring and summer, vine mealybugs are found on all parts of the vine: hidden under bark and exposed on trunks, cordons, first- and second-year canes, leaves, clusters, and roots. Ants may transport vine mealybug from the roots to above ground plant parts where they continue to tend vine mealybugs throughout the remainder of the growing season.

In the North Coast, vine mealybug has not been found on vine roots; however, in other regions with sandy soils it spends the winter almost exclusively on the root system. Other mealybugs found infesting grapes are only found on the aboveground portions of the vine. In addition, the vine mealybug is much more likely to be found on leaves during the growing season than the other mealybugs. During summer when vine mealybugs are in the canopy, they can be located well above the fruit zone and will lay eggs on the leaves, while *Pseudococcus* mealybugs do not. Vine mealybug does not diapause during the winter, and it appears to be more sensitive to cold temperatures than grape mealybug.

### DAMAGE

Damage by the vine mealybug is similar to that of other grape-infesting mealybugs in that it produces honeydew that drops onto the bunches and other vine parts and serves as a substrate for black sooty mold. If ants are not present, a vine with a large population of this pest can have so much honeydew that it resembles candle wax. Also, the mealybug itself will be found infesting bunches making them unfit for consumption. Like the grape, obscure, and longtailed mealybugs, vine mealybug can transmit grapevine leafroll-associated viruses.

### MANAGEMENT

Vine mealybug occurs in all major California production areas. In California, the vine mealybug feeds predominantly on grapevines, although in other countries it can be a pest of fig, date palm, apple, avocado, citrus, and a few ornamentals.

Because several different species of mealybugs may infest grapevines, it is important to know which species of mealybug is present because management programs for the various mealybugs differ. If you find mealybugs in your vineyard, collect the largest mealybugs you can find and place them in a jar of alcohol or sealed plastic bag. Take the sample to either your University of California Cooperative Extension (UCCE) farm advisor or county Agricultural Commissioner.

### Biological Control

The parasites that attack *Pseudococcus* mealybugs do not attack the vine mealybug; therefore two potential candidates for biological control have been imported and released in California. The most successful of these has been *Anagyrus pseudococci*. This species has provided up to 20% parasitism in some vineyards in the Coachella Valley and up to 90% parasitism of exposed mealybugs late in the season in the San Joaquin Valley. This parasitoid can be highly effective late in the season to reduce mealybug populations present after harvest before they return to the roots or lower trunk to overwinter. However, in the spring, the parasitoid does not emerge from its overwintering state until about bloom, providing minimal mealybug suppression during the early and

midseason. Growers can attempt to overcome this biological limitation of *A. pseudococci* by doing early-season releases of parasitoids that are purchased from commercial insectaries. Management of ants can reduce disruption of parasitism by *A. pseudococci*.

In coastal regions, several lady beetles such as the mealybug destroyer, *Cryptolaemus montrouzieri* and *Hyperaspis* sp. attack vine mealybug eggs and crawlers. Larvae of predaceous midges (family Cecidomyiidae) feed on mealybug eggs.

### Cultural Control

The female and nymphal mealybugs are wingless and are unable to fly so they must be carried by humans, equipment, wind, birds, or be present on vines at the time of planting. Do not allow contaminated equipment, vines, grapes, or winery waste near uninfested vineyards. Movement of equipment that pushes brush or any over-the-row equipment can be a major source of infestations in new locations; steam sanitize equipment before moving to uninfested portions of the vineyard. Do not spread infested cluster stems or pomace in the vineyard. To reduce contamination, cover all pomace piles with clear plastic for several weeks, and avoid creating piles that consist predominately of stems.

Reduce cluster infestation by pruning vines to prevent clusters hanging directly on the cordon. In areas where mealybugs overwinter exclusively on the roots, band application of Tanglefoot onto duct tape that has been wrapped around the trunk (with the bark removed) may help slow crawler movement up the vine in the spring.

### Organically Acceptable Methods

Biological and cultural controls are organically acceptable management tools. Repeated applications of oil approved for organic production can suppress vine mealybug in wine and raisin grapes. Oil applications are not used in table grapes, because they potentially affect the appearance of the fruit surface. Additionally, there are concerns about using oil in conjunction with sulfur due to the potential phytotoxic effects. Mating disruption is also approved for organic vineyards.

### Monitoring and Treatment Decisions

#### Monitoring

Monitor for vine mealybug by doing searches on the roots, trunk, cordon, leaves, and clusters depending on the time of year.

During the winter, look for vine mealybug on the lower crown; in areas with sandy soils, on the roots. During budbreak follow the monitoring guidelines in DELAYED-DORMANT AND BUDBREAK MONITORING (wine/raisin grapes or table grapes) to monitor these and other pests and record results on a monitoring form (*example form available online*).

In the spring, monitor the crown and trunk for adult females and the presence of crawlers moving up the vine. Starting at bloom, monitor for vine mealybug along with other pests as outlined in MONITORING INSECTS AND SPIDER MITES. Survey cordons, canes, and basal leaves. In coastal areas, also continue to monitor the trunk.

When fruit is present, especially after veraison, monitor clusters to ensure vine mealybug life stages or honeydew are not contaminating the fruit. In table grapes and other hand-harvested vineyards, picking crews can be trained to be a valuable resource for reporting the presence of mealybugs in vineyards not known to be infested.

Monitoring efforts can be aided by looking for ants and honeydew. Argentine and gray ants tend vine mealybugs; therefore, observing ant activity can direct ones attention to where mealybugs are present on the vine. The presence of honeydew may also be an indication of vine mealybug presence. Thus, when searching for vine mealybugs during summer, look for honeydew exudates on the clusters, trunk, and cordons. These exudates will resemble melted candle wax; if the infestation is severe, basal leaves will appear shiny and sticky. Eventually, sooty mold will grow on the honeydew and permanent parts of the vine will appear greenish black during the fall and winter.

Pheromone traps can help determine if vine mealybug is present within or near your vineyard. Place pheromone lures in small red delta traps in and around the vineyard by April 1 in the southern San Joaquin Valley, by May in areas further north, and by June in the North and Central Coast region:

- Choose two trap sites for each 20-40 planted acres.

- Put one trap in the center of the block and the other on the edge near a staging area. These traps can attract vine mealybug males from as far away as 1/4 mile.
- Attach traps to the trellis wires so that they are in the cluster area.
- Label the trap with the block name and row number of its location and the dates it remains in the vineyard.
- Check traps for the presence of male vine mealybug every 2 weeks through November.
- Follow the manufacturer’s recommendations for storing and replacing pheromone lures.
- Record observations on a monitoring form (*example form available online*).

It is essential to use a dissecting microscope to identify the male mealybug. (Male vine mealybugs are smaller than adult thrips and are very difficult to see even with a hand lens.) The sex pheromone is specific to the vine mealybug, but the traps may also contain other male mealybugs depending on the site. If there are questions as to the identification of the mealybug species, take samples to a farm advisor or county agricultural commissioner or refer to the Male Vine Mealybug Identification Sheet located online at <http://cesonoma.ucanr.edu/files/27218.pdf>.

The number of males found in a trap depends upon its proximity to the infestation and to the time of year. In the North Coast, new infestations have been located near traps that caught very low numbers in June (5 to 10 males per trap per week) and high numbers in fall (more than 50 males per trap per week). In the San Joaquin Valley, an infested vineyard will have between 20 to 300 or more males per trap per week. In either region, low numbers of male vine mealybugs found in a trap may mean that the infestation is located in an adjacent block or in a more distant vineyard. If males are found, increase the number of traps in the vineyard, and locate the infestation by examining lower leaves for honeydew.

**Treatment**

If vine mealybug is found in a vineyard, treatment is recommended. However, the level of treatment varies greatly depending on the region, type of grape, and harvest date:

- Coastal regions only have two to three generations of vine mealybug per year, compared to five to seven in the lower San Joaquin Valley.
- Table grapes have no allowance for mealybugs in the cluster, while wine grapes can tolerate low levels.
- Harvest dates vary widely in table grapes. Fruit from a Flame Seedless vineyard, harvested on the first of July, is less susceptible to damage than fruit in a neighboring Crimson Seedless vineyard, which might be harvested in October.

Due to the complexity of these and other factors, such as biological control, decisions about the level of mealybug control need to be made on a vineyard-by-vineyard basis.

In vineyards with low mealybug pressure, a single insecticide application in the spring or at bloom is often sufficient for season-long mealybug control. Effective control in heavily infested table grape vineyards, planted to a late-harvested variety, may require three or more treatments.

When treating for vine mealybug, consider other pests. Insect growth regulators can control scale pests, spirotetramat provides suppression of nematodes and phylloxera, and neonicotinoids are effective against sharpshooters and leafhoppers. When using soil-applied neonicotinoids, growers should also be cognizant of soil type: imidacloprid (Admire Pro) and clothianidin (Belay) are more effective on sandy soils whereas thiamethoxam (Platinum) and dinotefuran (Venom) are more effective on heavier soil.

Mating disruption has recently become available and can be used as an alternative or supplement to chemical control. Mating disruption is most effective when insecticides are used aggressively in the first year to reduce vine mealybug to low densities. In subsequent years, mating disruption supplemented with insecticides (as needed) can maintain the population at low levels. Mating disruption is most effective when applied over a large area (10 acres or greater). Greater success has been achieved in northern California, where there are fewer generations of vine mealybug per year.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
<i>The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.</i>			

**MATING DISRUPTION**

- |   |  |                   |    |    |
|---|--|-------------------|----|----|
| A.  | LAVANDULYL SENECEOATE-sprayable<br>(CheckMate VMB-F)   | 0.89 fl oz        | 4  | NA |
| <p>COMMENTS: Make the first pheromone application in the spring just before male emergence or when males are first detected in pheromone traps (usually in May). Reapply pheromone every 30 days for the period of time mating disruption is desired (typically May through October). Applications can be made as a tank mix with most pesticides that are not EC formulations or that do not contain oil. If pheromone is being applied by itself, applications can be made to every other row. An application rate of 5 g a.i./acre is sufficient to disrupt mating for 30 days. Higher application rates are allowed on the label but are not necessary.</p> |  |                   |    |    |
| B.  | LAVANDULYL SENECEOATE-dispenser<br>(CheckMate VMB-XL)# | 250<br>dispensers | NA | NA |
| <p>COMMENTS: Apply in the spring just before male emergence or when males are first detected in pheromone traps. Place dispensers on canes or trellis wire in the upper one-third of the canopy or higher. Most effective in large blocks or areawide, and when vine mealybug numbers are low. In sites with medium-to-high numbers, use an insecticide to reduce numbers.</p>  |  |                   |    |    |

**EARLY SPRING**

- |   |                         |       |    |   |
|---|-------------------------|-------|----|---|
| A.  | BUPROFEZIN<br>(Applaud) | 12 oz | 12 | 7 |
| <p>MODE-OF-ACTION GROUP NUMBER: 16<br/>COMMENTS: An insect growth regulator. Good coverage is essential. Buprofezin targets young nymphs on the vine that are exposed and still moving around before they settle down under the bark to feed. In regions outside of the North Coast, apply once in the delayed dormant period and once in early summer (May or June). In the North Coast, the first application is during late spring when crawlers are present or early summer. Do not tank mix.</p> |                         |       |    |   |

**BLOOM**

- |  |                            |           |    |   |
|--|----------------------------|-----------|----|---|
| A.                                     | SPIROTETRAMAT<br>(Movento) | 6–8 fl oz | 24 | 7 |
| <p>MODE-OF-ACTION GROUP NUMBER: 23</p> |                            |           |    |   |

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
COMMENTS: A foliar insecticide that is absorbed by the leaves and moves systemically in the phloem and xylem. Use with a non-ionic surfactant. Sufficient leaf canopy must be present for uptake and translocation. It takes about 4 weeks after treatment to see the full effect. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.			
B. IMIDACLOPRID (Admire Pro - Soil) MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: Efficacy of soil-applied neonicotinoids depends on soil texture. Imidacloprid binds readily to certain soil particles, has low water solubility, and long persistence (months). These characteristics allow it to be very effective in light soils, but ineffective in heavy soils. When the soil is rewetted and plant roots are actively absorbing water, the insecticide is also absorbed by roots. Best when applied in a drip irrigation system; otherwise, French plow the soil, apply as a ground spray, and immediately irrigate. Apply 7 to 14 fl oz/acre in one or two drip irrigation applications. On coarse soils or where the longest period of protection is required, make two applications. Make the first application from bloom through the pea-sized berry stage and the second 21 to 45 days later, keeping in mind the preharvest interval. The full rate of 14 oz/acre is recommended where vigorous vine growth is expected or in warmer growing areas such as the San Joaquin or Sacramento valleys or where mealybug numbers are high. Do not exceed 0.5 lb a.i. of imidacloprid (14 fl oz Admire Pro) /acre per year. Adequate soil moisture is important at the time of application; follow label instructions carefully.	7–14 fl oz	12	30
C. CLOTHIANIDIN (Belay - Soil) (Belay - Foliar) MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: Efficacy of soil-applied neonicotinoids depends on soil texture. Clothianidin has low water solubility, medium capacity to bind onto soil particles, and moderate to long persistence (weeks to months). Studies indicate it is effective in light soils. Adequate soil moisture is important at the time of application; follow label instructions carefully.	6–12 fl oz 6 fl oz	12 12	30 0
D. THIAMETHOXAM (Platinum) MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: Efficacy of soil-applied neonicotinoids depends on soil texture. Thiamethoxam has high water solubility, medium capacity to bind onto soil particles, and short to medium persistence (days to weeks). Studies indicate this is the most effective neonicotinoid for heavy soils. Adequate soil moisture is important at the time of application; follow label instructions carefully.	8–17 oz	12	60
E. DINOTEFURAN (Venom - Soil) MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: Efficacy of soil-applied neonicotinoids depends on soil texture. Dinotefuran has very high water solubility, low capacity to bind onto soil particles, and short to moderate persistence (days to weeks). Studies indicate it is moderately effective in heavy soils. Adequate soil moisture is important at the time of application; follow label instructions carefully.	6 oz	12	28

**SUMMER**

*(To obtain clean fruit and to avoid spreading the pest at harvest or by premature leaf drop)*

A. IMIDACLOPRID (Admire Pro - Soil) MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: If two applications are required because of coarse soils or where the longest period of protection is required, make the second application 21 to 45 days after the bloom application. Apply 7 to 14 fl oz/acre; the full rate of 14 oz/acre is recommended where vigorous vine growth is expected; in warmer growing areas such as the Coachella, San Joaquin, or Sacramento valleys; or where mealybug numbers are high. Do not exceed 0.5 lb a.i. of imidacloprid (14 fl oz Admire Pro) /acre per year. Adequate soil moisture is important at the time of application; follow label instructions carefully. Use allowed under a 24(c) registration.	7–14 fl oz	12	30
B. BUPROFEZIN (Applaud) MODE-OF-ACTION GROUP NUMBER: 16	12–24 oz	12	30



Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
<p>COMMENTS: An insect growth regulator. Buprofezin targets early-stage nymphs on the vine that are exposed and still moving around before they settle under the bark to feed. Good coverage is essential. Do not tank mix. Most effective when applied during peak crawler emergence in the spring (typically late April–early May in the lower San Joaquin Valley and through June in the North Coast region). Buprofezin may harm the mealybug destroyer (<i>Cryptolaemus montrouzieri</i>) when applied during the summer.</p>			
C. CLOTHIANIDIN (Belay - Soil)	6–12 fl oz	12	30
(Belay - Foliar)	6 fl oz	12	0
<p>MODE-OF-ACTION GROUP NUMBER: 4A            COMMENTS: Efficacy of soil-applied neonicotinoids depends on soil texture. Clothianidin has low water solubility, medium capacity to bind onto soil particles, and moderate to long persistence (weeks to months). Studies indicate it is effective in light soils. Adequate soil moisture is important at the time of application; follow label instructions carefully.</p>			
D. THIAMETHOXAM (Platinum)	8–17 oz	12	60
<p>MODE-OF-ACTION GROUP NUMBER: 4A            COMMENTS: Efficacy of soil-applied neonicotinoids depends on soil texture. Thiamethoxam has high water solubility, medium capacity to bind onto soil particles, and short to medium persistence (days to weeks). Studies indicate this is the most effective neonicotinoid for heavy soils. Adequate soil moisture is important at the time of application; follow label instructions carefully.</p>			
E. DINOTEFURAN (Venom - Soil)	5–7.5 oz	12	28
<p>MODE-OF-ACTION GROUP NUMBER: 4A            COMMENTS: Efficacy of soil-applied neonicotinoids depends on soil texture. Dinotefuran has very high water solubility, low capacity to bind onto soil particles, and short to moderate persistence (days to weeks). Studies indicate it is moderately effective in heavy soils. Adequate soil moisture is important at the time of application; follow label instructions carefully.</p>			
F. ACETAMIPRID (Assail 30SG)	2.5–5.3 oz	12	3
(Assail 70WP)	1.1–2.3 oz	12	3
<p>MODE-OF-ACTION GROUP NUMBER: 4A            COMMENTS: To protect honey bees, apply only during late evening, night, or early morning when bees are not present.</p>			

**POSTHARVEST**

A. SPIROTETRAMAT (Movento)	6–8 fl oz	24	7
<p>MODE-OF-ACTION GROUP NUMBER: 23            COMMENTS: A foliar insecticide that is absorbed by the leaves and moves systemically in the phloem and xylem. Use with a non-ionic surfactant. Sufficient leaf canopy must be present for uptake and translocation. It takes about 4 weeks after treatment to see the full effect. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.</p>			

\*\* Apply with enough water to provide complete coverage.

‡ 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 R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.

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

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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 <a href="http://www.irc-online.org/">http://www.irc-online.org/</a> .			
NA Not applicable.			
# Acceptable for use on organically grown produce.			

## WEBSPINNING SPIDER MITES (12/16)

**Scientific Names:** Pacific spider mite: *Tetranychus pacificus*  
 Willamette spider mite: *Eotetranychus willamettei*  
 Twospotted spider mite: *Tetranychus urticae*

### DESCRIPTION OF THE PESTS

The Pacific spider mite is the primary pest mite species in the San Joaquin Valley and may also be the primary pest mite in certain coastal grape-growing areas. Adult Pacific spider mite females vary from slightly amber to greenish in color. Later in the season as they go into diapause or under high population densities adult females can turn orange to reddish. Upon emergence adult Pacific spider mites are almost void of food spots. As feeding begins usually two large diffuse spots appear forward and two smaller spots appear on the rear portion of the abdomen. Pacific spider mite prefers the warmer upper canopy of the vine. Although it can cause damage early in the season, Pacific spider mite generally prefers the hotter, dryer part of the season. The Pacific mite is larger in size than the Willamette mite. Pacific spider mite forelegs are reddish in color and those of Willamette spider mite are translucent to pale yellow.

The Willamette spider mite is pale yellow. It is often considered an early-season mite. It prefers the cooler parts of the plant and is found mostly in the shady parts of the vine. In certain areas (e.g., North Coast), during certain years or conditions, and on certain varieties, populations can persist throughout the growing season. Willamette spider mite is primarily a problem in the Salinas Valley and Sierra foothill production areas where it can cause economic damage to varieties such as Zinfandel. In the North Coast it can cause damage in early spring when shoot growth is delayed or later in the season in vines with small canopies. Willamette spider mite is seldom a pest in the San Joaquin Valley, especially on Thompson Seedless.

The twospotted spider mite, *Tetranychus urticae*, is almost identical in appearance to the Pacific spider mite except it rarely has spots on the rear of the body. It is only occasionally found on grapes in California and rarely causes damage.

### DAMAGE

Damage specific to each species can be helpful in identification. Pacific spider mite damage begins as yellow spots. As damage progresses, dead (necrotic) areas appear on the leaves. High populations can render the leaves unfunctional with leaf burning and bronzing and copious amounts of webbing. Damage is worse along the shoulder and tops of the vine canopies. Willamette spider mite feeding in mid- or late season causes foliage to turn yellowish bronze, but usually no burn occurs unless vines are weak. In red varieties, infested leaves may turn reddish.

### MANAGEMENT

Manage webspinning spider mites in a vineyard by integrating biological, cultural and chemical controls.

#### Biological Control

Many natural enemies help to control pest mite populations. The western predatory mite, *Galendromus* (= *Metaseiulus*) *occidentalis*, is commonly present in vineyards and can be quite effective in reducing all stages of spider mite populations. In Sonoma and Napa vineyards, the most abundant predatory mite is *Typhlodromus pyri*; when present in spring, it can prevent the establishment of phytophagous mites. Predatory mites are translucent to light amber, pear shaped, and quite active. The effectiveness of this predator depends upon its ability to increase its population size as the season progresses. Disruptive sprays applied early will reduce the survival of this beneficial mite. Naturally occurring predator mites will survive sulfur sprays and dusts, but released ones may not survive dusting sulfur unless they have sulfur resistance. Predator mites, including insecticide-resistant ones, are available commercially to augment populations in the field. The western predatory mite, *Galendromus* (= *Metaseiulus*) *occidentalis* and *Neoseiulus californicus* are both available for release from commercial insectaries. *G. occidentalis* is used most commonly in hot inland valleys and *N. californicus* is more adapted to very cool coastal areas. The optimal timing for releases is in the spring when spider mite populations begin to appear.

Other predators, including sixspotted thrips (*Scolothrips sexmaculatus*), can also be important.

To preserve these natural enemies, avoid using disruptive materials.

**Cultural Control**

Apply water or other materials formulated to reduce dust on roads in the vineyard. If possible, maintain resident vegetation or other cover in the vineyard middles to further reduce dust. Irrigate in a manner that will avoid stressing vines. Although overhead watering has been shown to reduce mite problems, it can also increase some disease problems.

**Organically Acceptable Methods**

Organically acceptable methods include biological and cultural control methods as well as oil or soap sprays.

**Monitoring and Treatment Decisions**

Monitor for webspinning spider mites as part of dormant and budbreak spur monitoring as described in the DELAYED-DORMANT AND BUDBREAK SAMPLING (wine/raisin grapes or table grapes) and record observations on a monitoring form (*example form available online*). During rapid shoot growth, look for spider mites and predatory mites weekly on the first emerging leaves. During bloom, follow the guidelines for MONITORING INSECTS AND SPIDER MITES. When monitoring mites, note the presence of mite predators. The table below can be used in determining the treatment guidelines for various combinations of Pacific mite injury levels and predator-prey distributions in Thompson Seedless raisin vineyards. After bloom, record your observations on the insect and mite monitoring form (*example form (PDF) available online*).

<b>Predator-prey distribution ratios for Pacific spider mites in Thompson Seedless raisin vineyards<sup>1</sup></b>				
<b>Pacific mite injury levels (% leaves infested) <sup>1</sup></b>	<b>Rare (less than 1:30)</b>	<b>Occasional (1:30 to 1:10)</b>	<b>Frequent (1:10 to 1:2)</b>	<b>Numerous (greater than 1:2)</b>
<b>light (less than 50%)</b>	delay treatment to increase predators	delay treatment	treatment not likely necessary	treatment not necessary
<b>moderate (50-65%)</b>	treat if population is increasing rapidly	may delay treatment to increase predation	treatment may not be needed if the predator-prey distribution ratio is increasing rapidly	treatment not needed
<b>heavy (65-75%)</b>	treat immediately	may delay treatment a few days to take advantage of increasing predation	treatment may not be needed if predators are becoming numerous	treatment not needed, damage not increasing
<b>very heavy (greater than 75%)</b>	treat immediately	treat immediately	treat immediately unless predator-prey distribution ratio increasing very rapidly; carefully evaluate damage	treatment may not be necessary if population is dropping because of very high (greater than 1:1) predator-prey distribution ratios; carefully evaluate damage
<sup>1</sup>	Thompson Seedless vines are very vigorous and will tolerate more mite feeding than less vigorous varieties. Consequently, injury levels would be lower for other varieties, but predator-prey ratios and comments are applicable to all varieties.			

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
UPDATED: 12/16			
<i>The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.</i>			
A. CYFLUMETOFEN (Nealta) MODE-OF-ACTION GROUP NUMBER: 25A	13.7 fl oz	12	14
B. ETOXAZOLE (Zeal) MODE-OF-ACTION GROUP NUMBER: 10B COMMENTS: Only apply once per season.	2–3 oz	12	14
C. BIFENAZATE (ACRAMITE 50WS) MODE-OF-ACTION GROUP NUMBER: 20D COMMENTS: Only apply once per season.	0.75–1 lb	12	14
D. FENPYROXIMATE (FujiMite 5EC) MODE-OF-ACTION GROUP NUMBER: 21A COMMENTS: Apply in 50 to 200 gal water with higher volumes in vineyards with dense canopies. Do not apply more than twice per season. Long-persistence miticide; toxic to predatory mites.	2 pt	12	14
E. ABAMECTIN* (Agri-Mek SC) MODE-OF-ACTION GROUP NUMBER: 6 COMMENTS: Do not make more than two applications per growing season. Dust on leaves will inhibit absorption of this material. Effectiveness is also reduced by sulfur burn on leaves. To protect honey bees, apply only during late evening, night, or early morning when bees are not present. Many emulsifiable concentrate (EC) formulations emit high amounts of volatile organic compounds (VOCs); use low-VOC formulations of abamectin. Agri-Mek SC must be mixed with an adjuvant to avoid illegal residues; follow the label instructions. Certain formulations emit high amounts of volatile organic compounds (VOCs); use low-VOC formulations. <b>Regulations affect use for the San Joaquin Valley from May 1 to October 31, 2019.</b>	1.75–3.5 fl oz	12	28
F. SPIRODICLOFEN (Envidor 2SC) MODE-OF-ACTION GROUP NUMBER: 23 COMMENTS: Only apply once per season. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	16–34 fl oz	12	14
G. HEXYTHIAZOX (Onager) MODE OF ACTION: 10A COMMENTS: Only apply once per season.	12–24 oz	12	7
H. NARROW RANGE OIL# MODE OF ACTION: Contact including smothering and barrier effects. COMMENTS: For Pacific spider mite, apply before bloom to get the best coverage and to delay mite development by 3 to 4 weeks. If an additional treatment is needed, apply 2 weeks after berry set (on raisin and wine grapes only; do not use on table grapes after bloom). For Willamette spider mite, apply oil after budbreak in a 1% spray. Do not apply within 10 days of a sulfur application. Check with certifier to determine which products are acceptable in organic production.	Label rates	See label	See label
I. INSECTICIDAL SOAP# (M-Pede) MODE OF ACTION: Contact including smothering and barrier effects. COMMENTS: Can cause berry spotting.	Label rates	12	0

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
UPDATED: 12/16			
J. NEEM OIL# (Trilogy) MODE OF ACTION: Unknown. A botanical insecticide COMMENTS: For organically grown crops, check with your certifier for any restrictions that apply.	Label rates	4	0
K. CLOFENTEZINE (Apollo SC) MODE-OF-ACTION GROUP NUMBER: 10A COMMENTS: Apply only once per year. More effective early in the season on eggs. If there are many adults, clofentezine is not effective. Because this material is applied early in the season, it is best used in vineyards with chronic mite problems.	4–8 oz	12	21
L. <i>GALENDROMUS OCCIDENTALIS</i> or <i>NEOSEIULUS CALIFORNICUS</i> # COMMENTS: Releases are most successful when host plants (green beans) are placed directly on vines. Use a minimum of 1,000 predators per acre.			

\*\* Apply with enough water to provide complete coverage.

‡ 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 R.E.I. exceeds the P.H.I. 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/>.

# WESTERN GRAPELEAF SKELETONIZER (7/15)

**Scientific Name:** *Harrisina brillians*

## DESCRIPTION OF THE PEST

The metallic bluish or greenish black western grapeleaf skeletonizer moths fly during the day. Body length is about 0.6 inch and the wingspan is 1 to 1.3 inches. There are three generations per year in the Central Valley and two generations in the cooler coastal regions. Adult moths of the first generation in the Central Valley emerge from hibernating pupa in early spring to June. The pale yellow or whitish capsule-shaped eggs are laid in clusters on the underside of grape leaves. After hatching, the larvae line up and feed side-by-side on the leaf underside until the early fourth instar stages. There are five larval stages. The first two stages are cream colored, the third stage is brownish, and the fourth and fifth stages are yellow with two purple and several blackish bands. Larvae have conspicuous tufts of long black poisonous spines that cause skin welts on field workers. The fifth or last larval stage is about 0.6 inch long. When mature, larvae crawl under the loose bark or into ground litter and spin a dirty, whitish cocoon to pupate.

## DAMAGE

First through the early fourth instar larvae feed on the lower leaf surface, leaving only the veins and upper cuticle. This gives leaves a whitish paperlike appearance; eventually the entire leaf turns brown. The late fourth and all fifth stage larvae skeletonize the leaves, leaving only the larger veins. When abundant, larvae can defoliate vines by July. When vines are severely defoliated, larvae will then feed on grape clusters, which can result in bunch rot. Defoliation can also result in sunburn of the fruit and loss of quality. Defoliation after harvest may weaken vines by affecting stored reserves. Larvae also can cause problems for workers at harvest because hairs on their bodies can irritate the skin if they are brushed against.

## MANAGEMENT

Western grape leaf skeletonizer does not occur in all grape-production areas because the moths are not long-distance fliers and this pest has been slow to spread in California since its first appearance in the 1940s. In areas where it does occur, granulosis virus usually keeps populations below economically damaging levels. When the virus is insufficient, western grapeleaf skeletonizer is easily controlled with insecticides that are also effective on other caterpillars, leafhoppers, or thrips.

### Biological Control

Two insect parasites, *Apanteles harrisinae* and *Amedoria misella* (*Sturmia harrisinae*), attack western grapeleaf skeletonizer larvae. Thousands of these parasites have been released in the San Joaquin Valley, and *Amedoria misella* is common in many vineyards in the San Joaquin Valley.

A granulosis virus, endemic in southern California, has been introduced in selected areas with excellent success. It is extremely infectious when it is introduced into an outbreak population of western grapeleaf skeletonizer. Symptoms of populations infected with the virus include: (1) eggs within clusters are scattered instead of compactly laid, and the number of eggs is reduced; (2) most eggs fail to hatch; (3) larvae consume tiny patches of tissue rather than consuming entire areas of the leaf; (4) diseased larvae are sluggish and feed solitarily instead of in tight groups and usually tend to wander irregularly, leaving a visible trail of liquid excrement; and (5) larval growth and coloration change, and larvae shrink and eventually die. This virus is transmitted from one generation to the next by disease-carrying adults that survive a low degree of infection in the larval stage.

### Organically Acceptable Methods

Biological control and sprays of *Bacillus thuringiensis* and the Entrust formulation of spinosad are acceptable for organically certified grapes.

### Monitoring and Treatment Decisions

If the granulosis virus is not present, the amount of leaf damage will increase with each generation. Monitor end and border vines during the first generation. This can be done at bloom when monitoring for other caterpillars; see MONITORING CATERPILLARS. Record results on a monitoring form (*example form* (128 KB, PDF) *available online*). If larvae are found and the virus is not present, treat soon after bloom. If needed later in season, treat when young larvae are found.

Check table grapes for sunburned fruit, a possible sign of defoliation caused by western grape leaf skeletonizer.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
REVISED: 7/15			
<i>The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide’s properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.</i>			
A. METHOXYFENOZIDE (Intrepid 2F) MODE-OF-ACTION GROUP NUMBER: 18 COMMENTS: Do not apply more than 48 fl oz / acre per season.	10–16 fl oz	4	30
B. CHLORANTRANILIPROLE (RYNAXYPYR) (Altacor) MODE-OF-ACTION GROUP NUMBER: 28	2.0–4.5 oz	4	14
C. SPINETORAM (Delegate WG) MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: A stomach poison; most effective when ingested. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	3–5 oz	4	7
D. SPINOSAD (Entrust)# (Success) MODE-OF-ACTION GROUP NUMBER: 5 COMMENTS: Apply when eggs first hatch to target the young larvae. A stomach poison; most effective when ingested. Heavy infestations require a second application in 4 or 5 days. To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	1.5–2.5 oz 4–8 fl oz	4 4	7 7
E. CRYOLITE (Kryocide) (Prokil Cryolite 96) MODE-OF-ACTION GROUP NUMBER: 8C COMMENTS: Wine and raisin grapes: limit of two applications per season. Table grapes: One application only and not after fruit formation. If used on wine grapes or grapes that may be sold to a winery for export, observe their restrictions on applications. A stomach poison that must be consumed by larvae so thorough coverage is important. Less harmful to natural enemies than carbaryl and provides long residual action.	6–8 lb 6–8 lb	12 12	30 30
F. <i>BACILLUS THURINGIENSIS</i> ssp. <i>KURSTAKI</i> # (various products) MODE-OF-ACTION GROUP NUMBER: 11A COMMENTS: Only effective against young larvae. Provides fairly good control, has a short residual, and is not harmful to natural enemies. If coverage is not satisfactory or if all the eggs have not hatched, requires a second treatment.	Label rates	4	0
G. ACETAMIPRID (Assail 70WP) MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: To protect honey bees, apply only during late evening, night, or early morning when bees are not present.	1.1 oz	12	3
H. ABAMECTIN* (Agri-Mek SC) MODE-OF-ACTION GROUP NUMBER: 6 COMMENTS: Do not make more than two applications per growing season. Dust on leaves will inhibit absorption of this material. Effectiveness is also reduced by sulfur burn on leaves. To protect honey bees, apply only during late evening, night, or early morning when bees are not present. Certain formulations emit high amounts of volatile organic compounds (VOCs); use low-VOC formulations. <b>Regulations affect use for the San Joaquin Valley from May 1 to October 31, 2019.</b>	1.75–3.5 fl oz	12	28
I. IMIDACLOPRID (Admire Pro - Soil) (Admire Pro - Foliar)	7–14 fl oz 1.0–1.4 fl oz	12 12	30 0



Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: Do not exceed 0.5 lb a.i. of imidacloprid/ acre per year. To protect honey bees, apply foliar sprays only during late evening, night, or early morning when bees are not present.			
J. INDOXACARB (Avaunt) MODE-OF-ACTION GROUP NUMBER: 22A	3.5–6 oz	12	7

\*\* Apply with enough water to provide complete coverage.

‡ 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 R.E.I. exceeds the P.H.I. 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.irc-online.org/>.

## *Diseases*

(Section reviewed 12/14)

# ARMILLARIA ROOT ROT (OAK ROOT FUNGUS) (12/14)

**Pathogen:** *Armillaria mellea*

## SYMPTOMS AND SIGNS

Vines infected with *Armillaria* root rot become nonproductive and often die within 2 to 4 years after the first appearance of symptoms, which typically start as a slight stunting of shoots that progresses each year. Adjacent vines often become infected as well. Eventually, a group of dead and dying vines form a 'disease center', the location of which reflects the presence of the fungal pathogen, *Armillaria mellea*, in residual roots in the soil after infected trees (native species or tree crops) are removed. The diagnostic feature of *Armillaria* root rot is the white mycelial mat that forms under the bark at or below the soil line. The trunk or root wood below the mat is often visibly rotted, with a soft, spongy consistency and light brown color, as compared to white, dense wood on the portion of the trunk that has no sign of the pathogen. Dark, root-like structures (rhizomorphs) may also be seen on the surface of infected grapevine roots and the below-ground section of the trunk. In red cultivars all leaves on diseased vines may turn red late in the season.

## COMMENTS ON THE DISEASE

The pathogen can infect hundreds of woody plants, including the tree crops walnut, peach, and almond, which are much more susceptible than grape. Host plants include broad-leaved trees in oak woodlands and stands of conifers; the pathogen is indigenous in many regions. After infected tree crops, grapevines, or native trees are cleared, the vegetative stage of the fungus (mycelium) survives on infected, decaying roots below ground, potentially for many years. Healthy grapevine roots become infected when they come in contact with such inoculum. The fungus is favored by soil that is continually damp during the growing season. Although the pathogen produces mushrooms, the spores released from these fruiting structures are not considered significant in disease spread either to healthy vineyards or between vines within infected vineyards. Furthermore, mushrooms are not common and are very short-lived; they are not required to confirm the presence of the pathogen.

## MANAGEMENT

The best management strategy is to remove residual roots before vineyard establishment. In diseased vineyards or new sites supporting other woody plants, use deep ripping to bring thick, woody roots and root crowns to the surface and then remove. This sanitation measure is much more efficient than fumigation alone. There are no known *Armillaria*-tolerant grape rootstocks. If possible, avoid planting sites infested with *Armillaria*.

### **Saving infected vines**

Once symptoms of *Armillaria* root rot appear in vines, it may be possible to slow or stop spread of the pathogen in the early stages of infection by exposing the crown and upper roots and allowing them to dry out—a practice known as 'root collar excavation'. In spring, remove soil to a depth of 9 to 12 inches, to the point at which the main roots branch from the base of the trunk (the root collar). Keep the root collar permanently exposed to air. This practice is most effective for vines with moderately-stunted shoots and adjacent healthy-looking vines. It is not effective for vines that are severely stunted.

### **Fumigation**

Be aware that fumigants do not kill the pathogen in residual roots buried deep (> 3 feet) in the soil. The efficacy of soil fumigation can be improved, however, by proper sanitation (i.e., removing residual roots) and soil preparation. See your Cooperative Extension farm advisor for additional advice on soil preparation. Contact the county agricultural commissioner's office for current state and local regulations specific to fumigant use in agriculture lands. Set-backs may be required from property lines and on-site structures. Follow directions and regulations carefully. Fumigation is expensive and needs to be done correctly for the chosen fumigant to receive maximum benefit.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)
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REVISED: 7/15

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

A. METHYL BROMIDE*	Label rates	See label
COMMENTS: Preplant treatment. May only be used under a Critical Use Exemption. Fumigants such as methyl bromide are a source of volatile organic compounds (VOCs) but are not reactive with other air contaminants that form ozone: methyl bromide depletes ozone. Fumigate only as a last resort when other management strategies have not been successful or are not available.		
B. METAM SODIUM* (Vapam, etc.)	Label rates	See label
COMMENTS: Apply in winter when soil moisture is high. 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.		
C. CHLOROPICRIN*	Label rates	See label

- \*\* Apply with enough water to provide complete coverage. Maximum rate allowed in CA may be less than what is allowed in other states.
- \* Permit required from county agricultural commissioner for purchase or use.
- ‡ 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. Soil fumigants have an entry restricted period determined by tarping requirements.

## BOTRYOSPHAERIA DIEBACK (12/14)

**Pathogens:** Species in the fungal family *Botryosphaeriaceae*, including *Neofusicoccum parvum*, *Diplodia seriata*, and *Lasiodiplodia theobromae*.

### SYMPTOMS AND SIGNS

*Botryosphaeria dieback*, *Esca*, *Eutypa dieback*, and *Phomopsis dieback* make up a complex of 'trunk diseases' caused by different wood-infecting fungi. *Botryosphaeria dieback* (commonly known in California as 'Bot canker') causes death of spurs, arms, cordons, canes, and sometimes the upper section of the trunk, depending on the location of the wood canker. Wedge-shaped (sometimes circular to oblong) wood cankers form in infected wood and are indistinguishable from those associated with *Eutypa* and *Phomopsis dieback*. Unlike *Eutypa dieback*, no characteristic foliar symptoms are associated with *Botryosphaeria dieback*. Instead, the leaves on a shoot originating from an infected spur or cane will wilt and the shoot will die back completely during the growing season. Other symptoms of *Botryosphaeria dieback* include dead spurs, stunted shoots, and bud mortality. Such symptoms are shared in common among multiple trunk diseases, which often occur in mixed infection within the vineyard and even within an individual vine.

### COMMENTS ON THE DISEASE

*Botryosphaeria dieback* is the most common and widespread trunk disease in California and some of the causal species (e.g., *Neofusicoccum parvum*) are among the most aggressive trunk pathogens. Symptoms first become apparent in vineyards 5 to 7 or more years old, but the infections actually occur in younger vines. Pycnidia, the overwintering structures that produce spores, are embedded in diseased woody parts of vines. During winter rainfall, spores are released and wounds made by winter pruning provide infection sites. Wine, table, and raisin-grape cultivars are susceptible to disease. Under California conditions, pruning as late as possible in the dormant period has been shown to be very effective in reducing the risk of infection. Delayed pruning takes advantage of reduced susceptibility of pruning wounds to infection and avoids the period of highest spore release during winter rain events. After a pruning wound is infected, the pathogen establishes a permanent, localized wood infection, which cannot be eradicated by fungicide applications.

### MANAGEMENT

See EUTYPA DIEBACK for management practices.

# BOTRYTIS BUNCH ROT (12/16)

**Pathogen:** *Botrytis cinerea*

## SYMPTOMS AND SIGNS

Prior to fruit ripening, early-season shoot blight may occur following prolonged warm moist conditions caused by frequent spring rains. Patches of soft brown tissue develop resulting in the death of the infected plant part. Infections often occur in leaf axils causing shoots to wilt or break off. At veraison, individually infected berries in a cluster turn brown on white cultivars or reddish in red and black cultivars. If temperatures are moderate, moisture is high, and wind speed is low, epidermal cracks will form in which fungal growth produces mycelium and spores, resulting in the characteristic gray, velvety appearance of infected berries.

## COMMENTS ON THE DISEASE

The fungus overwinters as sclerotia most commonly in berry mummies on the ground or left hanging on the vine and in canes. After rain or irrigation the sclerotia germinate and produce spores, that are moved by air currents or splashing rain. Infections require free water for a definite period of time depending on temperature. Flowers can become infected through the stigma and scar tissue on the receptacle (tip of the pedicel) left by the detachment of the calyptra during bloom; generally the fungus then becomes dormant until late in the season when sugar concentration increases in the infected berry. The fungus then resumes growth and spreads throughout the berry. Infected berries split and leak, thus allowing the pathogen to grow and sporulate on berry surfaces and spread to adjoining berries by mid-season. Spores from infected fruit can directly infect intact, ripe berries as harvest approaches. Late-season infections are most severe when relative humidity exceeds 92%, free moisture is present on the fruit surface, and temperatures are in the 58° to 82°F range. Berries that have been damaged by insects, birds, machinery, etc. may become infected at any time after the fruit begins to ripen because the juice in the berry can provide the necessary water and nutrients for fungal growth.

## MANAGEMENT

Successful management of Botrytis bunch rot can be achieved through the use of several strategies. By employing cultural control methods, properly applying fungicides, and using resistant cultivars when practical, the disease can be managed.

### Cultural Control

Designing vineyards to the anticipated vigor of the site conditions will produce balanced canopies with moderate shoot vigor that optimizes leaf and cluster exposure and can reduce the conditions that promote Botrytis bunch rot. Canopy management practices such as shoot thinning, hedging, and leaf removal can be used to manage canopy density when appropriate. Removal of basal leaves immediately after berry set has resulted in significantly reduced incidence and severity of disease. In warmer growing areas, be careful not to remove excessive numbers of leaves, which can lead to sunburned fruit. This condition is made worse when leaves are removed later in the season especially on canopies with southern and western afternoon exposures. If leaves are removed at fruit set, the berries acclimate readily to the sunlight and develop a thicker cuticle that helps prevent sunburn as well as *Botrytis* infection.

The efficacy of a fungicide depends on getting good coverage, and coverage is affected by the canopy and stage of growth. If leaves are not removed and the interior of the canopy remains dry in the spring, one fungicide application should be made sometime between bloom and pea-size berries. Otherwise, apply sprays before rainfall especially at bloom or after veraison. Grapes expected to be harvested late in the season should be treated prior to bunch closure and as needed prior to harvest for table grapes that will be stored for an extended period.

Avoid unnecessary irrigation or nitrogen fertilization that may promote excessive canopy growth. Manage insect populations that feed and produce entry wounds that promote *Botrytis* infections.

### Organically Acceptable Methods

Canopy management and other cultural control methods along with sprays of Organic JMS Stylet Oil and Serenade are organically acceptable methods.

**Monitoring and Treatment Decisions**

Look for flagging shoot tips or entire shoots or numerous brown irregular lesions on leaves in the spring during rapid shoot growth especially when warm moist conditions occur. If the entire shoot is flagging, look for a hole at the base, which could indicate feeding by branch and twig borer.

If basal leaves are not removed, apply fungicides before rain in northern central valley and coastal production areas to prevent flower infections. Research data shows a trend toward better control if fungicides are applied at bloom, preclose, and veraison. If leaf removal is practiced, then sprays can be limited to applications prior to wet weather during bloom (or none if no rain occurs). Thorough coverage is essential for all fungicide treatments.

A fungicide application may also be warranted if a major rain is expected late in the season when grapes are nearly mature. Alternating fungicides with different modes of action within the season and/or between seasons is essential to prevent pathogen populations from developing resistance to classes of fungicides.

At harvest, survey vineyards for Botrytis symptoms to assess the current season’s management program and to plan for next year.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
UPDATED: 12/16			
<i>When choosing a pesticide, consider its usefulness in an IPM program by reviewing the pesticide's properties, efficacy, application timing, and information relating to resistance management, honey bees, and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.</i>			
<b>Note:</b> <i>Treatments can be made in conjunction with plant growth regulators and other applications.</i>			
A. CYPRODINIL (Vanguard WG)	10 oz	12	7
MODE-OF-ACTION GROUP NAME (NUMBER): Anilinopyrimidine (9)			
COMMENTS: Do not apply more than 20 oz/acre per season. Rate is 5 to 10 oz if tank-mixed with another fungicide.			
B. FENHEXAMID (Elevate 50WDG)	1 lb	12	0
MODE-OF-ACTION GROUP NAME (NUMBER): Hydroxylanilide (17)			
COMMENTS: Do not make more than two consecutive applications. Do not apply more than 3 lb a.i. product/acre per season.			
C. PYRIMETHANIL (Scala SC)	18 fl oz	12	7
MODE-OF-ACTION GROUP NAME (NUMBER): Anilinopyrimidine (9)			
COMMENTS: Do not apply more than 36 fl oz/acre per season. Rate is 9 fl oz if tank-mixed with another fungicide.			
D. FLUOPYRAM + TEBUCONAZOLE (Luna Experience)	8–8.6 fl oz	12	14
MODE-OF-ACTION GROUP NAME (NUMBER): Succinate dehydrogenase inhibitor (7) and Demethylation inhibitor (3)			
COMMENTS: For use on wine grapes only. Do not make more than two consecutive applications; rotate to a fungicide with a different mode of action. The R.E.I. is 5 days for treated grapes when conducting cane tying, turning, or girdling of wine grapes. Do not apply more than 34 fl oz/acre per season.			
E. CYPRODINIL + FLUDIOXONIL (Switch 62.5WG)	11–14 oz	12	7
MODE-OF-ACTION GROUP NAME (NUMBER): Anilinopyrimidine (9) and Phenylpyrrole (12)			
COMMENTS: Do not apply in less than 21-day intervals. Do not make more than two consecutive applications; rotate to a fungicide with a different mode of action.			
F. DIFENOCONAZOLE + CYPRODINIL (Inspire Super)	20 fl oz	12	14
MODE-OF-ACTION GROUP NAME (NUMBER): Demethylation inhibitor (3) and Anilinopyrimidine (9)			

COMMENTS: Do not apply more than 2 consecutive applications; rotate to a fungicide with a different mode of action.

G.	<p>IPRODIONE (Rovral 4F)</p> <p style="text-align: center;">1.5–2 lb</p> <p>MODE-OF-ACTION GROUP NAME (NUMBER): Dicarboximide (2)</p> <p>COMMENTS: Do not apply more than 4 times per season. Addition of a narrow range oil (superior, supreme) at 1% increases the effectiveness of this fungicide.</p>	48	7
H.	<p>PYRACLOSTROBIN + BOSCALID (Pristine)</p> <p style="text-align: center;">23 oz</p> <p>MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11) and Carboxamide (7)</p> <p>COMMENTS: Do not apply on Concord, Worden, Fredonia, Niagara, and related varieties. Do not make more than 2 consecutive applications; rotate to a fungicide with a different mode of action. The R.E.I. is 5 days when conducting cane tying, turning, or girdling.</p>	12	14
I.	<p>NARROW RANGE OIL# (JMS Stylet)</p> <p style="text-align: center;">1%</p> <p>MODE-OF-ACTION GROUP NAME (NUMBER): A contact fungicide with smothering and barrier effects.</p> <p>COMMENTS: Foliage burn may occur if oil is applied within 2 weeks of sulfur or captan sprays. Oil will temporarily remove the 'bloom' on the berries; to avoid this, do not spray within 2 weeks of harvest.</p>	4	0
J.	<p>BACILLUS SUBTILIS# (Serenade Max)</p> <p style="text-align: center;">1–3 lb</p> <p>MODE-OF-ACTION GROUP NAME (NUMBER): Microbial (44)</p>	4	0

\*\* Apply with enough water to provide complete coverage.

‡ 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 R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.

# Acceptable for use on organically grown produce.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a different Group number are suitable to alternate in a resistance management program. For more information, see <http://www.frac.info/>.

## CROWN GALL (12/14)

**Pathogen:** *Agrobacterium vitis*

### SYMPTOMS AND SIGNS

Gall formation is the typical symptom of this disease. Galls may be produced on canes, trunks, roots, and cordons and may grow to several inches in diameter. Internally, galls are soft and have the appearance of disorganized tissue.

### COMMENTS ON THE DISEASE

*Agrobacterium vitis* is systemic in grapevine wood and plant material that does not appear to be diseased may be infected. The pathogen can exist in living and dead vine debris buried in the soil where it can survive for several years and be an inoculum source causing new vines to become infected. Galls develop at wound sites. These include disbudding sites on rootstocks, sites where suckers have been removed and where the vine has been cut and a field graft made. Gall formation may push the bud shield or graft union off the vine. Injuries caused by cultivation or pruning may result in gall formation. Infected vines may have galls on roots caused by the cracking of woody root tissue during growth. Galls frequently appear where the vine tissue has been damaged by freezing temperatures, thus vineyard site plays a role disease severity. Galls may girdle the vine and disrupt the flow of nutrients, thus restricting vine growth.

### MANAGEMENT

Crown gall can be difficult to control. Site selection is critical in growing regions with temperatures near or below freezing; maximizing air drainage will reduce freeze injuries. Avoid injurious practices previously described. Plant vines in sites with no history of crown gall. Current efforts to eliminate the bacterium from vines generated using micro-shoot tip propagation techniques have produced inconsistent results. Certified vines may be infected or may become infected once the vine is planted in the field. In areas where winter injury to the vines occurs, disease incidence will be high if the vines are infected. Grow tubes left on young vines over the winter may increase the incidence of crown gall in infected vines. Chemical treatments are not effective. Currently available products only treat the symptoms and do not eliminate the bacterial infection.



# DOWNY MILDEW (12/14)

**Pathogen:** *Plasmopara viticola*

## SYMPTOMS AND SIGN

The fungus attacks all green parts of the vines, particularly the leaves. Depending on the incubation period and leaf age, lesions are yellowish and oily or angular, yellow to reddish and brown and limited by the veins. Sporulation of the fungus appears as a delicate, dense, white, cottony growth in the lesions. Infected shoot tips thicken, curl ("Shepherd's Crook") and become white with sporulation. They eventually turn brown and die. Similar symptoms are seen on petioles, tendrils and young inflorescences, which, if attacked early enough, ultimately turn brown, dry up and drop. The young berries are highly susceptible. They appear grayish when infected (gray rot) and become covered with a downy felt of fungus sporulation. Berries become less susceptible as they mature, but rachis infections can spread into older berries (brown rot, no sporulation). Infected berries of white cultivars may turn dull gray-green, while those of black cultivars turn pinkish red. Infected berries remain firm, compared to ripening healthy berries, and drop easily. Portions of the rachis or the entire cluster also may drop.

## COMMENTS ON THE DISEASE

Grape downy mildew occurs mainly in regions where it is warm and wet during the vegetative growth of the vine. Limited rainfall in spring and summer generally limits the spread of the disease in California. Surviving inoculum may be present in California at low levels and initially may have been introduced on plant material from outside of California. In most regions the fungus survives the winter mainly as oospores in fallen leaves. However, in California's generally mild winters, survival of the fungus in buds, shoot tips, and persistent leaves may be more important than in other grape-growing regions.

The pathogen is dispersed by splashing rain and wind. The infection process can take less than 90 minutes. Infection generally occurs in the morning and the incubation period is about 4 days. Downy mildew is favored by all factors that increase the moisture content of soil, air and host plant. Rain and irrigation practices are principal factors in promoting epidemics. The optimum temperature for development of the disease is 68° to 77°F (20° to 25°C) with extremes ranging from 50° to 86°F (10° to 29°C). In California the greatest potential for disease development exists when a wet winter is followed by late spring rains. The potential is high as well in the event of early fall rains.

## MANAGEMENT

Preventive management consists of effective soil drainage and reduction of sources of overwintering inoculum. In a vineyard that depends on sprinkler irrigation, extend the interval between irrigations as long as possible.

Fungicides for use against downy mildew can be categorized as either preventive or curative. The preventive fungicides must be applied before an infection period begins. New growth following application will not be protected. Include a spreader/sticker agent to prevent the material from washing off with rain. In vineyards with a history of downy mildew, apply early season copper sprays as part of a preventive program, especially during wet springs.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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REVISED: 7/15

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

- |  |               |   |    |
|--|---------------|---|----|
| A. AZOXYSTROBIN<br>(Abound)  | 11–15.4 fl oz | 4 | 14 |
| MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11)   |               |   |    |
| COMMENTS: Begin applications at budbreak. Alternate with chemicals that have a different mode of action. Do not apply more than 2 sequential applications of this material or more than 6 applications per year. |               |   |    |

(12/14) Downy Mildew

- B. PYRACLOSTROBIN + BOSCALID  
(Pristine) 8–10.5 oz 24 14  
MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11) and Carboxamide (7)  
COMMENTS: Do not apply on Concord, Worden, Fredonia, Niagara, and related varieties. Do not make more than 2 sequential applications; rotate to a fungicide with a different mode of action. The R.E.I. is 5 days when conducting cane tying, turning, or girdling.
- C. KRESOXIM-METHYL  
(Sovran) 3.2–4.8 oz 12 14  
MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11)  
COMMENTS: Begin application at budbreak.
- D. MEFENOXAM + COPPER HYDROXIDE  
(Ridomil Gold Copper) 1–2 lb 48 42  
MODE-OF-ACTION GROUP NAME (NUMBER): Phenylamide (4) and Multi-site contact (M1)  
COMMENTS: Apply up to four times beginning before bloom. Do not apply more than a total of 0.4 lb active ingredient mefenoxam per crop per season. Do not apply after bloom. Do not use on copper-sensitive varieties.
- E. COPPER HYDROXIDE Label rates 48 See label  
MODE-OF-ACTION GROUP NAME (NUMBER): Multi-site contact (M1)  
COMMENTS: Use 1 to 3 lb hydrated lime/acre in combination with cupric hydroxide. May be applied either as a dilute or concentrate spray. Use for the last 1 or 2 late-season applications following early-season application of another fungicide. Slight to severe foliar injury may occur on copper sensitive varieties.

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- \*\* Apply with enough water to provide complete coverage.
- ‡ 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 R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.
- # Acceptable for use on organically grown produce.
- 1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a different Group number are suitable to alternate in a resistance management program. For more information, see <http://www.frac.info/>.

## ESCA (BLACK MEASLES) (12/14)

**Pathogens:** Esca is caused by a complex of fungi that includes several species of *Phaeoacremonium*, primarily by *P. aleophilum* (currently known by the name of its sexual stage, *Togninia minima*), and by *Phaeoaniella chlamydospora*.

### SYMPTOMS AND SIGNS

Esca, Botryosphaeria dieback, Eutypa dieback, and Phomopsis dieback make up a complex of 'trunk diseases' caused by different wood-infecting fungi. The foliar symptom of Esca is an interveinal 'striping'. The 'stripes', which start out as dark red in red cultivars and yellow in white cultivars, dry and become necrotic. Foliar symptoms may occur at any time during the growing season, but are most prevalent during July and August. They are often restricted to an individual shoot or to shoots originating from the same spur or cane. Symptomatic leaves can dry completely and drop prematurely. On berries, small, round, dark spots, each bordered by a brown-purple ring, may occur. These fruit spots, which are better viewed on white cultivars, may appear at any time between fruit set and ripening. In severely affected vines, the berries often crack and dry or are subject to spoilage. Symptomatic fruit is found only on shoots with symptomatic leaves, but you can find shoots with symptomatic leaves and no symptomatic fruit. Cross-sectional cuts through canes, spurs, cordons, or trunks from which symptomatic shoots originate will reveal concentric rings of dark spots. Eventually the spur or cane from which symptomatic shoots originate may die. The appearance of foliar and especially fruit symptoms is inconsistent from year to year, which is thought to be due to possibly climate-induced variability in toxin production by the pathogen. A severe form of Esca known as "apoplexy", which is more common in Europe, results in a sudden dieback of the entire shoot or adjacent shoots, rather than a gradual development of foliar symptoms.

### COMMENTS ON THE DISEASE

Symptoms first become apparent in vineyards 5 to 7 or more years old, but the infections actually occur in younger vines. The overwintering structures that produce spores (perithecia or pycnidia, depending on the pathogen) are embedded in diseased woody parts of vines. During fall to spring rainfall, spores are released and wounds made by dormant pruning provide infection sites. Wounds may remain susceptible to infection for several weeks after pruning with susceptibility declining over time. After a pruning wound is infected, the pathogen establishes a permanent, localized wood infection, which cannot be eradicated by fungicide applications.

### MANAGEMENT

See EUTYPA DIEBACK for management practices.

# EUTYPA DIEBACK (12/14)

**Pathogens:** *Eutypa lata* and other fungi in the Diatrypaceae family.

## SYMPTOMS AND SIGNS

*Eutypa dieback*, *Botryosphaeria dieback*, Esca, and *Phomopsis dieback* make up a complex of 'trunk diseases' caused by different wood-infecting fungi. *Eutypa dieback* delays shoot emergence in spring, and the shoots that eventually do grow have dwarfed, chlorotic leaves, sometimes with a cupped shape and/ or tattered margins. Symptomatic shoots are likely to either die back later that growing season or the spur from which they originate will die the following year. *Eutypa dieback* causes death of spurs, arms, cordons, canes, and sometimes the upper section of the trunk, depending on the location of the wood canker. Wedge-shaped wood cankers form in infected wood and are indistinguishable from those associated with *Botryosphaeria dieback* and *Phomopsis dieback*. Dead spurs and shoot dieback caused by *Eutypa dieback* are canopy symptoms shared in common among multiple trunk diseases, which often occur in mixed infection within the vineyard and even within an individual vine.

## COMMENTS ON THE DISEASE

Symptoms first become apparent in vineyards 5 to 7 or more years old, but the infections actually occur in younger vines. Perithecia, the overwintering structures that produce spores, are embedded in a stroma in diseased woody parts of vines. During winter rainfall, spores are released and wounds made by winter pruning provide infection sites. After a pruning wound is infected, the pathogen establishes a permanent, localized wood infection, which cannot be eradicated by fungicide applications. In California several plants in addition to cultivated grapevines serve as reservoirs for the pathogen including almond, apricot, apple, blueberry, cherry, crab apple, *Ceanothus* spp., kiwi, pear, oleander, and native plants (California buckeye, big leaf maple, and willow).

## MANAGEMENT

Every California vineyard is likely to eventually become infected with one or more trunk diseases. Preventative practices (delayed pruning, double pruning, and applications of pruning-wound protectants) are the most effective management approach for all trunk diseases. When adopted in young vineyards (i.e., under 5 years old) and used on an annual basis, these practices are likely to extend the profitable lifespan of a vineyard.

Under California conditions, delaying pruning to as late as possible in the dormant season (February or later) has been shown to be very effective in reducing the risk of infection. Delayed pruning takes advantage of reduced susceptibility of pruning wounds to infection and avoids the period of highest spore release during typically frequent rain events in December and January. Double pruning is a modified version of delayed pruning for large acreages of cordon-trained, spur-pruned vines; pre-pruning is done in early winter (most often mechanically) by cutting canes to 12 to 18-inches above the final pruning cuts, followed by hand pruning to create spurs in February or later. If delayed pruning is not feasible or for additional protection, consider treating pruning wounds with a protectant. Keep in mind that all wounds made in the dormant season are susceptible; this includes pruning cuts made to canes or larger cuts made to re-position/re-orient spurs.

Although preventative practices are most effective in young vineyards (before the vines become infected by trunk diseases), these practices have some utility in diseased mature vineyards. Wood cankers are very localized, thus protecting more pruning wounds means fewer new cankers each year resulting in fewer dead spurs, arms or canes over time.

Post-infection practices (sanitation and vine surgery) for use in diseased, mature vineyards are not as effective and are far more costly than adopting preventative practices (delayed pruning, double pruning, and applications of pruning-wound protectants) in young vineyards. Nonetheless, sanitation and vine surgery may help maintain yields. In spring, look for dead spurs or for stunted shoots. Later in summer, when there is a reduced chance of rainfall, practice good sanitation by cutting off these cankered portions of the vine beyond the canker, to where wood appears healthy. Then remove diseased, woody debris from the vineyard and destroy it. Vine surgery involves retraining new cordons or trunks as needed to maintain production. There is a higher success rate when retraining a new trunk, as most of the infections are concentrated in the upper portions of the permanent vine framework.

In addition to the fungicides labeled as pruning-wound protectants, consider using alternative materials, such as a wound sealant with 5% boron in acrylic paint (Tech-Gro B-Lock), which is effective against Eutypa dieback and Esca, or an essential oil (Safecoat VitiSeal).

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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REVISED: 7/15

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

A.	THIOPHANATE-METHYL (Topsin-M WSB) MODE-OF-ACTION GROUP NAME (NUMBER): Methyl benzimidazole carbamates (B1) COMMENTS: Can be applied as a paint or spray application. Use allowed under a Special Local Needs label.	See label	48	—
B.	MYCLOBUTANIL (Rally 40WSP) MODE-OF-ACTION GROUP NAME (NUMBER): Demethylation inhibitor (G1) COMMENTS: Do not apply more than 1.5 lb of product / acre per season.	4–5 oz	24	14
C.	TETRACONAZOLE (Mettle 125ME) MODE-OF-ACTION GROUP NAME (NUMBER): Demethylation inhibitor (G1) COMMENTS: Do not apply more than 10 fl oz / acre per season.	3–5 oz	12	

\*\* Apply with enough water to provide complete coverage.

‡ 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 R.E.I. exceeds the P.H.I. 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. Fungicides with a different Group number are suitable to alternate in a resistance management program. For more information, see <http://www.frac.info/>.

NA Not applicable.

# PHOMOPSIS CANE AND LEAFSPOT (12/14)

**Pathogen:** *Phomopsis viticola* (sexual stage: *Diaporthe ampelina*)

## SYMPTOMS AND SIGNS

Phomopsis cane and leafspot appears as tiny dark spots with yellowish margins on leaf blades and veins. Spots first show 3 to 4 weeks following rain. Leaf death may occur if large numbers of spots build up. Basal leaves with heavy infection become distorted and usually never develop to full size. On shoots, small spots with black centers similar to those found on leaves occur usually on a basal portion of the shoot. After spots lengthen a few millimeters, the epidermal layers of the shoots usually crack at the point of infection. Heavy infection usually results in a scabby appearance of the basal portions of the shoot. On clusters, spots similar to those that occur on shoots occur on the flower cluster stems.

Lesions on leaves, shoots, and clusters become inactive during the summer heat but rain just before harvest can cause light brown spots on clean berries and spots quickly enlarge and become dark brown. Berries may shrivel and become mummified. Infected canes appear bleached during the dormant season. Severely affected canes or spurs exhibit an irregular dark brown to black discoloration intermixed with whitish bleached areas. The black specks visible in the bleached areas are pycnidia that develop during the dormant season.

*Diaporthe ampelina* can also be a trunk disease pathogen causing perennial wood cankers, lack of spring growth, and dead spurs and cordons. For more information on management practices for this disease see the EUTYPA DIEBACK section.

## COMMENTS ON THE DISEASE

Because moisture is required for infection, this disease is most severe in northern grape-growing regions (North Coast and northern San Joaquin Valley) where spring rains are common after budbreak. Infections generally occur when shoots begin to grow. Spores are released in large quantities from the overwintering pycnidia on diseased canes and spurs. These are splashed by rain onto early developing shoots and infection occurs when free moisture remains on the unprotected green tissue for many hours.

## MANAGEMENT

Spur and cane lesions provide the inoculum for new infections. Reducing the source of the disease is important. Look for presence of lesions on spurs and canes in areas in the vineyard exhibiting poor budbreak. A treatment of liquid lime sulfur at 10 gallons per acre in 100 gallons of water before rainfall in winter will reduce the viability of pycnidia as well as reduce overwintering *Botrytis sclerotia* and powdery mildew spores.

In all areas where the disease is prevalent, spring foliar treatments are advisable if rainfall is predicted after budbreak. Apply materials before the first rain after budbreak and before 0.5 inch shoot length (and again when shoots are 5 to 6 inches in length). Contact materials such as ziram, and mancozeb must be reapplied after significant rainfall in order to protect shoots up to 18 inches in length. If several rains are predicted, use systemic fungicides such as kresoxim-methyl.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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REVISED: 7/15

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

### DORMANT SEASON

A. LIQUID LIME SULFUR#	Label rates	See label	See label
MODE-OF-ACTION GROUP NAME (NUMBER): Multi-site contact (M2)			
COMMENTS: Reduces overwintering structures of <i>Phomopsis</i> as well as <i>Botrytis</i> and powdery mildew spores.			

(12/14) Phomopsis Dieback 97

Illustrated version: <http://www.ipm.ucanr.edu/PMG/selectnewpest.grapes.html>

**SPRING FOLIAR TREATMENT**

A.	KRESOXIM-METHYL (Sovran)	3.2–4.8 oz	12	14
	MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11)			
	COMMENTS: Begin application at budbreak.			
B.	AZOXYSTROBIN (Abound)	11–15.4 fl oz	4	14
	MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11)			
	COMMENTS: Do not apply more than 3 sequential sprays; rotate with a fungicide that has a different mode of action. Apply before disease development begins. Follow label directions, especially as they pertain to number of applications allowed per year.			
C.	CAPTAN 50WP	3–4 lb	4 days	0
	MODE-OF-ACTION GROUP NAME (NUMBER): Multi-site contact (M4)			
	COMMENTS: Captan-treated grapes are prohibited in Canada. Do not apply more than 24 lb/acre per year. Do not apply in combination with, immediately before, or closely following oil sprays.			
D.	MANCOZEB (Dithane M-45)	Label rates	24	See comments
	MODE-OF-ACTION GROUP NAME (NUMBER): Multi-site contact (M3)			
	COMMENTS: Do not apply after fruit set or more than 7.5 lb/acre per season. Do not apply after bloom.			
E.	PYRACLOSTROBIN + BOSCALID (Pristine)	8–10.5 oz	24	14
	MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11) and Carboxamide (7)			
	COMMENTS: Do not apply on Concord, Worden, Fredonia, Niagara, and related varieties. Do not make more than 2 sequential applications; rotate to a fungicide with a different mode of action. The R.E.I. is 5 days when conducting cane tying, turning, or girdling.			
F.	ZIRAM (Ziram 76DF)	3–4 lb	48	10
	MODE-OF-ACTION GROUP NAME (NUMBER): Multi-site contact (M3)			
	COMMENTS: Apply before buds swell and repeat after blossoming but before fruit forms. Do not apply after bloom.			
G.	SULFUR# (Micro Sulf)	10 lb	See comments	See label
	MODE-OF-ACTION GROUP NAME (NUMBER): Multi-site contact (M2)			
	COMMENTS: In some counties there is a 3-day restricted entry period when using sulfur; consult your county agricultural commissioner. Apply just before or immediately after post-budbreak rains. Do not apply within 3 weeks of an oil application.			

\*\* Apply with enough water to provide complete coverage.

‡ 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 R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.

# Acceptable for use on organically grown produce.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a different Group number are suitable to alternate in a resistance management program. For more information, see <http://www.frac.info/>.

## PHOMOPSIS DIEBACK (7/15)

**Pathogen:** *Phomopsis viticola* (sexual stage: *Diaporthe ampelina*)

### SYMPTOMS AND SIGNS

Phomopsis dieback, Botryosphaeria dieback, Esca, and Eutypa dieback make up a complex of 'trunk diseases' caused by different wood-infecting fungi. Wedge-shaped wood cankers form in infected wood and are indistinguishable from those associated with Botryosphaeria dieback and Eutypa dieback. Dead spurs and dieback caused by *Diaporthe ampelina* are symptoms shared in common among multiple trunk diseases, which often occur in mixed infection within the vineyard and even within an individual vine.

### COMMENTS ON THE DISEASE

Symptoms first become apparent in vineyards 5 to 7 or more years old, but the infections actually occur in younger vines. Pycnidia, the overwintering structures that produce spores, are embedded in diseased woody parts of vines. During fall to spring rainfall, spores are released and wounds made by dormant pruning provide infection sites. After a pruning wound is infected, the pathogen establishes a permanent, localized wood infection, which cannot be eradicated by fungicide applications.

### MANAGEMENT

See EUTYPA DIEBACK for management practices.



## PIERCE'S DISEASE (12/14)

**Pathogen:** *Xylella fastidiosa*

### SYMPTOMS AND SIGNS

Symptoms of Pierce's disease vary depending when a vine became infected. Chronically diseased vines were infected the previous growing season (or in years prior) and symptoms are more severe as compared to vines infected in the current spring. The following four symptoms in mid- to late summer indicate the presence of Pierce's disease in chronically diseased grapevines: (1) leaves become slightly yellow or red along margins in white and red varieties, respectively, and eventually leaf margins dry or die in concentric zones; (2) fruit clusters shrivel or raisin; (3) dried leaves fall leaving the petiole (leaf stem) attached to the cane ("matchsticks"); and (4) wood on new canes matures irregularly, producing patches of green, surrounded by mature brown bark ("green islands"). Not all four symptoms are required to be present in vines infected with the pathogen.

In vines that are infected in spring, usually only one or two shoots will show Pierce's disease symptoms late in the first season of infection, and these may be difficult to notice in varieties other than Pinot noir Barbara or Chardonnay which are very susceptible to this disease. Symptoms gradually spread along the cane from the point of infection toward the shoot tip and more slowly towards the base. By mid-season some or all fruit clusters on the infected cane of susceptible varieties may wilt and dry. Tips of canes may die back; roots may also die back.

Leaf symptoms vary among grape varieties. Pinot noir and Cabernet Sauvignon have highly regular zones of progressive marginal discoloration and drying on blades. In Chardonnay, Thompson Seedless, Sylvaner, and Chenin blanc, the discoloration and scorching may occur in sectors of the leaf rather than along the margins. Vines of susceptible varieties deteriorate rapidly after appearance of symptoms, especially in young vines where symptoms may appear over the entire vines in a single year.

Shoot growth of infected plants becomes progressively weaker as symptoms become more pronounced. In chronically diseased vines, the woody portions of the vine are usually dry and portions of the vine (arms or a cordon) may be dead. The last part of the vine to die is often the crown near the soil line; rootstock or scion suckers at the base of the vine may be present for a year or two prior to vine death.

Climatic differences between regions can affect the timing and severity of symptoms, but not the type of symptoms. Hot climates accelerate symptom development because vine water stress is more severe even with adequate soil moisture.

A year after the vines are infected some canes or spurs may fail to bud out, and shoot growth is stunted. This may occur in vines that did not have obvious symptoms the preceding year. New leaves become chlorotic (yellow) between leaf veins, and scorching appears on older leaves. From late April through summer infected vines may grow at a normal rate, but the total new growth is less than that of healthy vines. In late summer leaf burning symptoms reappear.

### COMMENTS ON THE DISEASE

*Xylella fastidiosa* is a bacterium that lives in the water-conducting system (the xylem) of host plants and is spread from plant to plant by sap-feeding insects that feed on xylem fluid. Symptoms appear when significant blockage occurs within xylem vessels due to the growth of the bacteria. (This bacterium is also responsible for alfalfa dwarf disease and almond leaf scorch in California.) Insect vectors for Pierce's disease belong to the sharpshooter (Cicadellidae) and spittlebug (Cercopidae) families. The blue-green sharpshooter (*Graphocephala atropunctata*) is the most important vector in coastal areas. The green sharpshooter (*Draeculacephala minerva*) and the red-headed sharpshooter (*Carneocephala fulgida*) are also present in coastal areas but are more important as vectors of this disease in the Central Valley. Other sucking insects, such as grape leafhoppers, are not vectors.

The glassy-winged sharpshooter is a vector of Pierce's Disease that became established in Southern California in the early 1990's and is a serious threat to California vineyards because compared to other vectors it flies greater distances and occurs on a wider range of host plants in various habitats. Unless

monitoring for glassy-winged sharpshooter and preventative measures are maintained, the insect is expected to spread north and eventually become established in more regions.

The principal breeding habitat for the blue-green sharpshooter is riparian (riverbank) vegetation, although ornamental landscape plants may also harbor breeding populations. As the season progresses, these insects shift their feeding preference, always preferring to feed on plants with succulent growth. In the Central Valley, irrigated pastures, hay fields, or grasses on ditch backs are the principal breeding and feeding habitats for the green and red-headed sharpshooters. These two grass-feeding sharpshooters also occur along ditches, streams, or roadsides where grasses and sedges provide suitable breeding habitat.

Glassy-winged sharpshooter feeds and reproduces on several genera of trees, woody ornamentals, and annuals in its region of origin, the southeastern United States. Crepe myrtle and sumac are especially preferred. It reproduces on Eucalyptus, coast live oaks, and a wide range of trees in southern California.

Some vines recover from Pierce's disease; the probability of recovery depends on the date of infection and temperatures in the winter following infection. Vines that become infected in June or later by blue-green, green and red-headed sharpshooter vectors have the greatest probability of recovery. Therefore preventing spring infections (bud break through May) is critical to prevent systemic infections that cause chronic disease. Recovery is promoted by low winter temperatures; mild winters result in fewer vine recoveries.

Recovery rates also depend on grape cultivar; recovery is higher in Chenin blanc, Sylvaner, Ruby Cabernet, and White Riesling, compared to Barbera, Chardonnay, Mission, Fiesta, and Pinot noir. Thompson Seedless, Cabernet Sauvignon, Gray Riesling, Merlot, Napa Gamay, Petite Sirah, and Sauvignon Blanc are intermediate in their susceptibility to this disease and in their probability of recovery. In tolerant cultivars the bacteria spread more slowly within the plant than in more susceptible cultivars. Once the vine has been infected for over a year (i.e., bacteria survive the first winter and symptoms occur the following spring) recovery is much less likely. In susceptible varieties, recovery is unlikely if disease symptoms are apparent in the growing season they became infected.

Young vines are more susceptible than mature vines. Rootstock species and hybrids vary greatly in susceptibility. Many rootstock species are resistant to Pierce's disease, but the rootstock does not confer resistance to susceptible *Vinifera* varieties grafted on to it.

## MANAGEMENT

Insecticide treatments aimed at controlling the vector in areas adjacent to the vineyard have reduced the incidence of Pierce's disease by reducing the numbers of sharpshooters immigrating into the vineyards in early spring. The degree of control, however, is not effective for very susceptible varieties such as Chardonnay and Pinot Noir or for vines less than 3 years old. If a vineyard is near an area with a history of Pierce's disease, plant varieties that are less susceptible to this disease. Monitor and treat for insect vectors as described in the section on SHARPSHOOTERS.

During the dormant season, remove vines that have had Pierce's symptoms for more than one year; they are unlikely to recover or produce a significant crop. Also, remove vines with extensive foliar symptoms on most canes and with tip dieback of canes even if it is the first year that symptoms have been evident. From summer through harvest, mark slightly symptomatic vines; reexamine for symptoms the following spring through late summer or fall and remove vines that have symptoms for a second year. Research has shown that severe pruning – cutting a few inches above the graft union – and training up a new trunk is not a viable management practice; Pierce's disease symptoms reappear the second year.

Late season (after May) and winter feeding by the glassy-winged sharpshooter results in infections that can survive the winter to cause chronic Pierce's disease. This enables vine-to-vine spread of Pierce's disease, which has previously not been the case in California. Removing diseased vines as soon as possible when Pierce's disease first appears in a vineyard when glassy-winged sharpshooter is the vector is critical to help reduce the infection rate. Insecticide treatments of adjacent breeding habitats, such as citrus groves, have been the most effective approach in Southern California.

Riparian vegetation management has proven to be effective in reducing the damaging spring populations of blue-green sharpshooters in the North Coast; however approval of this strategy must comply with federal,

state, and local regulations. The unauthorized removal of vegetation is prohibited or restricted due to concerns for water quality and habitat for anadromous fish (fish born in fresh water, spends most of its life in the sea and return to fresh water to spawn). Contact the California Department of Fish and Wildlife for more information.

# POWDERY MILDEW (12/14)

**Pathogen:** *Erysiphe necator*

## SYMPTOMS AND SIGNS

Initial symptoms of powdery mildew appear on leaves as chlorotic spots on the upper leaf surface. Signs of the pathogen appear a short time later as white, webby mycelium on the lower leaf surface. As spores are produced, the infected areas take on a white, powdery or dusty appearance. On fruit and rachises the pathogen appears as white, powdery masses that may colonize the entire berry surface. Black to brown web scarring can be seen on mature fruit, which represents former colonies. Symptoms of powdery mildew infection include red blotchy areas on dormant canes.

## COMMENTS ON THE DISEASE

The fungus survives the winter as mycelia infecting tissue inside dormant buds or as chasmothecia (spore producing fruiting bodies).

Chasmothecia are the most important sources of overwintering inoculum in most production areas. Ascospores mature in late summer and fall on infected green tissue and are washed onto the permanent vine parts such as cordons and arms with fall and winter rainfall where they overwinter. On warm winter and spring days when moisture is abundant, chasmothecia burst and release ascospores that stick and germinate on the underside of leaves. Conidial spore production occurs 7 to 10 days after primary infection by ascospores and conidia will continue to be produced throughout the season as long as moderate temperatures (70° to 85°F) exist.

If the fungus overwintered as mycelia inside dormant buds, then emerging shoots may become diseased shortly after bud break. These are flag shoots that will produce conidia that spread to adjacent shoots. At long duration high temperatures in the spring (over 80°F), symptoms are rarely seen. However at temperatures between 70° and 85°F, symptoms and signs of the fungus occur immediately after budbreak. Between 60° and 68°F, symptoms are delayed.

## MANAGEMENT

Season-long control is dependent upon reducing early-season inoculum and subsequent infection. Thus treatment must begin promptly and be repeated at appropriate intervals. Timing of the first treatment is dependent on the fungicide used, vine growth stage, and the potential for disease infection. Free moisture from fog, dew or rain events triggers ascospore release and after budbreak, infections caused by ascospores will occur on green tissue when temperature exceeds 50 °F. Apply a contact material as soon as possible to eradicate those colonies prior to the onset of conidial spore production. Under completely dry conditions, the potential for infection is significantly reduced. Research has shown that a micronized sprayable sulfur application or oil should be applied prior to other fungicides. If applied near budbreak, then apply an additional sulfur or oil treatment based on the Powdery Mildew Risk Index prior to using other fungicides. Frequency of treatment thereafter depends on fungicide choice and weather conditions. Monitor and use the UC Davis powdery mildew risk index model to determine necessary spray intervals and material choice. Treatment may be discontinued for wine and traditionally trellised raisin grapes when fruit reaches 12 Brix but should be continued up to harvest for table grapes or 3 to 4 weeks prior to cane severance for DOV trellised raisin grapes.

All powdery mildew fungicides, with the exception of oil, are best used as protectants. Discontinue the use of soft chemistry products (sulfurs, biologicals, systemic acquired resistance products, and contact materials) when disease pressure is high because by themselves they will not provide adequate control. If eradication is necessary, a light summer oil may be used anytime in the season if there is no sulfur residue present (i.e. at least 2 weeks before or after a sulfur treatment). Basal leaf removal can improve coverage of powdery mildew fungicides on clusters and leaf removal by itself (as done for Botrytis control) results in 50% disease control.

### Organically Acceptable Methods

Sulfur, Serenade Max, Sonata, M-Pede, Organic JMS Stylet Oil, and Purespray Green horticultural oil are acceptable on organically certified grapes; check with your certifier for details.

### Monitoring and Treatment Decisions

In spring, the overwintering chasmothecia produce ascospores which are released when 2mm of rain, irrigation or dew occurs to wet the cordons or canes. Infection occurs when the wetness period is followed by 10 to 13 hours of leaf wetness when temperatures remain between 50° and 80°F. Seven to 10 days after this initial infection, monitor vineyards for the presence of powdery mildew by collecting 10 to 15 basal leaves from approximately 20 vines at random and examining the undersurface for powdery mildew spores. If lesions are found, then monitor disease development by using the powdery mildew risk assessment index.

**Risk Index (RI)** . Once initial infection occurs, ideal temperatures for growth of the fungus are between 70° and 85°F. Temperatures above 95°F for 12 continuous hours or longer cause the fungus to grow more slowly. The RI assesses the risk of disease development by relating it to air temperature and predicts the need to spray to protect the vines. When using the RI, always monitor the vineyard for signs of the disease. You may monitor temperatures in your own vineyard and calculate the RI using the rules below, or you may use weather equipment that has the UC Davis powdery mildew risk index included in its software.

#### *Initiating the Risk Index*

After you find powdery mildew infections caused by ascospores, an epidemic will begin (conidia will begin generating new infection sites) when there are 3 consecutive days with 6 or more continuous hours of temperatures between 70° and 85°F as measured in the vine canopy.

1. Starting with the index at 0 on the first day, add 20 points for each day with 6 or more continuous hours of temperatures between 70° and 85°F.
2. Until the index reaches 60, if a day has fewer than 6 continuous hours of temperatures between 70° and 85°F, reset the index to 0 and continue.
3. If the index reaches 60, an epidemic is under way. Begin using the spray-timing phase of the index.

#### *Spray timing*

Each day, starting on the day after the index reached 60 points during the start phase, evaluate the temperatures and adjust the previous day's index according to the rules below. Keep a running tabulation throughout the season. In assigning points, note the following:

- If the index is already at 100, you can't add points.
- If the index is already at 0, you can't subtract points.
- You can't add more than 20 points a day.
- You can't subtract more than 10 points a day.
  1. If fewer than 6 continuous hours of temperatures occurred between 70° and 85°F, subtract 10 points.
  2. If 6 or more continuous hours of temperatures occurred between 70° and 85°F, add 20 points.
  3. If temperatures reached 95°F for more than 15 minutes, subtract 10 points.
  4. If there are 6 or more continuous hours with temperatures between 70° and 85°F AND the temperature rises to or above 95°F for at least 15 minutes, add 10 points. (This is the equivalent of combining points 2 and 3 above.)

Use the index to determine disease pressure and how often you need to spray to protect the vines. Spray intervals can be shortened or lengthened depending on disease pressure, as indicated in the table below. The schedule assumes adequate coverage; the use of calibrated sprayers and sufficient gallons per acre appropriate for type of sprayer and vineyard trellis.

**SPRAY INTERVALS BY FUNGICIDE GROUPS BASED ON DISEASE PRESSURE USING THE UC DAVIS POWDERY MILDEW RISK INDEX MODEL**

Index	Disease pressure	Pathogen status	Suggested spray schedule			
			Biologicals <sup>1</sup> and SARs <sup>2</sup>	Sulfur	Demethylation-inhibitors (DMI) <sup>3</sup>	Strobilurins and Quinolines <sup>4</sup>
0-30	low	present	7- to 14-day interval	14- to 21-day interval	21-day interval or label interval	21-day interval or label interval
40-50	moderate	reproduces every 15 days	7-day interval	10- to 17-day interval	21-day interval	21-day interval
60 or above	high	reproduces every 5 days	use not recommended	7-day interval	10- to 14-day interval	14-day interval

- <sup>1</sup> *Bacillus pumilis* (Sonata) and *Bacillus subtilis* (Serenade Max)
- <sup>2</sup> SAR = Systemic acquired resistance products
- <sup>3</sup> Tebuconazole (Elite), triflumizole (Viticure), and myclobutanil (Rally)
- <sup>4</sup> Trifloxystrobin (Flint), kresoxim-methyl (Sovran), and pyraclostrobin/boscalid (Pristine)

**Resistance Management**

Alternating fungicides with different modes of action is essential to prevent pathogen populations from developing resistance to classes of fungicides. This resistance management strategy should not include alternating or tank mixing with products to which resistance has already developed. Rotate with fungicides that have a different mode of action. Research has shown that sequential sprays of products with the same mode of action can lead to the development of reduced sensitivity to the active ingredient(s). Some fungicides have two active ingredients and thus two modes of action. When using such materials, do not alternate with other fungicides that contain one of the same modes of action (i.e. they represent the same fungicide class).

Common name (Example trade name)	Amount per acre**	R.E.I.† (hours)	P.H.I.‡ (days)
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*When choosing a pesticide, consider its usefulness in an IPM program by reviewing the pesticide's properties, efficacy, application timing, and information relating to resistance management, honey bees, and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.*

**Note:** Treatments can be made in conjunction with plant growth regulators and other applications.

**DEMETHYLATION INHIBITORS (DMIs)**

A. TEBUCONAZOLE (Elite 45WP)	4 oz	12	14
MODE-OF-ACTION GROUP NAME (NUMBER): Demethylation inhibitor (3)			
COMMENTS: Do not apply more than 2 lb of product/acre per season.			
B. TRIFLUMIZOLE (Viticure)	4–8 fl oz	12	7
MODE-OF-ACTION GROUP NAME (NUMBER): Demethylation inhibitor (3)			
COMMENTS: Do not apply more than 32 fl oz of product/acre per season.			
C. MYCLOBUTANIL (Rally 40WSP)	4–5 oz more gal water/acre	24	14
MODE-OF-ACTION GROUP NAME (NUMBER): Demethylation inhibitor (3)			
COMMENTS: Do not apply more than 1.5 lb of product/acre per season.			
D. TETRACONAZOLE (Mettle 125ME)	3–5 fl oz	12	14
MODE-OF-ACTION GROUP NAME (NUMBER): Demethylation inhibitor (3)			

<b>Common name (Example trade name)</b>	<b>Amount per acre**</b>	<b>R.E.I.‡ (hours)</b>	<b>P.H.I.‡ (days)</b>
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COMMENTS: Do not apply more than 10 fl oz of product/acre per season.

E. FLUTRIAFOL (Rhyme)	4-5 fl oz	12	14
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MODE-OF-ACTION GROUP NAME (NUMBER): Demethylation inhibitor (3)  
COMMENTS: The R.E.I. is 5 days for girdling or turning of grapes. The R.E.I. for all other activities is 12 hours.

**STROBILURINS (QUINONE OUTSIDE INHIBITORS)**

A. AZOXYSTROBIN (Abound)	10–15.5 fl oz	4	14
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MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11)  
COMMENTS: Do not apply more than 92.3 fl oz of product/acre per season.

B. TRIFLOXYSTROBIN (Flint)	1.5–2 oz	12	14
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MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11)  
COMMENTS: Do not apply to Concord grapes or crop injury may result. Do not apply more than 24 oz of product/acre per season.

C. KRESOXIM-METHYL (Sovran)	3.2–4.8 oz	12	14
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MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11)  
COMMENTS: Do not apply more than 1.6 lb of product/acre per season.

**QUINOLINES**

A. QUINOXYFEN (Quintec)	3–6.6 fl oz	12	See label
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MODE-OF-ACTION GROUP NAME (NUMBER): Quinoline (13)  
COMMENTS: Do not apply more than 33 fl oz of product/acre per season.

**BENZOPHENONE**

A. METRAFENONE (Vivando)	10.3–15.4 fl oz	12	14
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MODE-OF-ACTION GROUP NAME (NUMBER): Unknown (U8)  
COMMENTS: Do not apply more than 46.2 fl oz of product/acre per season.

**PHENYL-ACETAMIDE**

A. CYFLUFENAMID (Torino)	3.4 fl oz (0.022 lb a.i.)	4	3
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MODE-OF-ACTION GROUP NAME (NUMBER): Unknown (U6)  
COMMENTS: Do not apply more than 0.044 lb a.i. of product/acre per season. Do not make more than 2 applications per year.

**MULTIPLE ACTIVE INGREDIENT FORMULATIONS**

A. FLUOPYRAM + TEBUCONAZOLE (Luna Experience)	6–8.6 fl oz	12	14
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MODE-OF-ACTION GROUP NAME (NUMBER): Succinate dehydrogenase inhibitor (7) + Demethylation inhibitor (3)  
COMMENTS: For use on wine grapes only. The R.E.I. is 5 days for treated wine grapes when conducting cane tying, turning, or girdling. Do not apply more than 34 fl oz/acre per season.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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B. DIFENOCONAZOLE + CYPRODINIL (Inspire Super)	14–20 fl oz	12	14
MODE-OF-ACTION GROUP NAME (NUMBER): Demethylation inhibitor (3) and Anilinopyrimidine (9)			
COMMENTS: Do not apply more than 80 fl oz of product/acre per season.			
C. DIFENOCONAZOLE + AZOXYSTROBIN (Quadris Top)	10–14 fl oz	12	14
MODE-OF-ACTION GROUP NAME (NUMBER): Demethylation inhibitor (3) and Quinone outside inhibitor (11)			
COMMENTS: Do not apply more than 56 fl oz/acre per season.			
D. PYRACLOSTROBIN + BOSCALID (Pristine)	8–12.5 fl oz	12	14
MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11) and Carboxamide (7)			
COMMENTS: Do not use on Concord, Worden, Fredonia, Niagara, or related grape varieties. The R.E.I. is 5 days for treated grapes when conducting cane tying, turning, or girdling. Do not apply more than 69 oz/acre per season.			

**ELEMENTAL SULFUR**

A. SULFUR# (dust, wettable, flowable, or micronized)	Label rates	See comments	See label
MODE-OF-ACTION GROUP NAME (NUMBER): Multi-site contact (M2)			
COMMENTS: In some counties there is a 3-day restricted entry period when using sulfur; consult your county agricultural commissioner. To help prevent off-site drift, use sprayable sulfur instead of dusting sulfur when canopies are minimal (less than 12 inches). Begin treatment at budbreak to 2-inch shoot growth. Reapply at 7-day intervals if treating every other middle or at 10-day intervals if treating every middle. Using the Powdery Mildew Risk Index to time applications may reduce total applications in very cool or warmer production areas. Reapply if sulfur is washed off by rain or irrigation. Sulfur can cause injury to foliage and fruit when applied just before or on days when the temperature exceeds 100° F. The amount per acre may be reduced during periods of high temperature to prevent burning. Do not apply within 2 weeks of an oil application.			

**BIOLOGICALS**

A. BACILLUS PUMILIS# (Sonata)	2–4 qt	4	0
MODE OF ACTION: Microbial (44)			
COMMENTS: Begin making applications before disease onset or when disease pressure is low. Repeat at 7- to 10-day intervals until disease pressure is intermediate, then switch to a strobilurin, sterol inhibitor, oil, or sulfur; for certified organic production rotate to a fungicide approved by your certifier. Apply in sufficient water to obtain thorough coverage.			
B. BACILLUS SUBTILIS# (Serenade Max)	1–3 lb	4	0
MODE OF ACTION: Microbial (44)			
COMMENTS: Begin making applications before disease onset or when disease pressure is low. Repeat at 7- to 10-day intervals until disease pressure is intermediate, then switch to a strobilurin, sterol inhibitor, oil, or sulfur; for certified organic production rotate to a fungicide approved by your certifier. Apply in sufficient water to obtain thorough coverage.			



Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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**CONTACT MATERIALS**

A.	NARROW RANGE OIL# (JMS Stylet Oil, Saf-T-Side, etc.)	1–2%	4	0
	MODE-OF-ACTION GROUP NAME (NUMBER): A contact fungicide with smothering and barrier effects (NC)			
	COMMENTS: Never mix oil and sulfur or apply one within 2 weeks of the other. Can be used as a protectant or eradicant. As a protectant, alternate it prebloom with the sterol inhibitors. At the 1–2% rate, this oil is an excellent eradicant and can be used as a stand-alone program at anytime during the season (except within 2 weeks of a sulfur treatment); good coverage is essential. Apply at 14- to 18-day intervals. Oils can vary in their potential for phytotoxicity. Do not use on table grapes after berry set. For certified organic production, rotate to a fungicide approved by your certifier.			
B.	POTASSIUM BICARBONATE# (Kaligreen)	2.5–5 lb	4	1
	(MilStop)	2.5–5 lb	1	0
	MODE OF ACTION: An inorganic salt (NC)			
	COMMENTS: Conditionally acceptable for use on organically grown produce; check with your certifier. Apply by ground only in sufficient water (25 gal/ acre minimum) to ensure complete and thorough coverage of foliage and crop. Most effective when alternated with a sterol inhibitor and used as a protectant. Field reports suggest eradicant activity; but this has not been demonstrated in University research. If used as an eradicant, contact with the disease organism is essential. Use of non-acidifying spreader-sticker or nonphytotoxic crop oil is recommended.			
C.	FUNGICIDAL SOAP# (M-Pede)	1.5–2%	12	0
	MODE-OF-ACTION GROUP NAME (NUMBER): A contact fungicide with smothering and barrier effects.			
	COMMENTS: Alternate use with a fungicide of a different mode of action; for certified organic production rotate to a fungicide approved by your certifier. Apply in 100 to 150 gal water/ acre. Complete coverage of upper and lower leaf surfaces, as well as grape clusters, is essential for control. Apply every 7 to 10 days. Do not combine with sulfur or apply within 3 days of a sulfur application. Do not apply to Calmeria or Italia varieties of grapes. Do not apply past veraison.			
D.	LIQUID LIME SULFUR# (Brandt lime sulfur)	10 gal in 100 gal water	See label	See label
	MODE OF ACTION: Multi-site contact (M2)			
	COMMENTS: As a dormant application, reduces overwintering structures of powdery mildew as well as <i>Phomopsis</i> and <i>Botrytis</i> . Sprays should be directed to the cordons and fruiting wood to ensure drenching occurs.			

\*\* Apply with enough water to provide complete coverage.

‡ 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 R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.

# Acceptable for use on organically grown produce.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. NC = not classified. Fungicides with a different Group number are suitable to alternate in a resistance management program. For more information, see <http://www.frac.info/>.

## SUMMER BUNCH ROT (12/16)

**Pathogens:** *Aspergillus niger*, *Alternaria carbonarius*, *Alternaria tenuis*, *Botrytis cinerea*, *Cladosporium herbarum*, *Rhizopus arrhizus*, *Penicillium* sp., and others

### SYMPTOMS AND SIGNS

As berries ripen and sugar content exceeds 8%, injured fruit become increasingly susceptible to invasion by a wide variety of naturally occurring fungi. Invasion occurs at the point of berry injury caused by insect or bird feeding, mechanical or growth cracks, or lesions resulting from powdery mildew infection or esca (black measles) berry damage that results in cracking. The resulting rot can be severe as it progresses beyond the original injury. Masses of black, brown, or green spores develop on the surface of infected berries. Bunch rots often culminates in sour rot, primarily in the central and southern San Joaquin Valley. Sour rot is caused by a variety of microorganisms, including acetic acid bacteria, which are spread by drosophila flies attracted to the rotting clusters.

Melting decay or Non Botrytis Slip Skin (NBSS) of Redglobe and Crimson grapes is caused primarily by *Hanseniaspora* spp. These yeasts colonize the sugary and nutrient rich epidermis of berries after they are covered by the oozing liquid resulting from sour rot infections. Symptoms include hairline cracks in the berry skin, watery discoloration of berries, and general berry breakdown. Decay continues to develop slowly under cold storage conditions.

### MANAGEMENT

Rotting fruit clusters present during veraison are indicative of summer bunch rot. Management of this disease complex is based on reducing injury or damage to the fruit, thus preventing invasion by bunch rot organisms. Basal leaf removal at or after berry set has given excellent control of summer bunch rot in the San Joaquin Valley. In warmer growing areas, be careful not to remove excessive numbers of leaves, which can lead to sunburned fruit. Remove leaves only from the side of the vine that receives afternoon shade. Also, leafhopper populations and damage caused by omnivorous leafroller have been reduced by this cultural practice. Treat at preclose and veraison if summer bunch rot has been a problem in the past.

To reduce growth-related damage to the berries, follow proper irrigation, fertilizer, fruit thinning, and canopy management practices. Trellis and prune to achieve vine balance between vegetative growth and cluster number. Also control powdery mildew and damaging populations of omnivorous leafroller and other berry feeders.

In table grapes, look for symptoms of summer rot on fruit during harvest to assess this year's management program and to prepare for next year. The presence of drosophila flies may indicate summer bunch rot infections. Control of NBSS can be achieved by controlling sour rot in the vineyard and in table grape vineyards, by not harvesting "dripped on" clusters.

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
UPDATED: 12/16			
<i>When choosing a pesticide, consider its usefulness in an IPM program by reviewing the pesticide's properties, efficacy, application timing, and information relating to resistance management, honey bees, and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.</i>			
<b>Note:</b> <i>Treatments can be made in conjunction with plant growth regulators and other applications.</i>			
A. CYPRODINIL + FLUDIOXONIL (Switch 62.5WG)	11–14 oz	12	7
MODE-OF-ACTION GROUP NAME (NUMBER): Anilinopyrimidine (9) and Phenylpyrrole (12)			
COMMENTS: Do not apply in less than 21-day intervals. Do not make more than two sequential applications; rotate to a fungicide with a different mode of action.			
B. PYRACLOSTROBIN + BOSCALID (Pristine)	8–12.5 oz	12	14
MODE-OF-ACTION GROUP NAME (NUMBER): Quinone outside inhibitor (11) and Carboxamide (7)			
COMMENTS: Do not use on Concord, Worden, Fredonia, Niagara, or related grape varieties. Do not make more than two sequential applications; rotate to a fungicide with a different mode of action. The R.E.I. is 5 days for treated grapes when conducting cane tying, turning, or girdling.			
C. COPPER# (various)	Label rates	48	See label
MODE-OF-ACTION GROUP NAME (NUMBER): Multi-site contact (M1)			
COMMENTS: For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. rate on any label when tank mixing products that contain the same a.i.			

\*\* Apply with enough water to provide complete coverage.

‡ 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 R.E.I. exceeds the P.H.I. 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. Fungicides with a different Group number are suitable to alternate in a resistance management program. For more information, see <http://www.frac.info/>.

# Acceptable for use on organically grown produce.

## VIRUS DISEASES (7/15)

**Pathogens:** Various viruses

Grapevines harbor over 60 virus and virus-like agents that cause a range of disease symptoms that can vary from mild causing little to no economic effect to very serious causing reduced yield, delayed ripening, and even vine death. In California there are several damaging diseases caused by virus and virus-like agents that are widespread in vineyards. Fanleaf degeneration, Leafroll Disease, Rootstock Stem Lesion and Corky Bark are the most common virus diseases in California. The virus that causes Grapevine Red Blotch Disease was found in 2012 and the incidence of this disease relative to other virus diseases is currently not known. For more information on specific virus diseases refer to Grape Pest Management, UC ANR 3343.

The intensity of virus symptoms depends on the cultivar of grape (scion and rootstock), and the weather during the growing season. Although some disease symptoms are diagnostic, the absence of symptoms is not a reliable indication that a plant is virus-free. Many grapevine viruses are latent (not showing symptoms nor causing disease) under certain circumstances. Using propagating wood that carries these latent viruses may lead to serious diseases or even vine death in a highly susceptible cultivar of rootstock or scion.

Vineyards planted or grafted with virus-infected material will often be impacted in the first year and any chronic effects of the viral infection are experienced over the entire life of the vineyard. To avoid losses from virus diseases, it is necessary to use clean stock in propagation that has been tested for known grape viruses.

### MANAGEMENT

Laboratory testing is an available tool to diagnose potential virus infected vines. Commercial labs offer serological (ELISA) and nucleic acid based assays (PCR) for identifying the presence of specific viral pathogens. The diagnostic lab should be consulted prior to collecting samples to avoid test results which are false negatives. Timing, type of material to be collected and sample handling is important.

The most important control of virus disease is the use of clean plant material for the propagation of vines to be planted in growers' vineyards and for budwood used for grafting mature vineyards. The most reliable way to avoid planting virus-infected vines is to use plant material that has been certified to have been planted, grown and distributed under the California Registration & Certification (R & C) Program administered by the California Department of Food and Agriculture (CDFA). Growers should insist that grapevine nurseries provide certified stock, which should be accompanied by an official tag issued by CDFA. Nurseries participating in the R & C program obtain their wood from the Foundation Plant Services at the University of California, Davis. UC Davis has a foundation vineyard for major grape cultivars and clonal selections. Before planting in the foundation vineyard, selections are tested for viruses using various methods including biological indicators, as well as ELISA and advanced PCR assays. The foundation vineyard is visually monitored in spring and fall and a portion is retested each year for viruses known to be spread naturally.

Natural spread of specific grapevine viruses can occur by insects and nematodes. Vectors can acquire the virus by feeding on vines infected with such viruses. To prevent vines from becoming infected in the field, control measures target the vectors. *Grapevine leafroll associated virus-3* (GLRaV-3) is vectored by mealybugs and scale insects. As vectors, mealybugs typically carry GLRaV-3 in their foregut for short periods, losing the virus after each molt. The smaller stages (crawlers and second instars) are the most effective life stages in terms of their efficiency at acquiring leafroll virus (feeding on an infected plant and picking up the virus) and transmitting it (placing the pathogen in another plant by feeding). Mealybug crawlers acquire the pathogen from an infected vine, disperse short or long distances by wind, feed for a short time and transmit the virus to clean vines. Disease symptoms may not be apparent until the season following the year vines are infected. This type of spread occurs even at low densities of mealybugs that would not be considered an economic problem if not for the potential for disease spread.

Leafroll infected blocks can be a source for mealybug vector and disease spread into adjacent clean plantings. Treatment of mealybugs in virus source blocks should reduce the number of infective vectors leaving the block. Treatment of clean blocks should target these vectors the same season they are first detected to reduce secondary spread to adjacent vines. Research has shown that secondary spread of virus is reduced when growers coordinate their efforts in area wide programs that reduce insect vector populations in combination with removal of GLRaV-infected vines. Vine removal as a control measure is most effective when disease incidence is low. See MEALYBUGS for recommended control practices.

## Nematodes

(Section reviewed 6/16)

**Scientific Names:** Root knot nematodes: *Meloidogyne incognita*, *M. javanica*, *M. arenaria*, *M. hapla* and *M. chitwoodi*  
 Dagger nematodes: *Xiphinema americanum* and *X. index*  
 Needle nematodes: *Longidorus africanus*  
 Citrus nematode: *Tylenchulus semipenetrans*  
 Root lesion nematode: *Pratylenchus vulnus*  
 Ring nematode: *Mesocriconema* (= *Criconemella*) *xenoplax*  
 Sheath nematode: *Hemicriconemoides* spp.

### DESCRIPTION OF THE PESTS

Plant-parasitic nematodes are microscopic, unsegmented roundworms that feed on plant roots by puncturing cell walls and withdrawing cell contents by means of a protrusible hypodermic structure called a stylet. They live within root tissues and in the water films that surround soil particles and roots.

The types of plant-parasitic nematodes that become established in a vineyard are determined by the nematodes present in the soil at planting, the nematodes in irrigation water, sanitation and cleanliness of nursery stock, susceptibility of the selected rootstock, the nematode host status of cover-crops and native vegetation, and the movement of nematodes with soil by vehicles. Of the many genera of plant parasitic nematodes detected in soils from California vineyards, dagger, ring, and lesion nematodes are the most prevalent in north and central coast vineyards, and in the San Joaquin Valley.

As the name implies ring nematodes have a deeply striated cuticle, which gives the appearance of rings. Ring nematode occurs in sandy or fine clay soils, especially waterlogged soils. Root knot, dagger and citrus nematodes occur most commonly in the San Joaquin Valley and southern California. Populations of root-knot nematodes are best adapted to loamy sand and sandy loam soils; citrus nematodes favors sandy and clay loam soils. The needle nematode is mainly found in southern California.

Other nematodes associated with grape in California include stubby root nematode, *Paratrichodorus minor*; spiral nematode, *Helicotylenchus pseudorobustus*; sheath nematode, *Hemicycliophora* spp. and pin nematode, *Paratylenchus hamatus*.

### DAMAGE

Plant-parasitic nematodes feed on roots, reducing vigor and yield of the vine usually in irregular patterns across the vineyard. Damage patterns are frequently associated with soil textural differences. The plant-parasitic nematodes that afflict grapevines have a wide diversity of feeding habits and invoke a variety of host responses at the cellular, tissue, root and whole plant levels. The damage caused by nematodes may be exacerbated by climatic conditions, geographic region, moisture and nutrient stress, and horticultural practices.

Root knot nematodes are sedentary endoparasites penetrating into roots and inducing giant cell formation, usually resulting in root galls. Giant cells and galls disrupt uptake of nutrients and water, and interfere with plant growth.

Both dagger and needle nematodes cause slow, gradual decline. *Xiphinema americanum*, the most common species of dagger nematode found in California, weakens vines by feeding near the root tip and is a vector of tomato ringspot virus (causal agent of grapevine yellow vein disease). *Xiphinema index* can cause yield reduction in some varieties but is more important for its transmission of grapevine fanleaf virus (causal agent of grapevine fanleaf degeneration disease). Both ring and dagger nematodes feed from outside the roots (ectoparasites), but can reach the vascular tissues with their long stylet. Ring nematodes cause general aboveground lack of vigor and reduced vine growth and yields; in severe cases, more than half the fruit and leaf buds along a cordon or spur may be absent.

Root lesion nematodes are migratory endoparasites that restrict the growth of roots as they feed and migrate in and out of roots.

Young female and juvenile stages of citrus nematodes feed initially from the outside of roots before penetrating deeper into root tissues. They establish feeding sites with their heads embedded in cortical tissue and their posterior ends outside the roots. Their feeding disrupts the uptake of nutrients and water, and interferes with plant growth.

## SYMPTOMS

Aboveground symptoms of nematode damage to roots are generally non-specific and may be manifested as unthrifty vines, poor growth, reduced yields, nutrient deficiency, and greater sensitivity to stress. These effects of damage to the root system are often misdiagnosed as water stress or nutrient deficiency. The symptoms described below are indicative of a nematode problem, but most are not diagnostic as they could result from other causes as well. Generally, nematode infestations are seen in areas of the vineyard with vines that lack vigor and have restricted growth and reduced yields.

**Root knot nematodes** produce small swellings or galls on young feeder roots (about 0.125 inch in diameter) or secondary rootlets. Larger galls may result from multiple infections. The galling response varies across cultivars and rootstocks; it also differs with nematode species (see *Grape Pest Management Manual*, 3<sup>rd</sup> edition, UC ANR Publication #3343). When galls are broken apart, tiny, glistening white bodies of mature females can be detected with the aid of a hand lens. Gelatinous egg masses are often attached to the female bodies. Root-knot nematodes can be found wherever roots occur; they are most prevalent within a soil depth of 6 to 35 inches.

The **dagger nematode**, *X. index*, feeds on root tips causing swelling and bending in a manner similar to the nodosities caused by phylloxera as well as many dead feeder roots if population levels are high; multiple prolonged attacks can result in darkened, necrotic spots that spread through the root tip. Virus transmission by dagger nematode produces symptoms on leaves such as yellowing of veins, mosaic, and malformation with symptom expression less apparent among white varieties and in warmer regions.

Infestation by **root lesion nematode** restricts top growth of young vines. If young vines are planted in soil infested with root lesion nematode, root systems may be severely restricted, including an absence of major roots, many dead feeder roots and on rare occasion brown lesions at feeding sites.

The **citrus nematode** causes death of feeder roots. The bodies of adult females protrude from the roots; females deposit eggs in a gelatinous matrix to which soil adheres giving citrus nematode infested rootlets a dirty appearance.

The **ring nematode** can cause a reduction of small feeder roots and there may be abnormal tufted growth of small roots; it does not enter the root but feeds deep into root tissues using a long stout stylet. Population densities of ring nematode are highest in areas where grape roots are most abundant, within the top 18 inches of soil.

## FIELD EVALUATION

To make management decisions, it is important to know the nematode species present and to estimate the size of the population. If a previous orchard or vineyard had problems caused by nematodes that are also listed as pests of grape, population levels may be high enough to cause damage to the young vines.

If nematode species have not previously been identified, take soil samples and send them to a diagnostic laboratory for identification. The best time to sample differs according to region, type of nematode, and cultivar of grapes. Bloom and harvest times, which influence nematode populations, also differ according to region. Research has shown that populations of citrus nematode are highest in the Coachella Valley from February through March and again in October. In the San Joaquin Valley, *X. index* populations are most likely to be detected in November through February. Root knot nematodes are found at any time of the year.

Sample when the soil is moist, (irrigate three days before sampling or wait for three consecutive days of rain). Select areas that are different due to cropping history, soil texture, or crop injury. Place samples in plastic bags, label with your name, address, location, the previous crop/cultivar, and the current cultivar grown, keep sample cool (do not freeze), and send to a diagnostic lab as soon as possible.

**Preplant situation:** Take 10 soil samples down to 3 feet and include roots if previously planted to another crop.

**Established vineyards:** Include soil and roots sampled 12 to 18 inches from around the vine trunk to a depth of 30 inches, discarding the top 3 inches. Select five vines, each from a different area, mix thoroughly the soil sampled from each vine and make a composite sample of 1 quart (1 liter) for each block. Observe root irregularities. Consult UC ANR Publication 3343, *Grape Pest Management*, 3rd edition for sampling procedures and how to interpret the results.

Look for nematode symptoms in the vineyard late in the growing season to prepare for future management.

## MANAGEMENT

Effective nematode management programs rely upon a suite of practices. Every precaution should be taken to exclude plant-parasitic nematodes if the area is free of them; once established, nematode infestations are permanent. Nematode management requires consideration of the host ranges, life cycles, survival strategies and longevity of nematode species present. Knowledge of the host-status of rootstocks and cover crops to the resident nematode species, and an appreciation for the importance and stewardship of natural regulators of populations of pest species is also required.

Only certified nematode-free stock should be planted. There is a high risk of introducing nematodes in rooted cuttings that have been propagated in soil that is not known to be free of plant-parasitic nematodes. Nematodes are easily moved and introduced on soil adhering to vehicles, implements and animals; ensure that such potential sources are eliminated by appropriate sanitation practices. Nematodes are also moved and introduced by water, either through flooding or drainage, through irrigation with water drained from a neighboring field or drawn from rivers that have passed through infested areas. Tactics for reducing infestation levels of irrigation water, include redesign of the supply system, settling ponds, use of water from deep wells, and ozone treatment.

**Vineyard Preparation.** Deep tillage may be necessary to disrupt restrictive layers that may be naturally occurring or that have resulted from previous cultural practices. Some nematodes are susceptible to soil disturbance. For example, population levels of large-bodied dagger nematodes, *Xiphinema* spp., can be reduced by repeated tillage of fallow soil. However, this practice can be detrimental to soil structure and does not affect nematodes below the tilled profile. Old vines must be removed with equipment that removes the greatest amount of root mass from the soil profile. There may be advantages in applying herbicide to vine stumps some time before root removal so that roots that remain after the removal process are killed and do not provide a resource for plant-parasitic nematode survival. Population levels of potentially-harmful nematode species may be reduced by crop-rotation with appropriate non-host or resistant plant species. The length of rotation will depend upon the survival capabilities of the target nematode with a shorter time period for the citrus nematode (1 year) and longer for dagger



nematodes (4 or more years). If a fallow period is implemented, good weed management must be achieved since many weeds are hosts to nematodes. Cover crops and organic amendments may be used to build soil carbon levels and to provide resources for the beneficial organisms of the soil food web. The selection of a rotation or cover crop should be made with knowledge of the host range of the target plant-parasitic nematode.

**Virus Vector Considerations.** Besides their direct damage to plants, some nematodes are vectors of plant viruses. In that case, very low numbers of surviving viruliferous nematodes can cause serious damage by transmitting virus particles to new vines. The viruses transmitted by dagger nematodes are classified as Nepoviruses and it is important to attempt elimination of their vectors prior to establishing a new vineyard. Two dagger nematode species are particularly important in this regard in vineyards; *X. index* transmits grapevine fanleaf virus (GFLV) and the *X. americanum* species complex transmits tomato ringspot virus (ToRSV). In the past, elimination of these vectors has been attempted through the use of high rates of soil fumigants. Where such practices are no longer available, a very long non-host crop rotation may be necessary. Virus infected root remnants are slow to decay and can support a residual inoculative vector population, often for longer than 10 years. Some rootstocks are available with resistance to *X. index*, although that does not necessarily confer resistance to the virus because particles may be transmitted during exploratory stylet thrusts by the nematode. However, at least one rootstock, O39-16, which is resistant to *X. index*, confers a tolerance to the virus and vines remain productive for long periods even though they are infected.

**Rootstocks.** In recent years, grape rootstocks have been developed and released that have resistance to several species of plant-parasitic nematodes. Besides their nematode-resistance characteristics, it is important to select rootstocks that have appropriate vigor and horticultural characteristics suitable for the local conditions. Summary of available data on the host status of grape rootstocks to nematodes is presented in Table 1.

Table 1. Host status of grape rootstocks to nematodes.

Genotype	<i>M. incognita</i> Race 3	<i>M. javanica</i>	<i>Meloidogyne</i> pathotypes Harmony A&C	<i>M. chitwoodi</i>	<i>X. index</i>	<i>M. xenoplax</i>	<i>P. vulnus</i>	<i>T. semipenetrans</i>	<i>X. americanum</i>	<i>Para. hamatus</i>
101-14Mgt			R		S	S	MR			S
1103Paulsen			S		S	S	MS			S
110Richter			MR		S	S	S			S
140Ruggeri			MR		S	S	S			MS
1613Couderc	R	R	S	S	MR	S	MS	S	S	
1616Couderc			MR		S	S	MS			S
3309Couderc	S	S	S		MS	S	S	S	S	S
420A			R		S	S	MS			S
44-53Malegue			S		S	MR	MS			S
AxR1			S		S	S	S			S
Borner			R		R	S	MS			
Dog Ridge	R	R	S		S	S		MR	MR	MS
Freedom	R	R	S	S?	R	MS	MS	S	MS	MR
Harmony	R	R	S	S	MS	S	S	S	S	S
K51-32	MR				MS	S	R	S		S
Kober 5BB			R		S	S	MS			MR
Ramsey	R	R	S	S?	MR	S	MS	MS	S	S

Genotype	<i>M. incognita</i> Race 3	<i>M. javanica</i>	<i>Meloidogyne pathotypes</i> Harmony A&C	<i>M. chitwoodi</i>	<i>X. index</i>	<i>M. xenoplax</i>	<i>P. vulnus</i>	<i>T. semipenetrans</i>	<i>X. americanum</i>	<i>Para. hamatus</i>
Riparia Gloire			R		R	S	MR			S
RS-3	R	R	MR	MR	S	S	MR			S
RS-9	R	R	R	R	S	S	MS			S
Schwarzmann	S	MR	S		MR	MS	S	S	MS	S
St. George	S		S		S	S	MS			MS
Teleki 5C	MS	MR	S		MR	MS	S	S	S	MS
USDA 10-17A	R	R	R	R	R	MS	R	R		
USDA 10-23B	R	R	R	R	R	MR	R	R		
USDA 6-19B	R	R	MS	R	MR	MR	R	R	R	
VR O39-16	S	S	S		R	R	MR	S	MR	MR
UCD GRN1	R		R		R	R	MR	R		MR
UCD GRN2	R		R		R	MS	MR	MS		MR
UCD GRN3	R		R		R	MR	MR	MR		MR
UCD GRN4	R		R		R	MR	MR	MR		MS
UCD GRN5	R		R		R	R	MR	MR		MR

From: Ferris, H., Zheng, L. and Walker, M.A. 2012. Resistance of grape rootstocks to plant-parasitic nematodes. *Journal of Nematology* 44:385-394.

**Soil health.** A healthy soil has physical, chemical, and biological characteristics favorable for sustaining plant growth while providing organic matter decomposition, nutrient cycling, soil fertility, and water purification. Favorable physical characteristics include good soil structure and particle aggregation, and the absence of restrictive layers. Favorable chemical characteristics include a balance of mineral nutrients at levels necessary for sustained plant growth but below levels toxic to resident organisms. Favorable biological characteristics usually include an abundance and diversity of soil organisms supported by high organic carbon and high microbial biomass. As soil conditions change diurnally, seasonally, and with depth, different organisms among a diverse assemblage become functionally dominant in different regions of the soil profile. Under such circumstances, plant-parasitic nematodes are seldom observed at damaging levels and their populations may be regulated by several factors: bottom up effects of innate resistance of plants to the resident nematodes, and top-down effects of predation by organisms feeding on the plant-parasitic nematodes. When natural systems are converted to conventional agricultural practices, soil carbon levels decline, biological activity is reduced, and predator organisms are decimated due to lack of resources. The decline of the converted system occurs rapidly. It appears to be more difficult, and requires much more time, to rebuild the system than to destroy it.

**Cultural practices.** Manures and other soil amendments can improve vine vigor and frequently reduce the effect of nematode infestation. To reduce stress on vines, take measures to prevent soil compaction and stratification, to improve soil tilth and drainage, and to control other pests. Proper irrigation, improving soil-water holding capacity, avoiding over-cropping, and fertilizer application also reduce stress on vines and help lessen the effect of plant-parasitic nematodes.

**Chemicals.** Application of fumigant nematicides can be an effective way to reduce plant-parasitic nematode populations. Soil fumigants have a broad spectrum effect; they kill not only pest species but beneficial organisms as well. The resurgence of pest species after soil fumigation may occur more rapidly than that of some of the beneficial organisms that might otherwise regulate the pest species. The advantage of a postplant systemic material is that small applications can move to the zone where nematodes are feeding, avoiding high dosage rates necessary to diffuse throughout the soil and root zone. Repeated applications of nematicides over time may be necessary to realize yield benefits. Once a previously-damaged plant is protected from nematode damage, some time will be required for the plant to rebuild its root system so that productive vine growth is supported.

Always read and carefully follow all label information when applying soil fumigants.

Common name (Example trade name)	Amount / Acre	REI‡ (hours)	PHI‡ (days)
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6/16

*When choosing a pesticide, consider information relating to environmental impact. Not all registered pesticides are listed. Always read label of product being used.*

**PREPLANT**

A. METAM SODIUM\* 75 gal See label —  
 COMMENTS: Metam sodium is seldom as effective as methyl bromide because it is seldom applied properly. It also does not penetrate plant roots very well and it is very difficult to get 4 to 5 ft down from the surface. Before applying this material, thoroughly cultivate the area to be treated to break up clods and deeply loosen the soil. After cultivation and about 1 week before treatment, flood irrigate the field with 6 to 8 acre-inches of water. After treatment, do not plant for 30 days, or 60 days if soil is high in organic matter or below 50°F. Fumigants such as metam sodium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.

B. 1,3-DICHLOROPROPENE\* Label rates See label —  
 (Telone II)  
 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.

**POSTPLANT**

A. MYROTHECIUM VERRUCARIA STRAIN AARC-0255# 0.31–2.4 lb/1000 sq ft 4 —  
 (Ditera DF)

B. SPIROTETRAMAT 6–8 fl oz 24 7  
 (Movento)  
 COMMENTS: For suppression of nematodes. When fruit is present, certain adjuvants may not be used; see label.

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

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

— Not applicable.

## Weeds

(Section revised 7/15)

### INTEGRATED WEED MANAGEMENT (7/15)

Weed control in vineyards enhances the establishment of newly planted vines and improves the growth and yield of established vines. Growers have many weed management tools available to achieve these objectives, but the method in which these tools are utilized vary from year to year and from vineyard to vineyard.

Weed management is an integral part of an overall vineyard management system. Plants on the vineyard floor influence the presence of other pests such as vertebrates, insects, mites, nematodes, and diseases. A weed management program should start before new vines are planted. The more difficult-to-control weeds (particularly perennials) are easier to manage before vines are planted. Weeds reduce vine growth and yield by competing for water, nutrients, and sunlight. Competition from weeds is most severe during the first few years after planting in areas where vine root growth is limited due to shallow or compacted soil. Weeds growing around the trunk compete directly with vine growth and provide a good habitat for field mice or voles, which can girdle and kill young vines. Gophers are most often found in nontilled vineyards and are common where broadleaf weeds, such as field bindweed and perennial clovers, predominate. These subterranean animals feed on the roots and can weaken or kill young vines. Additionally, weeds that have dried out can become a serious fire hazard.

The effect of competition from weeds is most severe in the first three years of grapevine establishment, where competition can reduce cane growth and delay fruit production. As the canopy develops in older vineyards, weed growth may be suppressed because less sunlight is striking the vineyard floor. In mature vineyards, weed growth can interfere with harvest and cultural practices. For example, seed from mature weeds can contaminate raisins as they dry on trays in the field.

Integrated weed management practices vary considerably from vineyard to vineyard. Location in the state, climatic conditions, soils, weed species present, age of vines, irrigation practices, topography, and grower preferences significantly influence vineyard floor management decisions and the techniques and tools used.

In the strip under the vine row, weeds are commonly controlled either chemically or mechanically. The area between vine rows may be sprayed, mowed, or cultivated. Alternatively, mulches and flammers can be used to limit weed growth in vineyards. Use of subsurface irrigation will reduce weed growth during the warm season.

Soil characteristics play an important role in weed management. Soil texture and organic matter influence the composition of weed species present, the number and timing of cultivations required, and the activity and residual effects of herbicides applied. Sandy loam soils usually dry more quickly than clay soils and may require more frequent cultivation to achieve effective weed control. On light-textured soils, annual species, such as puncturevine, crabgrass, horseweed, and *Panicum* spp., and perennial weeds, such as johnsongrass, nutsedge, and bermudagrass, are more prevalent. On heavier-textured soils, perennials such as curly dock, field bindweed, and dallisgrass are commonly found. Many herbicide labels recommend using low rates of the product on soils considered high in sand or low in organic matter, in order to reduce the potential for vine injury as herbicides can move deeper in the profile. A second, or split application, may be necessary.

Weed growth is affected by the method of irrigation, amount of water applied, and the timing of rainfall received. Irrigation or precipitation also influences the frequency and timing of cultivation and the herbicides needed, as well as their residual soil activity. Frequent wetting promotes more rapid herbicide degradation in the soil. This degradation is generally faster in moist, warm soils than in dry, cold soils and also more rapid when drip emitters or micro-sprinklers, rather than furrow irrigation, are used. The first irrigation following an herbicide application is the most critical in determining how

deep into the soil the herbicide moves; subsequent irrigation is less important to the movement of the herbicide.

When properly used, herbicides will usually control the weed species listed on their label. In most situations, combinations (tank-mixes) or sequential applications of herbicides will be required to provide effective, economical control. Before using any herbicide, identify the species of weeds to be controlled, then read and follow product label directions carefully.

Herbicides are traditionally discussed as belonging to two groups: those that are active against germinating weed seeds (preemergence herbicides) and those active on growing plants (postemergence herbicides). Some herbicides have pre- and postemergence activity. Herbicides vary in their ability to control different weed species. In most vineyards, herbicides are only used on a narrow strip centered on the vineyard row that comprises 15 to 30% of the total vineyard area. Check the SUSCEPTIBILITY OF WEEDS TO HERBICIDE CONTROL tables and consult product labels for specific weed control activity.

**Preemergence herbicides** are active in the soil against germinating weed seedlings. These herbicides are applied to bare soil and then moved into the soil with rain or irrigation where they affect germinating weed seeds. However, some herbicides like trifluralin, require mechanical incorporation. If herbicides remain on the soil surface without being activated within a reasonable amount of time through rain, irrigation, or mechanical incorporation, some will degrade rapidly from exposure to sunlight, resulting in reduced weed control. Large weed seeds, such as wild oat, may germinate in the soil below the herbicide zone and will not be controlled by a treatment.

**Postemergence herbicides** are applied to control weeds already growing in the vineyard. They can be applied alone as strip sprays, combined with preemergence herbicides early in the season, or be applied as spot treatments during the growing season. Protect young vines from contact with postemergence herbicide sprays. Be sure to check and follow individual label instructions.

Application equipment must be accurately calibrated to apply the proper amount of carrier and herbicide to the soil and young growing weeds. For safe application and to minimize drift, spray equipment should be equipped with a short boom that has nozzles designed to minimize the amount of very small spray particles generated. Avoid spray nozzles and spray pressures that produce spray droplets less than 200 microns in size (very fine and fine-sized droplets) as these tend to drift more. Nozzle technology has advanced significantly in recent years and all major nozzle manufacturers have developed one or more nozzles that will minimize drift. Check your nozzle catalog or the internet. Off center (OC) nozzles are often used alone or on the end of the boom to direct herbicide applications toward the center of the row. Some herbicides require special use precautions as indicated in the table below. Always read and follow the entire product label before using any pesticide.

A backpack sprayer or low-volume controlled droplet applicator can be used to effectively control weeds in small areas. This method works especially well for perennial weeds. Extreme care should be exercised to avoid drift of herbicides, such as glyphosate (Roundup), oxyfluorfen (GoalTender), and paraquat (Gramoxone SL2.0), to vine leaves, green stems, or suckers. Use a shroud or shield with this equipment to help prevent spray drift and protect the vines and other desired vegetation.

## MONITORING FOR WEEDS

Several species of summer and winter annual and perennial weeds can be found infesting California vineyards. The total number and species of weeds, even within a vineyard, vary from area to area and year to year. Conduct weed surveys at least twice each year; once in late winter and again in late spring or summer. The results from these surveys will show the spectrum of weeds present and will help to determine the most effective control strategy.

### Summer weed survey

A survey in summer will tell you the spectrum of weeds present and determine the effectiveness of herbicides or cultivation practices. Keep records of your weed surveys (*example form available online*) to track weed population information from year to year to better understand ongoing weed control problems such as perennial weeds or herbicide resistance.

**Winter weed survey**

By surveying weeds in late winter and keeping track of your observations (*example form available online*), you can identify any species that escaped control from earlier management. Surveying will help you determine if a change in herbicides or cultural methods is needed.

**How to survey your fields for summer and winter weeds**

- Survey your vineyard in late winter to identify winter annuals and again in summer after perennials and summer annuals have germinated.
- If you use cultivation for weed control, monitor far enough ahead of cultivation so weeds do not become too large and difficult to dislodge from the soil.
- Pay particular attention to perennials. Sketch a diagram of the vineyard and mark areas where perennials are found. A hand held GPS unit also works well for recording locations of perennials. Check for re-growth of perennials a few weeks after cultivation.
- Pay attention to low-lying areas or where water tends to accumulate. These are usually problem areas for weed growth.
- Survey areas around the vineyards as potential sources for wind disseminated weed seeds such as maretail, fleabane etc.
- Keep records of your survey results and control techniques used. By knowing what species are present, you will be able to make appropriate decisions on cultural and chemical controls.

Information collected over a period of years can help you determine shifts in weed populations and the effectiveness of your management operations.

**WEED MANAGEMENT BEFORE PLANTING**

Control annual and perennial weeds before planting a vineyard to reduce competition during vineyard establishment. It is especially important to control established stands of perennial weeds before grapevines are planted. This will also reduce potential injury to young vines from herbicides that would have been used to control these perennial after the vines are planted. Field bindweed, johnsongrass, dallisgrass, bermudagrass, and nutsedge are especially troublesome perennial weeds.

**Nonchemical controls**

A cycle of cultivation and irrigation is an especially effective weed control method used before planting vines. First cultivate to remove existing weeds, this is followed by irrigation to encourage germination of new weeds, and concluded with a second cultivation to kill the newly emerged weed seedlings. Frequent cultivation lowers weed seed populations in the soil, thus reducing weed density. At least two cycles of cultivation, irrigation, followed by a shallow cultivation are needed for a marked reduction in weed seedlings. This method is not effective for the control of established perennial weeds.

Cultivation when the soil is very dry is an effective method to control perennial grasses such as bermudagrass and johnsongrass. Cultivation cuts the rhizomes into small pieces so they can dry out. Rework the soil frequently with a spring tooth harrow to pull new rhizomes to the surface to dry out. If the soil is irrigated, or rain occurs before control of the perennial plant is achieved, the rhizome pieces will begin to grow and the effectiveness of this practice is greatly reduced. Working the soil when wet can increase the population of perennial weeds, because each piece of cut rhizome can root and develop into a new plant.

Field bindweed growth can be reduced for up to two years by treating with a high dose of glyphosate or by deep plowing, using a reclamation blade (a large V-shaped blade) to cut the roots at a depth of 16 to 18 inches in dry soil. Nutsedge infestations can be reduced by deep plowing with large moldboard plows that bury the nutlets to a depth of at least 12 inches. Seedlings of many perennials can be controlled by repeated cultivation.

Soil solarization is a nonpesticidal method of controlling soil-borne pests by placing clear plastic sheets on moist soil during periods of long day length. The plastic sheets trap the sun's radiant energy in the soil, heating the upper levels to temperatures (108–131°F at a depth of 2 inches) that kill many disease-



causing organisms (pathogens), nematodes, and weed seedlings. In areas where summer fog is prevalent, solarization should be done during the warm late summer or early fall when foggy days are less frequent. Solarization leaves no toxic residues and can be easily used on a small or large scale. Soil solarization also improves soil structure and increases the availability of nitrogen (N) and other essential plant nutrients. (For additional information see *Soil Solarization*, UC ANR Publication 21377.)

### **Chemical control**

Seedling and established annual weeds can be controlled with preemergence or postemergence herbicides before planting. Before planting a vineyard use a preemergence herbicide in conjunction with a rotation crop. Make sure the residual period of the herbicide is not so long that it will interfere with planting the vines. Postemergence herbicides generally have little or no soil residual and are safer to use before planting vines. Many growers prefer to use preemergence herbicides only after the vines have been planted and soil settled around the plants to avoid possible exposure of the vines' roots to herbicides that may be in the backfill soil. Follow all label precautions and directions, including requirements for protective equipment.

## **WEED MANAGEMENT IN NEW VINEYARDS**

Grapevines are most sensitive to weed or cover crop competition during the first few years of growth and where vine rooting depth is limited. Weedy vineyards may require several more years to become economically productive than weed-free vineyards. Regardless of the method used to control weeds, damage to the vine trunk or roots by chemicals and mechanical equipment should be avoided. As grapevines become established, direct competition from weeds is lessened.

### **Cultivation**

Some growers prefer to manage weeds without herbicides for up to 2 years after planting in order to prevent damage to vines. This usually requires hoeing, cultivating, or the usage of weed knives (set less than 2 inches deep around vines) several times during the spring and summer.

The area between the vine rows is usually mowed or cultivated. Weeds are most effectively controlled when they are in the seedling stage. To minimize injury, particularly when vines are young, hand tools are used to cultivate close to the vine. Mechanical cultivators available for use in the vine row include weed knives, spyder cultivators, and rotary tillers. Rotary tillers such as a Weed Badger, Kimco, or Clements Hoe are most effective if used on loose soil free of large rocks. Hand-held mechanical flails (Weed Eaters) may be used, but can injure vine trunks.

Discs or mowers can be used between the rows. Mechanical control of weeds must be done repeatedly when weeds are small. The equipment should be set to cut shallowly to minimize damage to vine roots. As weeds mature they become more difficult to control, may clog equipment, and will produce seed.

### **Cover crops**

Planted cover crops can be used to reduce weed populations between vine rows. The cover crop and management chosen for vineyards will differ from one area of the state to another. Select a cover crop that will not compete with young vines or decrease the cover crop strip width. Cultivation prior to planting a winter annual cover crop may reduce weed growth. Mowing cover crops at their recommended height will help preserve surface cover.

### **Mulches**

Weeds in the vine row can be controlled using mulches. Organic mulches (cereal straw, green waste, composted wood chips) or synthetic mulches (polyethylene, polypropylene, or polyester) can be used around young vines. Apply mulches when the soil surface is free of weeds. Mulches prevent the germination and growth of weed seedlings by blocking light and preventing them from reaching the soil surface. They create a more uniform moisture condition, which promotes young vine growth. However, mulches may also provide a good habitat for gophers, voles, field mice, and snakes, and can be contaminated with weed seeds. Organic and some synthetic mulches do not control perennial weed growth unless all light can be completely excluded. Some woven fabric mulches offer excellent weed control for several years, but the initial cost of purchase and installation is high.

## Herbicides

To control weeds after grapevines have been planted and before bearing fruit, apply a preemergence herbicide (e.g., oryzalin, napropamide, or oxyfluorfen) as a band down the vine row or in an area three to six feet around each vine. Herbicides can also be applied to control weeds after they emerge. Selective grass herbicides (e.g., sethoxydim, fluazifop, and clethodim) are available for the control of annual grasses and the suppression of perennial grasses. To be effective, these grass herbicides require the addition of a nonphytotoxic oil or a nonionic surfactant. These materials do not control nutsedge or broadleaf weeds and clethodim is the only selective grass herbicide that will control annual bluegrass. Paraquat can be used to control most weeds and grasses near young vines if they are protected with shields or wraps. The systemic herbicide glyphosate will control broadleaf weeds after emergence, but should only be used around mature vines that have brown bark. Glyphosate should not be allowed to contact leaves or green shoots as substantial crop injury can occur. Follow all label precautions and directions, including requirements for protective equipment.

Herbicide application in the vine row should be used in conjunction with mowing or cultivation between the rows. Mowing may be required four to eight times during spring and summer, or whenever weeds are 6 to 8 inches high. Cultivation is required after each irrigation, because irrigation causes weed seeds to germinate.

## WEED MANAGEMENT IN ESTABLISHED VINEYARDS

Under normal growing conditions it will take at least three years for a vineyard to become established. Established vines are more tolerant of many herbicides than are newly planted vines, thus increasing the options available for weed control. Weeds are generally controlled between vine rows with discing or mowing and in the vineyard row with a strip application of herbicide or a basal treatment of herbicide around each vine.

### Cultivation

Cultivation can be used in established vineyards to control annual and biennial weeds and the seedlings of perennial weeds. Control seedlings of field bindweed, bermudagrass, and johnsongrass before they are three weeks old, which is before they begin to form perennial structures such as rhizomes. Cultivation to remove established perennials in an irrigated vineyard often increases the weed problem. Frequent cultivation near vines can injure vine roots or the trunk, which reduces the vine's ability to uptake nutrients and allows soil pathogens (crown gall and collar rot) access. Irrigation tubing must be suspended high enough off the soil surface to accommodate in-row cultivation.

### Flaming

Flaming can be used to control young weeds in mature vineyards. Use either a single flame directed to the base of the vine or several burners on a boom to flame the weeds between the vineyard rows. For more on flaming see the section WEED MANAGEMENT IN ORGANIC VINEYARDS.

### Mulches

Mulches can also be used for weed control as discussed in the section WEED MANAGEMENT IN NEW VINEYARDS. Organic mulches degrade and they may become a perfect growth medium for weed species such as common groundsel, prickly lettuce, common sowthistle, and tall annual willowherb. Escaped weeds should be managed with herbicides, flaming or hand removal and the mulch replenished annually.

### Herbicides

After grape harvest, preemergence herbicides can be applied alone or in combination with other herbicides. This treatment can be split into two applications (fall and spring) or applied as a single treatment in the winter, where it is combined with a postemergence (foliar) herbicide to target weeds present in the vineyard. It may be necessary to use postemergence herbicides repeatedly as new weeds germinate. For greatest safety, direct the herbicide spray at the soil or weed foliage and not at the vine leaves, shoots, or less than 2-year old wood. Using a visual weed-seeking sprayer can reduce herbicide use if weed density is sparse or appear spotty.

Two or more herbicides may need to be combined in one spray application (tank mix) to achieve adequate weed control. It is critical to identify the weed species present in the vineyard to determine

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which herbicide, or combination of herbicides, will provide the most effective control. This is described in detail in the above MONITORING section. Combinations may include one or more preemergence herbicides or a mixture of preemergence and postemergence herbicides. Read and follow label directions carefully before combining herbicides, including requirements for protective equipment.

### **Cover crops**

Cover crops are often used to replace the resident weed vegetation found on the vineyard floor. As with resident vegetation, keep cover crops away from young vines. Winter annual cover crops are often fall-seeded cereal crops such as oat, cereal rye, or barley. Others, such as 'Blando' bromegrass, 'Zorro' fescue, or subterranean clovers, are commonly used in no-till vineyards. Cover crops are seeded into a prepared seedbed between vine rows in late September through mid-November. Most of these cover crops will reseed themselves if mowed in January or early February and, if allowed, will re-establish by April or May.

Where late frosts are a hazard, mow cover crops just before budbreak. If reseeding is desired, mow after the cover crop matures to greatly increase the number of seeds for the next season. Periodically changing cover crop species reduces the potential for buildup of disease pathogens, weeds, rodents, and insect pests. For more information on cover crops, consult UCANR Publication 21471, *Covercrops for California Agriculture*, or UC ANR Publication 3338, *Cover Cropping in Vineyards: A Growers Handbook*.

# WEED MANAGEMENT IN ORGANIC VINEYARDS

(7/15)

If you choose not to use synthetic pesticides, then your goal should be to maintain the vineyard as clean as possible. Weeds serve as an excellent host for insect pests fungal pathogens and should be routinely controlled by all grape growers. Vineyards differ from orchards in that the foliage and fruit in vineyards are typically much closer to the ground.

While perennial weeds are definitely considered more of a problem, annual weeds, such as horseweed (marestail) (*Conyza canadensis*), are capable of growing within the vinerow up to the clusters to a height of six feet in a single season and serve as a host for disease. Weed control in organically managed vineyards requires special attention to prevent weed problems before they start. Cover crops planted in the row middles and mechanical control of weeds in the vine rows are key components of an organic weed management program. In some cases, particularly where the weed population is high, it may be desirable to use conventional herbicides for the first couple of years after planting and then transition into organic production. This usually helps to reduce weed pressure, making weed management easier once organic certification has been obtained.

## WEED MANAGEMENT BEFORE PLANTING

It is important to have little or no weed competition at the time of planting vines. This makes weed control before planting critical. Take measures to deplete the soil weed seed bank. A summer fallow treatment of irrigation (to encourage weed seed germination) followed by tillage (to uproot newly emerged weed seedlings) will desiccate weeds and reduce the number of weed seeds in the soil. Repeat this cycle several times to further deplete weed seeds in the soil. Alternatively, weed seeds located in the top four inches of soil can be buried with a soil-inverting plow such as a Kverneland plow to depths from which seeds cannot emerge. Here, the soil should not be deep-plowed again for at least three years to help prevent bringing up viable seed. A moldboard plow will not sufficiently invert the soil to be effective.

### Soil solarization

Soil solarization can be used in the area planned for vine rows to significantly reduce weed populations. The soil in the area designated for solarization must be moist and at least six feet wide in each row. The plastic should be buried on all sides to create a seal on the soil and help prevent the plastic from being blown away by wind. Machines are available that lay down the plastic and automate this otherwise labor-intensive process.

In areas where summer fog is not a concern, solarization should begin when day length is as long as possible, or at least be started by the beginning of August to have sufficient time (4 to 6 weeks) to complete the process. Use clear plastic with a UV inhibiting component to prevent breakdown before the process is completed. Black plastic suppresses weed seed germination but will not heat the soil sufficiently for solarization. Solarization may not be successful in suppressing species like nutsedge. The plastic should be removed before planting the vines.

## WEED MANAGEMENT AFTER PLANTING

### Cultivation

Mechanical cultivation uproots or buries weeds. Weed burial works best on small weeds. Larger weeds are better controlled by destroying the root-shoot connection or by slicing, cutting, or turning the soil to separate the root system from the soil. Keep cultivation shallow to minimize damage to grape roots and to avoid bringing more weed seeds near the surface to germinate.

Perennial weeds with established root systems are difficult to kill with a single tillage operation. For tillage to be successful on perennials, the top should be removed by cultivating to a depth of 3-4 inches. This will cause the underground portion of the plant to regenerate a new top, forcing the weed to use a greater portion of the reserves available. Repeated cultivation may eventually kill these weeds by eliminating the amount of reserves available for growth. Trip mechanisms on under vine vineyard cultivators are often used to prevent damage to the vines. These mechanisms move the knife or cutting

blade before it hits the vine. Even the best cultivators will not eliminate all weeds, thus hand hoeing is often needed. Hand cultivation alone may be effective on a small scale.

### **Mulches**

Mulches can be used for weed control in the vineyard. Mulches block light, preventing weed germination and growth. Many materials can be used as mulch: municipal yard waste, wood chips, straw, hay, sawdust, newspaper, and others. To be effective, mulches must block all light to germinating weeds. Materials vary in the depth necessary to accomplish this. In general, the larger or looser the mulch pieces, the deeper the mulch needs to be. Organic mulches must be maintained in a layer at least four inches thick. Organic mulches breakdown with time and the original thickness is typically reduced by 60% after one year. Winter cover crops grown in vineyard middles can be the source of organic mulch. The process, known as “mow-and-throw” or ‘mow and blow’, involves cutting the cover crop and moving (‘throwing’ or ‘blowing’) it in the vine row to the base of the vines. Weeds that emerge through the mulch can be controlled using an organic contact herbicide or with hand hoeing. Cover crops planted under the vine row may compete with weeds, but they may also increase competition with the vine, possibly reducing grape yields. Mulches may harbor voles, gophers, and field mice, which feed on vine trunks and roots.

### **Herbicides**

Several contact-type herbicide products are approved for use in organic vineyards. Many of these products can damage any green vegetation contacted, including the leaves and young stems of grape vines. Apply products as directed sprays to the base of woody stems and trunks. These herbicides only kill plant tissue that they contact; so good coverage (60 or more gallons per acre spray volume) is essential. Adding an organically acceptable surfactant is recommended. These materials all lack residual activity and repeated applications will be needed to control new flushes of weeds. These products are more effective on broadleaved weeds than grasses. Follow all label precautions and directions, including requirements for protective equipment.

### **Flaming**

Flamers can be used for weed control in the vine row. Propane-fueled models are the most commonly used. Flaming works on the principle that heat causes the sap of plant cells to expand, causing the cell membrane to rupture. This process occurs in most plant tissues at about 130°F. To work effectively, weeds must have less than two true leaves. Flaming is usually less effective on grasses because their growing point is at or below ground level. Weeds that have been killed by flaming change from a glossy to a matte or dull finish. This occurs very rapidly in most cases. Foliage that retains a thumbprint when pressed between thumb and finger has been adequately flamed; it is not necessary to burn the plants. Typically, flaming can be done at 3 to 5 mph, depending on the heat output of the unit. Avoid flaming during windy conditions, as wind can displace the flame, resulting in poor weed control or vine injury. Repeated flaming can be used to suppress perennial weeds such as field bindweed. Care must be taken to avoid igniting dry vegetation, which could not only injure the vines, but start a wildfire.

### **Animals**

Before using any animals for weed suppression in vineyards, check federal, state, and local food safety regulations and comply with them.

Sheep are often used for weed control in organic vineyards and can be very effective in controlling weeds. Their effectiveness depends on several factors, among them the amount of feed available (cover crop and weeds), and the density (number per acre) of sheep used. Goats are browsers, and are often used to control the brush around vineyards. If goats are used in the vineyard, they must be carefully managed to avoid damage to the vines. Unless the animals used have been otherwise trained, goats and sheep should be removed before bud break to reduce the chance of damage to young shoots.

Geese can also be used in vineyards. Geese prefer grass species and will eat other weeds and crops only after the grasses are gone. They have a particular preference for the rhizomes of two especially troublesome vineyard weeds, johnsongrass and bermudagrass; geese will dig them up and eat them if confined. Generally, four geese per acre are needed. Consult the following website for further information on geese <http://www.metzerfarms.com/UsingWeederGeese.cfm>. In most cases, all animals used in vineyards will require some form of protection from predators (dogs, coyotes, etc.).

For further information on grazing animals, please consult the following websites:  
<http://www.webpages.uidaho.edu/rx-grazing/index.htm> and <http://extension.missouri.edu/p/G8922>

**Vineyard Irrigation –Special considerations:**

While some vineyards are not irrigated (dry-farmed or rain-fed), most are irrigated in one form or another. Vineyards that are flood or furrow irrigated are amenable to most of the previously described forms of organic weed control. When microsprinklers or drip irrigation is used, some considerations must be made when choosing a weed control method. In-row cultivators may damage irrigation lines and emitters. However, surface lines can be suspended in the vines or on stakes to allow for in-row mowing, cultivation, or flaming underneath. If the microsprinklers are suspended upside down, hand hoeing, possibly flaming, organically approved herbicides, and weeder geese could also be used for weed control.

## SPECIAL WEED PROBLEMS (7/15)

Most of these special weed problems can be minimized through an active preplant weed management program.

### BERMUDAGRASS

Bermudagrass is a vigorous perennial weed that grows in the spring and summer. Bermudagrass is propagated by seed and an extensive rhizome and stolon system that is often spread during cultivation. It competes aggressively with grapevines for moisture and nutrients. Seedlings can be controlled with preemergence herbicides. Immediately spot treat any developing areas of bermudagrass in a vineyard with a postemergence herbicide such as sethoxydim (Poast) or glyphosate (Roundup). Glyphosate at high rates provides better control of bermudagrass than sethoxydim, however, sethoxydim is safer to use around grapes. Do not allow any herbicide to drift onto the grapevines.

### BLACKBERRY

Blackberries (Himalayan and California) are vigorous perennial plants often found around vineyard margins and occasionally around grapevines. They can interfere with all cultural operations, especially pruning and harvest. For best control, spot treat with glyphosate at the flower stage or after fruiting when there is good soil moisture and the plants are not water stressed. If regrowth appears, especially on large clumps, re-treatment may be required. If blackberry is growing into a vine, separate the berry stem from the grapevine before treating to reduce the chance of herbicide contacting the grapevine.

### DALLISGRASS

Dallisgrass is a common perennial weed found in vineyards. It has a clumpy growth habit that gives it a bunchgrass appearance. It can be highly competitive in newly planted and in established vineyards, where it competes with grapevines for soil moisture and nutrients. Dallisgrass seedlings germinate in spring and summer and form new plants on short rhizomes that developed from the original root system. Dallisgrass seedlings can be controlled with cultivation or preemergence herbicides. Treatment with glyphosate has been successful for control of dallisgrass infestations.

### FIELD BINDWEED

Field bindweed is a vigorous perennial weed that grows from rhizomes, an extensive sprouting root system, or seeds. Seeds can survive for up to 30 years in the soil, therefore it is critical to control these plants before they can produce seed. Seedlings of field bindweed are controlled with cultivation, but mature plants may spread from stem or root fragments created by tillage operations. If field bindweed is present in or around the vineyard, spot treat with high label rates of glyphosate.

### HAIRY FLEABANE

Hairy fleabane, also called flax-leaf fleabane, is a summer annual that reproduces by seed. If emergence occurs in late summer, it may act like a biennial. Each plant can produce over 40,000 wind-disseminated seeds. Hairy fleabane is often found growing in the same location as horseweed, a related species. Frequent tillage or soil disturbance can significantly reduce the population. Soil-residual herbicides, such as simazine (Princep) and rimsulfuron (Matrix), can provide good control before the plants emerge. Once plants have emerged, applications of glufosinate (Rely), 2, 4-D, or combinations of these two herbicides can provide good control of seedlings. Grapevines are very sensitive to 2,4-D; only use this material when vines are dormant. In both, the US and worldwide, glyphosate-resistant hairy fleabane is less prevalent than glyphosate-resistant horseweed. Do not use repeated applications of low rates of glyphosate (Roundup, Touchdown), especially when plants are taller than 6 inches, or resistance to this herbicide may develop.

### HORSEWEED

Horseweed, also referred to as maretail, is typically a summer annual weed. However, plants that germinate from seed in late summer, often act like a biennial. More than 200,000 seed are produced by a single plant and can be disseminated by wind more than a 1/4 mile. Horseweed hosts the glassy-winged

sharpshooter (a carrier of Pierce's Disease). Frequent mechanical tillage offers good control if done before plant growth reaches the rosette stage. Flaming or mowing does not provide adequate control of horseweed. Soil-residual herbicides, including simazine (Princep), isoxaben (Gallery, Trellis), rimsulfuron (Matrix), and flumioxazin (Chateau), provide good control at high label rates. Glufosinate (Rely) and 2, 4-D provide the best control of emerged plants from the seedling to the rosette stage. Control in California with glyphosate (Roundup, Touchdown) is variable. Horseweed is known to develop resistance to glyphosate where repeated applications are used.

## **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 newly planted vines and competes for light, moisture, and nutrients. Under these conditions, severe setback of a young vineyard can occur. Postemergence application of fluazifop or clethodim can be used around newly planted vines. If johnsongrass develops in or around vines in an established vineyard, spot treat it with glyphosate to prevent the spread of its rhizomes. Do not allow herbicide to drift onto grapevines. Always read and follow all label instructions.

## **LITTLE MALLOW (CHEESEWEED)**

Little mallow is an annual or biennial plant that occasionally is not controlled with preemergence herbicides. Glyphosate may provide inconsistent control of plants larger than 4 to 6 inches. Mature plants are tall and woody with a large taproot that can be removed with a shovel or with cultivation. Oxyfluorfen effectively controls seedlings and young plants.

## **NUTSEGE**

Yellow nutsedge is a perennial weed that reproduces from underground tubers that survive for 2 to 5 years in the soil. The tubers are easily spread by cultivation equipment. Each tuber contains several buds that are capable of producing plants. If the tuber is not killed by cultivation or sprayed with an herbicide, one or two buds germinate to form new plants. If nutsedge develops in established vineyards, spot treat with glyphosate.



# COMMON AND SCIENTIFIC NAMES OF WEEDS COMMONLY FOUND IN CALIFORNIA VINEYARDS

(7/15)

Common Name	Scientific Name
asparagus	<i>Asparagus officinalis</i>
barley, hare	<i>Hordeum murinum</i>
barnyardgrass	<i>Echinochloa crus-galli</i>
bermudagrass	<i>Cynodon dactylon</i>
bindweed, field	<i>Convolvulus arvensis</i>
blackberries	<i>Rubus</i> spp.
bluegrass, annual	<i>Poa annua</i>
bromegrasses	<i>Bromus</i> spp.
burclover, California	<i>Medicago polymorpha</i>
canarygrass	<i>Phalaris canariensis</i>
catsear, common	<i>Hypochaeris radicata</i>
chickweed, common	<i>Stellaria media</i>
clover, white	<i>Trifolium repens</i>
cockleburs	<i>Xanthium</i> spp.
crabgrasses	<i>Digitaria</i> spp.
cudweeds	<i>Gnaphalium</i> spp.
dallisgrass	<i>Paspalum dilatatum</i>
dandelion	<i>Taraxacum officinale</i>
dock, curly	<i>Rumex crispus</i>
fescue, red	<i>Festuca rubra</i>
fescues	<i>Festuca</i> spp.
fiddlenecks	<i>Amsinckia</i> spp.
filarees	<i>Erodium</i> spp.
fleabane, hairy	<i>Conyza bonariensis</i>
fluvellins	<i>Kickxia</i> spp.
foxtails	<i>Setaria</i> spp.
goosefoot, nettleleaf	<i>Chenopodium murale</i>
groundcherries	<i>Physalis</i> spp.
groundsel, common	<i>Senecio vulgaris</i>
henbit	<i>Lamium amplexicaule</i>
horseweed, common	<i>Conyza canadensis</i>
johnsongrass	<i>Sorghum halepense</i>
knotweed, oval-leaf	<i>Polygonum</i> spp.
ladysthumb	<i>Polygonum persicaria</i>
lambsquarters, common	<i>Chenopodium album</i>
lettuce, prickly	<i>Lactuca serriola</i>
ovegrasses	<i>Eragrostis</i> spp.
mallow, little (cheeseweed)	<i>Malva parviflora</i>
miner's lettuce	<i>Claytonia perfoliata</i>
mullein	<i>Verbascum</i> spp.
mustards	<i>Brassica</i> spp.
nettles	<i>Urtica</i> spp.
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.
pineappleweed	<i>Chamomilla suaveolens</i>
poison-oak, Pacific	<i>Toxicodendron diversilobum</i>
polypogon, rabbitfoot	<i>Polypogon monospermiensis</i>
puncturevine	<i>Tribulus terrestris</i>
purslane, common	<i>Portulaca oleracea</i>
radish, wild	<i>Raphanus raphanistrum</i>
redmaids (desert rock purslane)	<i>Calandrinia ciliata</i>

(7/15) Common and Scientific Names of Weeds Commonly Found in California Vineyards

*Common and Scientific Names of Weeds Commonly Found in California Vineyard, continued*

<b>Common Name</b>	<b>Scientific Name</b>
rocket, London	<i>Sisymbrium irio</i>
ryegrass, Italian	<i>Lolium multiflorum</i>
sandburs	<i>Cenchrus</i> spp.
shepherd's-purse	<i>Capsella bursa-pastoris</i>
smartweed, pale	<i>Polygonum lapathifolium</i>
sorrel, red	<i>Rumex acetosella</i>
sowthistles	<i>Sonchus</i> spp.
speedwells	<i>Veronica</i> spp.
sprangletop	<i>Leptochloa</i> spp.
starthistle, yellow	<i>Centaurea solstitialis</i>
thistle, Russian	<i>Salsola tragus</i>
velvetleaf	<i>Abutilon theophrasti</i>
willowherb, tall annual	<i>Epilobium brachycarpum</i>
witchgrass	<i>Panicum capillare</i>

# SUSCEPTABILITY OF SPRING AND SUMMER WEEDS IN GRAPE TO HERBICIDE CONTROL (7/15)

Mode of Action <sup>1</sup>	PREEMERGENCE										POSTEMERGENCE									
	DIU	FLM	IND	ISO	NAP	ORY	OXY	PEN	RIM	SIM	CAR	CLE	FLU	GLU	GLY	OXY	PAR*	SET	24D*	
	7	14	29	21	15	3	14	3	2	5	14	1	1	10	9	14	22	1	4	
<b>ANNUAL GRASSES</b>																				
Barnyardgrass	C	C	—	N	C	C	P	C	C	P	N	C	C	C	C	N	P	C	N	
Crabgrasses	C	C	—	N	C	C	P	C	C	N	N	C	C	C	C	P	C	C	N	
Fescues	C	P	—	—	C	C	P	C	C	C	N	P	N	P	C	N	C	N	N	
Foxtails	C	C	—	N	C	C	N	C	C	C	N	C	C	C	C	N	C	C	N	
Lovegrasses	C	C	—	N	C	C	P	C	P	P	N	C	C	C	C	N	C	C	N	
Sandburs	C	P	—	N	C	C	N	C	—	P	N	C	C	C	C	N	P	C	N	
Sprangletops	N	C	—	N	C	C	P	C	P	N	N	C	C	C	C	N	C	C	N	
Witchgrass	P	P	—	—	C	C	P	C	C	C	—	C	C	P	C	N	C	C	N	
<b>ANNUAL BROADLEAVES</b>																				
Cocklebur	C	—	—	—	C	N	C	N	P	C	P	N	N	P	C	C	C	N	C	
Cudweeds	C	—	—	C	C	N	N	N	N	C	—	N	N	P	C	P	N	N	P	
Fleabane, Hairy	C	P	—	C	N	N	P	N	C	C	N	N	N	C	C	P	C	N	C	
Fluvelins	P	—	—	—	N	N	P	—	—	P	—	N	N	—	P	P	P	N	—	
Goosefoot, Nettleleaf	C	C	—	C	C	C	C	P	P	N	—	N	N	P	C	C	C	N	C	
Groundcherries	C	C	—	C	N	C	C	N	P	C	C	N	N	C	C	C	C	N	C	
Horseweed	P	C	—	C	N	N	P	N	C	C	N	N	N	C	C	P	P	N	C	
Knotweed, Common	C	—	—	C	C	C	C	C	P	C	—	N	N	P	C	P	P	N	P	
Ladysthumb	C	—	—	—	—	—	—	—	—	C	—	N	N	—	C	—	P	N	—	
Lambsquarters, Common	C	C	—	C	C	C	C	C	P	C	—	N	N	P	C	C	P	N	C	
Lettuce, Prickly	C	P	—	C	C	N	C	N	C	C	—	N	N	C	C	C	C	N	C	
Mallow (Cheeseweed)	C	C	—	C	P	P	C	N	C	N	—	N	N	C	P	C	N	N	P	
Nightshades	C	C	—	C	N	N	C	N	C	C	C	N	N	C	C	C	C	N	C	
Pigweeds	C	C	—	C	C	C	C	C	C	C	—	N	N	C	C	C	C	N	P	
Puncturevine	C	C	—	C	P	P	C	C	P	P	—	N	N	P	C	C	C	N	C	
Purslane, Common	C	C	—	C	C	C	C	C	C	C	N	N	N	C	C	C	C	N	C	
Smartweed, Pale	C	—	—	—	—	—	—	—	—	C	—	N	N	—	C	—	P	N	P	
Speedwells	P	—	—	—	C	P	C	P	N	C	N	N	N	—	C	P	C	N	—	
Starthistle, Yellow	C	—	—	—	P	N	C	N	P	C	N	N	N	P	C	C	P	N	C	
Thistle, Russian	P	C	—	C	P	P	P	P	N	P	—	N	N	C	C	P	C	N	C	
Velvetleaf	C	P	—	C	N	P	C	N	P	C	C	N	N	C	C	N	P	N	C	
Willowherb, Tall Annual	C	C	—	P	N	C	C	—	C	C	—	N	N	C	C	N	P	N	C	
<b>PERENNIALS (seedlings)</b>																				
Bermudagrass	C	N	—	N	C	C	N	C	N	P	N	C	C	C	C	P	C	C	N	
Bindweed, Field	P	N	—	C	N	P	C	P	P	P	C	N	N	C	C	P	C	N	C	
Dallisgrass	C	N	—	N	P	C	N	C	—	C	N	C	C	C	C	N	C	C	N	
Dandelion	C	—	—	C	C	N	C	N	—	C	—	N	N	C	C	C	N	N	C	
Dock, Curly	C	—	—	C	P	P	C	P	P	C	—	N	N	C	C	C	C	N	C	
Johnsongrass	C	N	—	N	P	P	N	C	C	P	N	C	C	C	C	N	C	C	N	

	PREEMERGENCE										POSTEMERGENCE								
	DIU	FLM	IND	ISO	NAP	ORY	OXY	PEN	RIM	SIM	CAR	CLE	FLU	GLU	GLY	OXY	PAR*	SET	24D*
<b>Mode of Action<sup>1</sup></b>	7	14	29	21	15	3	14	3	2	5	14	1	1	10	9	14	22	1	4
<b>ESTABLISHED PERENNIALS</b>																			
Asparagus	N	N	—	—	N	N	N	N	—	N	—	N	N	N	P	N	N	N	—
Bermudagrass	N	N	—	N	N	N	N	N	N	N	N	C	P	P	C	N	P	P	N
Bindweed, Field	N	N	—	C	N	P	N	N	P	N	P	N	N	P	P	N	P	N	P
Blackberries	N	N	—	—	N	N	N	N	—	N	—	N	N	N	C	N	N	N	—
Catsear, Common	N	N	—	—	N	N	N	N	—	N	—	N	N	P	P	N	N	N	—
Clover, White	N	N	—	C	N	N	N	N	P	N	—	N	N	P	P	N	N	N	P
Dallisgrass	N	N	—	N	N	N	N	N	—	N	N	C	P	P	C	N	N	P	N
Dandelion	N	N	—	C	N	N	N	N	P	N	—	N	N	P	C	N	N	N	P
Dock, Curly	N	N	—	N	N	N	N	N	P	N	—	N	N	P	P	N	N	N	P
Johnsongrass	N	N	—	N	N	N	N	N	P	N	N	C	P	P	C	N	N	P	N
Nutsedge, Purple	N	N	—	N	P	N	N	N	N	N	N	N	N	P	P	N	N	N	N
Nutsedge, Yellow	N	N	—	N	N	N	N	N	P	N	N	N	N	P	P	N	N	N	N
Poison-Oak, Pacific	N	N	—	—	N	N	N	N	—	N	—	N	N	N	C	N	N	N	—
Sorrel, Red	N	N	—	—	N	N	N	N	—	N	—	N	N	N	P	N	N	N	—

## SUSCEPTIBILITY OF WINTER WEEDS IN GRAPE TO HERBICIDE CONTROL (7/15)

	PREEMERGENCE										POSTEMERGENCE								
	DIU	FLM	IND	ISO	NAP	ORY	OXY	PEN	RIM	SIM	CAR	CLE	FLU	GLU	GLY	OXY	PAR*	SET	24D*
<b>Mode of Action<sup>1</sup></b>	7	14	29	21	15	3	14	3	2	5	14	1	1	10	9	14	22	1	4
<b>ANNUAL GRASSES</b>																			
Barley, Hare	C	C	—	N	C	C	P	C	C	C	N	C	C	C	C	P	C	C	N
Bluegrass, Annual	C	C	—	N	C	C	P	C	C	C	N	C	N	C	C	P	C	N	N
Bromegrasses	C	P	—	N	C	C	P	C	C	C	N	C	C	C	C	N	C	C	N
Canarygrasses	C	P	—	N	C	C	P	C	—	C	N	C	C	C	C	N	C	C	N
Oat, Wild	P	P	—	N	C	P	P	P	P	C	N	C	C	C	C	N	C	C	N
Polypogon, Rabbitfoot	C	P	—	—	C	C	P	C	C	C	N	C	C	P	C	—	C	C	N
Ryegrasses	C	P	—	N	C	C	P	C	C	C	N	C	C	C	C	N	C	C	N
<b>Annual Broadleaves</b>																			
Chickweeds	C	C	—	C	C	C	P	C	C	C	P	N	N	C	C	P	C	N	P
Burclover, California	P	P	—	—	P	N	P	N	P	P	—	N	N	C	C	P	P	N	—
Fiddlenecks	C	—	—	C	C	C	C	C	C	C	C	N	N	P	C	C	C	N	P
Filarees	C	C	—	C	C	N	C	N	C	C	—	N	N	C	P	C	C	N	C
Groundsel, Common	N	C	—	C	P	P	C	N	C	C	—	N	N	P	C	C	C	N	C
Henbit	C	C	—	C	P	P	C	C	C	C	—	N	N	C	C	C	C	N	P
Miner's Lettuce	C	—	—	—	C	C	C	C	C	C	—	N	N	C	C	C	C	N	—
Mustards	C	C	—	C	P	N	C	N	C	C	—	N	N	C	C	P	C	N	C
Nettles	C	C	—	C	P	P	C	C	N	C	C	N	N	C	P	C	P	N	P
Pineappleweed	P	—	—	—	C	N	C	N	P	C	N	N	N	C	C	P	P	N	P
Redmaids	C	—	—	—	N	C	C	C	C	C	—	N	N	C	C	C	C	N	—
Rocket, London	C	C	—	C	C	P	C	N	C	C	C	N	N	C	C	C	C	N	C
Shepherd's-Purse	C	C	—	C	P	N	C	C	C	C	P	N	N	C	C	P	C	N	C

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

Herbicide	Mode of action <sup>1</sup>	Herbicide	Mode of action <sup>1</sup>	Herbicide	Mode of action <sup>1</sup>
CAR = carfentrazone-ethyl (Shark)	14	GLY = glyphosate (Roundup, Touchdown)	9	PAR = paraquat* (Gramoxone SL2.0)	22
CLE = clethodim (Select Max)	1	IND = indaziflam (Alion)	29	PEN = pendimethalin (Prowl H20)	3
DIU = diuron (Karmex DF, etc.)	7	ISO = isoxaben (Trellis)	21	RIM = rimsulfuron (Matrix)	2
FLM = flumioxazin (Chateau)	14	NAP = napropamide (Devrinol)	15	SET = sethoxydim (Poast)	1
FLU = fluazifop-p-butyl (Fusilade)	1	ORY = oryzalin (Surflan)	3	SIM = simazine* (Princep)	5
GLU = glufosinate (Rely)	10	OXY = oxyfluorfen (GoalTender)	14	24D = 2,4-D*	4

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

<sup>1</sup> Mode of action 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.

# HERBICIDE TREATMENT TABLE (4/19)

Common name (Example trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
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The following are listed alphabetically. When choosing a pesticide, consider information relating to environmental impact, resistance management, the pesticide's properties, and application timing. Not all registered pesticides are listed. Always read the label of the product being used.

## SITE PREPARATION

### Established weeds

A.	2,4-D* (Dri-clean) WSSA MODE-OF-ACTION GROUP NUMBER: 4 COMMENTS: Controls horseweed and hairy fleabane. Can use in combination with glyphosate for broader weed control. Apply before weeds bolt for most effective control.	Label rates	48	See label
B.	GLYPHOSATE (Roundup PowerMax) WSSA MODE-OF-ACTION GROUP NUMBER: 9 COMMENTS: Apply with a controlled applicator or with low-pressure, flat fan nozzles. For annual weed control use 1 lb/acre in 10 to 40 gal water/acre. Apply to young annuals or vigorously growing perennials in the flowering stage. Some perennials require the high rate for control. May be used on young weeds in strips that will be the vine row, followed by planting into the dead weeds. Addition of ammonium sulfate at 8.5 to 17 lb/100 gal spray volume increases weed control. Weeds should not be cultivated for 7 to 14 days after treatment to obtain maximum control. New weeds usually do not establish for a month or more, due to the no-till effect.	0.387–3.71 lb a.e. 11 oz–3.3 qt	4	NA
C.	PARAQUAT* (Gramoxone SL2.0) WSSA MODE-OF-ACTION GROUP NUMBER: 22 COMMENTS: Apply in 20 to 60 gal water/acre to young weeds. Use 0.5% nonionic surfactant. Repeat treatment as new growth occurs.	0.625–1 lb a.i. 2.5–4.0 pt	24	NA

## AFTER PLANTING

### Before weeds emerge

A.	DIURON (Karmex DF) (Direx 4L) WSSA MODE-OF-ACTION GROUP NUMBER: 7 COMMENTS: For best results, apply during the winter months when weeds are less than 2 inches. Direct spray to the soil under grapevines at least 3 years of age. Do not apply around vines with trunks less than 1.5 inches in diameter. Diuron is sometimes combined with other preemergence herbicides to broaden the spectrum of weeds controlled. These combination treatments frequently use lower rates of diuron. Considered to be a ground water contaminant and requires a use permit within Ground Water Protection Areas. See label for rainfall concerns. <b>Note:</b> Pay special attention to soil texture rate adjustments; do not use on soils with less than 1% organic matter. Residual period: 8 to 12 months.	2.4–3.2 lb a.i. 3–4 lbs (Karmex DF) 2.4–3.2 qt (Direx 4L)	12 12	0 0
B.	FLUMIOXAZIN (Chateau SW) WSSA MODE-OF-ACTION GROUP NUMBER: 14 COMMENTS: Nonbearing and bearing grapevines. Applied as a directed spray; avoid contact with foliage or green wood. Rainfall 1/4 to 1/2 inch needed within 21 days for activation. Can be tank-mixed with other herbicides for broader weed control. Provides about 1 month residual activity for every 2 oz applied. See supplemental label for further restrictions.	0.19–0.38 lb a.i. 6–12 oz	12	60
C.	INDAZIFLAM (Alion) WSSA MODE-OF-ACTION GROUP NUMBER: 29	0.045–0.065 lb a.i. 3.5–5 fl oz	12	14

Common name (Example trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
COMMENTS: Use only on grapes 5 years and older. Do not apply to grapes grown in sand or soil containing 20% or more gravel content. If soil contains less than 1% organic matter, the maximum rate is 3.5 fl oz/acre (0.045 lb a.i.); if the soil contains more than 1% organic matter, the maximum rate is 5 fl oz/acre (0.065 lb a.i.).			
D. ISOXABEN (Trellis)	Label rates	12	60
WSSA MODE-OF-ACTION GROUP NUMBER: 21			
COMMENTS: For use in bearing and nonbearing vineyards. Provides control of hairy fleabane, horseweed, and many other broadleaf weeds. Apply before seeds germinate and incorporate with rainfall or irrigation within 21 days. Mix with glyphosate or 2,4-D if emerged weeds are present at time of application.			
E. NAPROPAMIDE (Devrinol 50 DF)	4 lb a.i. 8 lbs	24	35
WSSA MODE-OF-ACTION GROUP NUMBER: 15			
COMMENTS: Nonbearing and bearing grapevines for selective control of broadleaf weeds. Apply to the surface in 20 to 60 gal water/acre. Must be incorporated within 7 days of application or sprinkler irrigated. A second application of 4 lb/acre can be made during any one growing season. May be combined with a postemergence herbicide if weeds have emerged. Residual period: 4–10 months.			
F. ORYZALIN (Surflan AS Agricultural)	2–6 lb a.i. 2–6 qt	24	0
WSSA MODE-OF-ACTION GROUP NUMBER: 3			
COMMENTS: Nonbearing and bearing vineyards. Apply to the surface in 20 to 60 gal water/acre. Best if irrigated after application or applied before rainfall. If rain does not occur within 21 days, sprinkle irrigate with 0.5 to 2 inches of water. May be combined with a postemergence herbicide if weeds are present. The higher rates give the longest soil residual. Usually used at 4 lb/acre. Residual period: 6–12 months.			
G. OXYFLUORFEN (GoalTender)	Dormant: 1.25–1.5 lb a.i. Nondormant: 0.5 lb a.i. Dormant: 2.5–3 pt Nondormant: 1 pt	24 24	14 14
WSSA MODE-OF-ACTION GROUP NUMBER: 14			
COMMENTS: Nonbearing and bearing grapevines. Apply in 20 to 60 gal water/acre on firm soil. Must not be mechanically disturbed or poor weed control will result. Often combined with oryzalin. Check label for use period, cut-off dates, and restrictions. Certain formulations emit high amounts of volatile organic compounds (VOCs); use low-VOC formulations. <b>Regulations affect use for the San Joaquin Valley from May 1 to October 31, 2019.</b> Residual period 4–10 months.			
H. PENDIMETHALIN (Prowl H2O)	3–5.98 lb a.i. 3.2–6.3 qt	24	21
WSSA MODE-OF-ACTION GROUP NUMBER: 3			
COMMENTS: Will not control emerged weeds. Apply in 10 to 40 gal water/acre to soil under vines. May be applied to bearing and nonbearing vines. <b>Nonbearing vines:</b> apply only to dormant grapevines. Do not apply if buds have started to swell or injury may occur. May be applied before or after transplanting; see label for directions and restrictions. <b>Bearing vines:</b> may be applied anytime after fall harvest, during dormancy, or in the spring 21 days before harvest. Best control is achieved when irrigation or rainfall occurs within 7 days. Will not control emerged weeds. Reduced post harvest interval (PHI) allowed under a supplemental label that expires November 30, 2021. Residual period: 10 months.			
I. RIMSULFURON (Matrix FNV)	0.0625 lb a.i. 4 oz	4	14
WSSA MODE-OF-ACTION GROUP NUMBER: 2			
COMMENTS: For use on nonbearing and bearing vines. Apply in 10 or more gal water/acre to soil under vines. Apply only to vines that have been established for at least one full growing season. Best control is achieved when irrigation or rainfall occurs within 2 weeks after application. When band applications are made, treating 50% or less of a vineyard, a second application can be made. Residual period: 4–10 months.			
J. SIMAZINE (Princep 4L) (Princep Caliber 90)	2–4 lb a.i. 2–4 qt 2.2–4.4 lb	12 12	0 0
WSSA MODE-OF-ACTION GROUP NUMBER: 5			

Common name (Example trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
<p>COMMENTS: Apply to the soil under vines older than 3 years anytime between harvest and early spring. Make only 1 application per year. Use the high rate for heavy soils. Simazine is frequently used in combination with other preemergence herbicides. On light soils, simazine often is used at rates of 0.5 to 1 lb/acre. Do not use on gravel, sand, or loamy sand soils. If irrigation is applied immediately after application, limit water to 0.5 inch. Considered to be a ground water contaminant and requires a use permit within Ground Water Protection Areas. Residual period: 8–12 months.</p>			
<i>Established weeds</i>			
A. 2,4-D* (Dri-clean)	Label rates	48	See label
WSSA MODE-OF-ACTION GROUP NUMBER: 4			
COMMENTS: Can control horseweed and hairy fleabane alone or in combination with glyphosate for broader weed control when grapes are established for at least 3 years. Apply before weeds bolt for most effective control. In areas where horseweed and fleabane emerge in fall or early winter, make an application in fall and again before bloom if weeds are present. Irrigation immediately before or after treatment reduces control and can increase the risk of crop injury. Use flat fan or other appropriate low-pressure nozzles and a shield to prevent drift onto the grapes or other sensitive plants. Check the label for use period, cutoff dates, and other restrictions.			
B. CARFENTRAZONE-ETHYL (Shark EW)	0.016–0.031 lb a.i. 1–2 fl oz	12	3
WSSA MODE-OF-ACTION GROUP NUMBER: 14			
COMMENTS: Postemergence broadleaf control only. Mix with glyphosate for a broader spectrum of weed control. Do not use on newly transplanted vines. Do not allow spray to contact green stem tissue, foliage, or blooms. Use nozzles that produce coarse or very coarse droplets (volume median diameter (VMD) greater than 450 microns).			
C. CLETHODIM (Select Max)	0.0954–0.12125 lb a.i. 12.5–16 fl oz	24	365
WSSA MODE-OF-ACTION GROUP NUMBER: 1			
COMMENTS: For use on nonbearing vineyards only. Apply to rapidly growing grasses when they have reached the height recommended on the label. Do not apply to drought stressed plants. Use a crop oil concentrate.			
D. FLAZASULFURON (Mission)	0.033–0.044 lb a.i. 2.14– 2.85 oz	12	75
WSSA MODE-OF-ACTION GROUP NUMBER: 2			
COMMENTS: Apply only to 3rd year planted vines and older. Apply only as a directed spray to the soil beneath the vines to prevent injury to foliage and bark of young vines. Use of a protective sleeve is required for third year vines to minimize injury potential. Do not apply to areas where roots are exposed. Do not apply to stony soils. Do not apply more than two applications at 2.985 oz/acre per acre per year. Do not apply more than 5.7 oz/acre per year. The minimum retreatment interval is 3 months.			
E. FLUAZIFOP-P-BUTYL (Fusilade DX)	0.25–0.375 lb a.i. 16–24 oz	12	50
WSSA MODE-OF-ACTION GROUP NUMBER: 1			
COMMENTS: For use in bearing and nonbearing vineyards. For selective control of grasses when they are 2 to 8 inches tall but before tillering or heading. Use a crop oil (1%) or nonionic surfactant (0.25%) to increase penetration and control. Do not apply to grass that is stressed or poor control may result.			
F. GLUFOSINATE (Rely 280)	0.88–1.50 lb a.i. 48–82 fl oz	12	14
WSSA MODE-OF-ACTION GROUP NUMBER: 10			
COMMENTS: For use in bearing and nonbearing vineyards. Very effective on little mallow (cheeseweed), nettle, horseweed, and hairy fleabane. Apply at 20 to 50 gal/acre with a minimum pressure of 30 p.s.i. Good spray coverage of target weeds is essential for control. Addition of ammonium sulfate at 5 lb/100 gal spray volume increases weed control. Weeds should be less than 6 inches tall.			
G. GLYPHOSATE (Roundup PowerMax)	0.387–3.71 lb a.e. 11 oz–3.3 pt	4	14
WSSA MODE-OF-ACTION GROUP NUMBER: 9			



Common name (Example trade name)	Amount per acre	R.E.I.‡ (hours)	P.H.I.‡ (days)
<p>COMMENTS: Rates vary depending on the formulation used. Apply with a controlled applicator or with low-pressure, flat fan nozzles. For annual weed control, use 1 to 2 lb in 10 to 40 gal water/acre. Apply to young annuals or vigorously growing perennials. Addition of ammonium sulfate at 8.5 to 17 lb/100 gal spray volume increases weed control. Avoid drift onto green bark and foliage or injury will result. Weeds should not be cultivated for 7 to 14 days after treatment to obtain maximum control.</p>			
H. OXYFLUORFEN (GoalTender)	0.5–1 lb a.i. 1–3 pt	24	14
<p>WSSA MODE-OF-ACTION GROUP NUMBER: 14            COMMENTS: Dormant application to young (4-leaf stage) weeds. May be combined with other postemergence herbicides for specific weeds. Certain formulations emit high amounts of volatile organic compounds (VOCs); use low-VOC formulations. <b>Regulations affect use for the San Joaquin Valley from May 1 to October 31, 2019.</b></p>			
I. PARAQUAT* (Gramoxone SL2.0)	0.625–1 lb a.i. 2.5–4.0 pt	24	0
<p>WSSA MODE-OF-ACTION GROUP NUMBER: 22            COMMENTS: Apply in 20 to 60 gal water/acre to young weeds. Use 0.5% nonionic surfactant. Repeat treatment as new growth occurs. Residual period: less than 1 month.</p>			
J. SETHOXYDIM (Poast)	0.28–0.46 lb a.i. 1.5–2.5 pt	12	50
<p>WSSA MODE-OF-ACTION GROUP NUMBER: 1            COMMENTS: For selective control of grasses, apply to young annual or perennial grasses. Repeat applications will be required for the control of perennial grasses. Add 2 pt crop oil concentrate to the spray solution. Do not apply to grass that is stressed or poor control may result. Residual period: less than 1 month.</p>			
*	Permit required from county agricultural commissioner for purchase or use.		
‡	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 R.E.I. exceeds the P.H.I. The longer of two intervals is the minimum time that must elapse before harvest.		
1	Group numbers are assigned by the Weed Science Society of America (WSSA) according to different modes of action. Although weeds may exhibit multiple resistance across many groups, mode of action numbers are useful in planning mixtures or rotations of herbicides with different modes of action. For more information, see <a href="http://www.hracglobal.com">http://www.hracglobal.com</a> .		
NA	Not applicable.		

## *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 fruit and on tree bark, shoots, and roots, which can stunt growth or kill plants. Injury to trees by rodents or rabbits, for example, is often serious, killing the tree 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								Repellents
	Habitat modification	Trapping	Baiting	Fencing	Tree guards	Frightening	Shooting	Fumigating	Fumigation
Deer				X	X	X	X <sup>1</sup>		X

Pest	Control Measures								
	Habitat modification	Trapping	Baiting	Fencing	Tree guards	Frightening	Shooting	Fumigating	Repellents Fumigating n
Eastern fox		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/>) 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 that are available online (<http://cdpr.ca.gov/>). 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://cdpr.ca.gov/docs/endspec/>).

For more information on vertebrate management, see the Vertebrate Pest Control Handbook online.

## BIRDS (7/16)

**Common Name:** *Scientific Name:*

**American robin:** *Turdus migratorius*

**Crow:** *Corvus brachyrhynchos*

**Crowned sparrow:** *Zonotrichia* spp.

**European starling:** *Sturnus vulgaris*

**House finch:** *Carpodacus mexicanus*

**House sparrow:** *Passer domesticus*

**Scrub-jay:** *Aphelocoma californica*

### DESCRIPTION OF THE PEST

Several bird species may cause serious problems in grape production in California.

#### American robin

The American robin is commonly observed on lawns looking for earthworms or found in gardens and landscapes feeding on fruits and berries. It is about 10 inches long with an orange-red breast, grey to brown upper parts, white throat, and a dark brown to black head and tail.

The American robin is a migratory nongame bird and can only be lethally removed with a depredation permit from the U.S. Fish and Wildlife Service or under supervision of the local county agricultural commissioner.

#### Crow

The crow is chunky, black, 17 to 21 inches long with a thick, black bill and feet. They are easy to recognize by their loud *caw caw caw* sound. Crows are gregarious and often feed in large numbers, moving from orchard to orchard.

California Fish and Wildlife regulations allow crows to be taken only by landowners or tenants, or by persons authorized in writing by such landowners or tenants, when crows are committing or about to commit depredations (damage to crops).

#### European starling

Starlings are dark colored birds with light speckling on the feathers. They are about 7.5 to 8.5 inches long with a short tail. They have a long, slender yellow bill in summer and a dark one during the winter. Starlings have a wide habitat range but prefer areas with trees. If their excrement or droppings contact the fruit, it will cause unsightly blemishes and may transmit diseases.

Starlings are an invasive, exotic species and can be lethally removed at any time.

#### House finch

House finches are highly adapted to human environments. House finches are typically 5 to 6 inches long and feed in small flocks. Male finches have a rosy-red or orange head, rump, and breast with brownish wings and back, and a brown streak on their sides. Females have the brown body and wings, but lack the red or orange coloration.

House finches are migratory, nongame birds, and can only be lethally removed with a depredation permit from the U.S. Fish and Wildlife Service or under supervision of the local county agricultural commissioner.

#### Scrub-jay

Scrub-jays are aggressive birds, 10 to 12 inches long, and are distinguished by their crestless head, olive-gray back, and white throat with a blue outline. Their head, tail, and wings are blue. Scrub-jays are usually solitary birds but occasionally feed in pairs. Where jay habitat is adjacent to an orchard, however, several dozen may invade the trees daily, forming almost continuous lines moving to and from trees.

Scrub-jays are classed as a migratory nongame bird and may only be removed under permit from the U.S. Fish and Wildlife Service.

### **Sparrow**

White-crowned and golden-crowned sparrows cause damage in California. Both are about 6 to 7 inches long. White-crowned sparrows have a distinct pink or yellowish bill, erect posture, gray throat and breast, and a visible crown streaked with black and white. Their call is a clear whistle. Golden-crowned sparrows are similar, except they have no white head stripes. A golden-yellow central crown stripe is prominent with black borders. Their call is three to five clear whistles. Overall, golden-crowned sparrows are less numerous and cause fewer problems than white-crowned sparrows.

Crowned sparrows are migratory, nongame birds, and can only be lethally removed with a depredation permit from the U.S. Fish and Wildlife Service or under supervision of the local county agricultural commissioner.

The house sparrow is a small (approx. 6 inches), stocky songbird with short legs and a thick bill. Male house sparrows have a black throat and white cheeks. The male has a reddish back and black bib, while the female is distinctly brown. The house sparrow is an invasive, exotic species, and as such, can be lethally removed at any time.

## **DAMAGE**

Several bird species including house finches, European starlings, American robins, and white-crowned sparrows may cause substantial damage by feeding on ripening fruit; other less common bird pests include California quail (*Callipepla californica*), mourning doves (*Zenaida macroura*), ring-necked pheasant (*Phasianus colchicus*), scrub-jays, and wild turkeys (*Meleagris gallopavo*).

House finches are typically much more numerous and problematic than white-crowned sparrows. Starlings are typically more numerous and damaging than robins.

- House finches and white-crowned sparrows peck at grapes and berries damaging the fruit.
- European starlings and American robins remove the entire grape or berry; they also can puncture lower berries with their feet.
- In grapes, additional damage occurs when juice drips on other grapes, resulting in a buildup of secondary organisms and bunch rot.

## **MANAGEMENT**

### **Biological Control**

Natural predators such as raptors and bobcats will feed on some of the smaller bird species, although these numbers mean little for controlling such bird pests.

### **Cultural Control**

#### *Habitat modification*

Always consider habitat modification as a first step for controlling bird pests.

- Look for and eliminate brush or pruning piles, stacks of irrigation pipes, piles of boxes, etc., where birds may rest and nest.
- Consider removing roosting trees along perimeters to reduce bird invasion into fields.

However, there are few situations when habitat modification can be used to control high bird numbers. As such, alternative control methods will likely be needed.

#### *Exclusion*

Netting is often used only for high value crops. In grapes and berry crops, netting can be used to exclude most damaging bird pests. It is the most effective method for reducing damage to these crops, but is also expensive.

Be sure to extend netting to the ground and tie off all ends to stop birds from entering underneath.

## Monitoring and Treatment Decisions

Count birds weekly to help you determine when damage will occur so you can take action early. This is particularly important to reduce damage to fruiting buds and newly sprouted row crops.

1. Watch for bird movement into or within the field.
2. Keep track of species, numbers, and location if you have had substantial damage in the past.
3. As fruit begins to ripen or as the nuts develop, look for fruit or nuts that are damaged or that have been knocked from the tree or vine.

These records will help you plan control strategies in advance and assess the effectiveness of previous control actions.

### *Frightening devices*

Frightening devices can deter some species (e.g., crowned sparrows, crows, magpies, starlings), but are less effective for others (e.g., horned larks, house finches, house sparrows, robins, scrub-jays).

The most effective way to frighten birds from a field is to use a combination of noisemakers and visual repellents such as mylar streamers and "scare-eye" balloons. For example, scare-eye balloons may be attached to trees or posts that are next to electronic distress call devices. This combination may increase effectiveness over using either approach by itself. For maximum effectiveness, rotate from one type of frightening device to another and do not use one combination of devices for more than a week; otherwise, birds will become used to it.

Common noisemakers include roving patrols of bird bombs and shell crackers. Stationary devices such as gas cannons and electronic distress calls also provide relief. These stationary devices are most effective when you have at least 1 device per 5 acres and when they are elevated above the canopy.

Regardless of the approach used, pay attention to bird responses when using frightening devices. When birds no longer respond negatively to a specific approach, you must switch to a different frightening tactic to continue to scare birds out of the field. At best, an appropriate rotation of frightening devices will control bird pests for a few weeks. Therefore, only use these scare-tactics when needed to prevent birds from habituating to these auditory and visual repellents. Additionally, once birds become accustomed to feeding in a field, frightening tactics become much less effective. Therefore, have frightening devices ready to implement before damage occurs so that birds can be deterred right at the onset of damage.

### *Falconry*

A growing body of evidence indicates that the use of falconry is an effective management option for grape and berry crops, and likely has similar utility in field crops as well. Falcons are typically flown for several hours during morning and late afternoon or early evening hours, although this can be modified given bird activity. The falcons are not typically allowed to attack crop-damaging birds, but rather serve to frighten birds out of desired areas.

Although somewhat expensive, they are typically less expensive than exclusion through netting and may serve as a good alternative to more traditional frightening devices and netting.

### *Shooting*

Birds that invade orchards in small numbers, such as scrub-jays and magpies, can often be controlled by shooting. Check with California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, and county agricultural commissioner officials before shooting any birds as depredation permits are often needed.

Where permissible, occasionally shooting at a few birds will increase the effectiveness of your noisemaking techniques, especially if noise makers go off at the same times as the actual shots, because birds will begin associating loud noises with the real hazards of firearms.

### *Trapping*

Trapping can be an effective way to control house finches, house sparrows, crowned sparrows, and starlings, especially if conducted over a relatively large area such as several orchards or vineyards. The most effective trap for these species is the modified Australian crow trap.

Successful trapping must take into account the behavior patterns of the birds being controlled. These traps use live birds as decoys to attract additional birds. Therefore, place traps in suitable locations with adequate food, water, shade, and roost locations to keep the trapped birds alive.

Trapping is best carried out by someone experienced with the technique. For house finches and crowned sparrows, trapping must be conducted under supervision of the county agricultural commissioner.

Trapped birds are usually euthanized through the use of a CO<sub>2</sub> chamber. Leave some birds alive to serve as future decoys.

### *Repellents*

Chemical repellents rely on objectionable tastes, odors, or learned aversions to deter birds from consuming or damaging fruit.

Commercial repellents containing the active ingredient methyl anthranilate are currently registered for use in some crops. This repellent has been shown to effectively reduce bird damage to several fruit species in some studies, while showing little efficacy in others. Efficacy is likely influenced by the availability of alternative food sources and ability of the user to apply the repellent following the label recommendations. In some situations, methyl anthranilate may provide some relief for small orchards although overall efficacy is uncertain. If you decide to use methyl anthranilate, be sure to carefully read the label as California restrictions are different than most other states.



# CALIFORNIA GROUND SQUIRRELS (7/16)

**Scientific Name:** *Otospermophilus beecheyi* and *O. douglasii*

## DESCRIPTION OF THE PEST

The adult California ground squirrel:

- Head and body 9 to 11 inches long
- Somewhat bushy tail is about as long as its body
- Fur is mottled dark and light brown or gray

Ground squirrels live in colonies that may grow very large if left uncontrolled. They are active during the cooler times on hot days and sunny periods during the cooler months; they are usually most active in morning and late afternoon. In periods of high winds, ground squirrels retreat to their burrows.

California ground squirrels live in underground burrows and form colonies of 2 to 20 or more animals. Each ground squirrel burrow system can have several openings with scattered soil in front. Individual ground squirrel burrows may be 5 to 30 feet long, 2.5 to 4 feet below the surface, and about 4 to 6 inches in diameter. Burrows provide the ground squirrels a place to retreat, sleep, hibernate, rear their young, and store food. Ground squirrels often dig their burrows along ditches and fencerows around buildings, within and bordering many agricultural crops, and on other uncultivated land. They tend to avoid flood irrigated areas, thick chaparral, dense woods, very moist areas, and lands that are under complete and frequent cultivation. They will travel 100 yards or more to feed in adjacent crops. When uncontrolled, they frequently move into perennial crops, such as orchards and vineyards, and dig burrows beneath the trees or vines.

The California ground squirrel can be active throughout the year in coastal areas of Southern California. Ground squirrels in the southern San Joaquin Valley become much less active during the winter, but seldom truly hibernate. Especially in hot locations, adult ground squirrels become temporarily dormant (estivate) when food is scarce or temperatures are extreme, primarily in late summer. Winter hibernation and summer estivation are more typical among ground squirrels in inland areas where temperature variations are more extreme. Regardless of location, young ground squirrels tend to be active all summer.

Ground squirrels that do hibernate generally emerge around January when weather begins to warm. In late winter and spring, they feed on green vegetation but switch to seeds and fruit in late spring and early summer as the vegetation dries up. Females have one litter, averaging 8 young, in spring. Young ground squirrels emerge from their burrow when about 6 weeks old; they do not estivate their first summer, and many may not hibernate during their first winter.

## DAMAGE

California ground squirrels are responsible for major damage throughout the state. Their damage is most prevalent in crops adjacent to uncultivated areas where ground squirrels are not controlled.

- They easily climb trees and vines and feed on fruit and nuts from set to maturity and through harvest. Adult ground squirrels often cache seeds and nuts in their burrows, especially in the late summer and early fall. During this period, crop losses greatly exceed the amount the ground squirrels have consumed. Ground squirrels also consume vegetative crops (e.g., alfalfa, cole crops, and lettuce) and berries.
- Ground squirrels also gnaw fruit and bark, girdle trunks and scaffold limbs, and are capable of girdling and killing trees or vines in a relatively short time.
- In addition to above ground damage, they can damage roots, enabling fungal pathogens to infect trees.
- They often chew plastic irrigation lines, and their burrows can contribute to soil erosion.
- When digging burrows, ground squirrels bring soil and rock to the surface and deposit it in mounds near burrow openings. They enlarge burrow systems each year by constructing new tunnels and creating more entrances, so the longer the ground squirrels occupy the burrow, the more extensive it becomes. They create more entrances to serve a growing population. Large and numerous burrow openings and soil mounds are hard on equipment and can make mechanical harvesting especially difficult.

- The burrows of ground squirrels can divert irrigation water and have been known to cause severe damage to levees and other water retention systems.
- In some areas, ground squirrels can also pose a health risk to humans through the spread of sylvatic plague.

## MANAGEMENT

The management action needed for ground squirrels depends on their activity pattern and feeding preferences during the time of year when action is taken. The choice of tactics is also influenced by the location of the infestation and number of ground squirrels present. For more detailed information on managing ground squirrels, see Ground Squirrel Best Management Practices (available online at <http://www.groundsquirrelbmp.com/management-cgs.html>).

### Biological Control

Predators such as coyotes and hawks are usually not sufficient to effectively control ground squirrels. These predators consume a number of ground squirrels, but usually not enough to keep populations at sufficiently low numbers to eliminate the need for additional control measures.

### Cultural Control

#### *Habitat modification*

Ground squirrels often burrow beneath long-standing piles of prunings, wood, or rock, or use them as harborage. Removing such piles may make the area somewhat less desirable to them, but the base of trees, fence lines, and ditch banks still offer burrowing sites. Peripheral cleanup may somewhat reduce the potential for ground squirrels. In addition, it makes burrow detection and monitoring easier and improves access to burrows during control operations. Ground squirrels are extremely adaptable so habitat modification has limited benefit in a management program. Squirrels may quickly reinvade abandoned burrow systems. Deep plowing (ripping) along field perimeters will destroy burrow entrances and will help slow the rate of invasion. Burrow fumigants, toxic baits, and traps currently are the most effective control methods.

### Monitoring and Treatment Decisions

To make it easier to monitor and help reduce numbers, remove brush piles, debris, and stumps in and around the crop fields. Monitor for ground squirrels year round, even in winter, especially during midmorning when they feed most actively. Monitor within the crop field during routine activities. Mid morning is usually the best time of day to observe squirrel activity.

To monitor:

1. Observe feeding grounds and watch for other signs of activity especially the appearance of burrows.
2. Check the perimeter of the crop fields at least once a month during the times of year when ground squirrels are active.
3. Periodically monitor areas from which ground squirrels are likely to invade, such as along ditch or road banks or in crops adjacent to your field.

Keep records and use them as the basis for future management decisions, noting:

- When ground squirrels emerge from hibernation
- When the first young are seen above ground
- Approximate number of ground squirrels you see and the location and number of burrows
- Changes in the general number of ground squirrels
- Management actions implemented, dates of use, and their effect

#### *Treatment options*

When even one or two ground squirrels are present in or immediately adjacent to the crop field, be prepared to take action. Treatment options for ground squirrels include the use of fumigants (e.g., gas cartridges, aluminum phosphide,\* and carbon monoxide-producing devices) and baiting with multiple-

dose anticoagulants (e.g., chlorophacinone\* and diphacinone\*) or zinc phosphide\*. These are restricted-use pesticides that require a permit from the county agricultural commissioner for purchase or use.

Select the control method best suited for the time of year.

- The most effective time to control ground squirrels is in late winter or early spring when adults have emerged from their burrows but before they reproduce. For best control, use burrow fumigation about 2 to 3 weeks after the first ground squirrels emerge from hibernation.
- Because ground squirrels feed almost exclusively on green vegetation early in the season, poisoned grain baits are generally not effective until late spring or early summer.
- Trapping can be used year round but is most effective when numbers are low.
- In late spring or summer, at locations where squirrels are moving from adjacent lands into the crop field to feed, baiting or trapping along the perimeter offers the most effective control if access to the neighboring property is not possible.

### *Fumigants*

Fumigation can be very effective against ground squirrels. The best time to fumigate is late winter or early spring when the ground squirrels are active and soil is moist. Fumigation is also possible later in the year as long as sufficient soil moisture is present, although it is not effective when ground squirrels are hibernating or estivating: at those times, they seal themselves off from within their burrows. When the soil is dry, fumigation is much less effective because more of the toxic gas escapes from burrows through cracks in the soil.

When using a fumigant, make sure to treat all active burrow systems in and around the crop field. Recheck all areas a few days after fumigation and re-treat any that have been reopened. For safety's sake, do not fumigate burrow systems that are adjacent to buildings or may open under structures.

A relatively easy way to fumigate is with the use of gas cartridges. They are available commercially and from some county agricultural commissioners' offices. Use one or two cartridges for each burrow that shows signs of activity. A large burrow system may require more than two.

1. Quickly shove the ignited cartridge into the burrow using a shovel handle or stick and seal the burrow entrance with soil.
2. Watch nearby burrow entrances; treat and seal any that begin to leak smoke.
3. If smoke is observed escaping from other entrances, it means the burrows are connected. If the burrow is believed to be small, this additional entrance only needs to be sealed. If the burrow appears to be large, an additional cartridge may need to be inserted following the above-outlined protocol.

The larger and more complex the burrow system, the more smoke it takes to be effective.

Aluminum phosphide\* is also a highly effective burrow fumigant. In fact, studies of this material for ground squirrel management indicate an efficacy of 95 to 100%. When aluminum phosphide\* tablets come into contact with moist soil and air in the burrow they produce phosphine gas, which is highly toxic to any animal (never add water directly to the burrow to increase moisture as spontaneous combustion can occur if the product contacts water). When using aluminum phosphide\*, treat every active burrow, fill the entrance with a wad of newspaper, and cover with soil. In addition to being somewhat more effective than gas cartridges, aluminum phosphide\* is also much cheaper to apply. However, aluminum phosphide\* is a highly restricted-use material, and these restrictions are frequently changing. Be sure to understand the current restrictions in place before using for ground squirrel control. Application personnel should be trained in the material's proper use and on its potential hazards.

As of 1 January 2012, pressurized exhaust machines can now be used to apply carbon monoxide to burrow systems. As of 2014, the author is aware of two commercial products available: the Pressurized Exhaust Rodent Controller (PERC®) machine and the Cheetah rodent control machine. Initial research into the efficacy of these devices has indicated that the PERC® is moderately effective for California ground squirrels, although results were highly variable. The Cheetah rodent control machine did not prove to be effective. Plans are in place to further test these devices in the future.

**Baiting**

Poison bait is usually the most cost-effective method for controlling ground squirrels, especially when numbers are high. Bait consists of grain or pellets treated with a poison registered for ground squirrel control. To be effective, bait must be used at a time of year when ground squirrels are feeding on seeds and will readily accept baits such as in late spring or early summer. In fall, ground squirrels store a lot of the seed instead of eating them, so it may require more bait to control the population.

Before you use baits, place a small amount of untreated grain, such as breakfast oats, near burrows in the morning and check in the late afternoon to see if the ground squirrels have taken it (this ensures that nocturnal animals have not eaten the grain). If the grain is taken during the day, proceed with baiting. If it is not taken, wait several days or a week and try again. Remember: bait is only effective if eaten by the target pest. If in a nut orchard, once squirrels begin feeding on nuts, they no longer show much interest in grain baits. Therefore, baiting programs must be initiated before this time to ensure effective control of ground squirrels. When using poison baits, make sure to follow label directions carefully to reduce hazards to nontarget species.

Multiple-dose anticoagulant baits (e.g., chlorophacinone\* and diphacinone\*) can be applied in bait stations, as spot treatments near burrows, or broadcast over larger infested areas. Check the label to make sure that the bait you plan to use is registered for the method you intend to use. For a multiple-dose bait to be effective, animals must feed on it over a period of 3 to 5 days so if spot or broadcast treatments are used, 2 or 3 applications may be necessary.

Zinc phosphide\* is an acute toxicant that can also be used to control ground squirrels. It kills ground squirrels after a single feeding, so it can reduce numbers more quickly than anticoagulants. However, zinc phosphide\* has a distinctive odor and taste that many ground squirrels seem to avoid. Likewise, ground squirrels will occasionally consume a sublethal dose of zinc phosphide\* that will cause individuals to get sick but will not kill them. This leads to bait shyness in a ground squirrel population. These problems with bait acceptance and bait shyness sometimes result in greater control of ground squirrels when using anticoagulant baits. Pre-baiting the area with untreated grain 2 to 3 days prior to the application of zinc phosphide\* may reduce the chances of bait shyness and improve the effectiveness of baiting programs. Control with zinc phosphide\* is usually achieved within 48 hours of the bait application.

**Baits applied as broadcast or spot treatments**

When specified on the label, zinc phosphide\* and anticoagulant baits\* can be applied as spot-treatments, which are economical and effective for small populations. Reapply according to label directions to make sure there is no interruption in exposure to the bait. Scattering the bait takes advantage of the ground squirrels' natural foraging behavior and minimizes risks to nontarget species that are not as effective at foraging for seeds. Never pile the bait on the ground because piles increase the hazard to livestock and certain nontarget wildlife.

When ground squirrel populations are larger or cover a broader area, broadcast applications of zinc phosphide\* or anticoagulants\* may be used. This can be an effective and economical method for controlling this species over a large area. Usually squirrels retreat back to burrows when sick and will die there, although up to 20 to 30% of ground squirrels may die aboveground.

**Baits applied in bait stations**

Various kinds of bait stations are commonly used with diphacinone\* and chlorophacinone\* 0.005% baits; all are designed to let ground squirrels in but to exclude larger animals. Special types of stations must be used within the ranges of the San Joaquin kit fox or endangered kangaroo rats to ensure that these species are excluded. Consult your local agricultural commissioner or the California Department of Pesticide Regulation website (<http://www.cdpr.ca.gov/docs/endspec/>) for the latest recommendations on use of poison baits in areas that are within the range of endangered species.

1. Place bait stations near runways or burrows and secure them so they cannot easily be tipped over. If ground squirrels are moving into the crop field from adjacent areas, place bait stations along the perimeter of the field where ground squirrels are invading, one station every 100 feet. Use shorter intervals between stations when the number of ground squirrels is high.

2. Check bait stations daily at first, then as often as needed to keep the bait replenished. If bait feeding is interrupted, the bait's effectiveness will be greatly decreased. Make sure to pick up any bait that spills and to replace bait that is wet or moldy. Successful baiting usually requires 2 to 4 weeks. Continue to supply bait until feeding ceases and you observe no ground squirrels; then remove and properly dispose of unused bait if there is not a threat on continued reinvasion.
3. Zinc phosphide\* cannot be used in bait stations.

After treatment, pick up and dispose of any carcasses whenever possible to prevent secondary poisoning of dogs or other scavengers. Burial is a good method for disposal as long as the carcasses are buried deep enough to discourage scavengers. Do not touch dead animals with bare hands.

Assess the potential hazard to humans, livestock, and nontarget wildlife before you use baits; if it is risky, use another method for ground squirrel control.

### *Trapping*

Because trapping is time-consuming, it is most practical for small infestations any time of year when ground squirrels are active. Trapping is especially effective from mid-spring through fall. Ground squirrel traps include Conibear traps and modified gopher box traps. As with all traps, take precautions to minimize trapping of nontarget wildlife and pets.

#### **Conibear traps**

Conibear kill traps are usually placed unbaited in the burrow entrance, where ground squirrels are trapped as they pass through. Trap effectiveness can be increased by putting a tunnel of roofing paper (24 inches long) at the entrance of the burrow. The ground squirrel will mistake the light at the end of the tunnel for the burrow opening and run full speed through the trap. The tunnel also minimizes any sun reflection off the metal trap.

If you are using this type of trap within the range of the San Joaquin kit fox, you must place the trap in a covered box with an entrance no larger than 3 inches wide to exclude the fox, or you must spring the traps at dusk and reset them again in the morning.

#### **Box traps**

Modified wooden pocket gopher box traps consist of a pair of box traps that have been joined together by removing the backs, connecting the two traps with wire mesh, and then to a board. Another very effective trap is a single wooden box trap. The single wooden box trap (Critter Getter DK-3) is larger than the pocket gopher box trap (DK-2) and has a pull trigger rather than the push type for pocket gophers. The traps are baited with foods such as almonds, barley, melon rinds, oats, or walnuts. Place bait in traps well behind the trigger or tied to the trigger without setting the traps for several days, until the ground squirrels become used to taking the bait. Then put in fresh bait and set the traps. With the single pull trap, secure the bait to the trigger and wire the trap to a stake, fence, or other stationary object. Place traps so that nontarget animals are not likely to be caught. For example, place traps inside a larger box with openings no larger than 3 inches wide, just large enough to allow ground squirrels to enter.

#### **Live traps**

Live-traps, such as wire-cage and multiple-capture traps, can also be used to capture ground squirrels. The Black Fox repeating live trap has proven to be very effective in catching several individuals at one time. This 24" x 24" x 4" heavy gauge wire trap has doors that are wired open for several days for pre-baiting. When the self-closing doors are dropped down after pre baiting, the ground squirrel pushes to get in but cannot get out. As with box traps, pistachios, almonds, walnuts, oats, barley, and many fruits and vegetables are all effective baits. Because these traps keep ground squirrels alive after capture, they are useful in areas where nontarget captures are a concern (e.g., areas with pets, children, etc.). However, ground squirrels must be euthanized by the trapper upon capture as translocation of ground squirrels is illegal unless in possession of a permit issued by the California Department of Fish and Wildlife, unloads your problem on others, and can spread disease such as sylvatic plague. It is this extra step that limits the utility of live-trapping for some growers. Methods considered humane by the American Veterinary Medical Association include: gassing with carbon dioxide and shooting. Drowning is not an approved method of euthanasia and is illegal in California. Traps need to be checked once daily, and any animals found must be removed and should be euthanized.

*Gas explosive device*

The use of a gas explosive device that combines propane with oxygen has been used to kill ground squirrels through concussive force. This device has the added benefit of destroying part or all of the ground squirrel's burrow system, thereby potentially slowing reinvasion rates. This control method carries with it a substantial fire hazard. To date no scientific studies have shown this method to be overly effective at ground squirrel control.

*Repellents*

No repellents have proven effective at substantially reducing damage caused by ground squirrels.

*Frightening devices*

No frightening devices have proven effective at substantially reducing damage caused by ground squirrels.

\* 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.

## DEER (7/16)

**Scientific Name:** *Odocoileus hemionus*

### DESCRIPTION OF THE PEST

Deer are large mammals, typically around 3 to 3.5 feet at the shoulder. Deer are often not seen, in large part because they forage primarily during low-light hours (i.e., early morning and late evening). However, in residential and residential interface areas, deer often habituate to people, and are seen regularly during light hours.

When not visible, other forms of deer sign, such as hoof prints, must be observed to verify their presence. Deer hoof prints are split and about 2 to 3 inches in length. They are easily distinguished from pig and sheep prints in that deer prints are more pointed at the front and rounded at the back; the opposite is true for pigs and sheep. Deer droppings can also be used to verify deer presence. The appearance of droppings vary, but commonly each fecal pellet is oblong, somewhat pointed at one or both ends, and 0.25 to 0.5 inch long.

Deer occur in many foothill and coastal areas and sometimes in the Central Valley near riparian habitats.

### DAMAGE

Mule deer, including the subspecies called black-tailed deer (*O. hemionus columbianus*), can be serious pests to tree and vine crops. They are also occasional pests to alfalfa and a variety of row crops.

Deer can completely defoliate young trees or vines. They can stunt, distort, or kill plants by repetitive browsing. Although relatively rare, buck deer can severely scar the bark when they rub their antlers on trunks and lower limbs. Deer may browse on older trees or vines, but the damage to them is usually less severe than that caused to young plants.

### MANAGEMENT

Deer can cause significant damage in areas where adjacent habitat supports moderate to high deer populations. Foothill and coastal districts with brush or woodlands that provide cover for deer usually experience the most frequent damage. Some valley orchards or vineyards near stream bottoms may also suffer. State game management laws limit the control methods available to growers and make combating deer damage expensive. Primary control methods include exclusion, repellents, frightening devices, and shooting.

#### Cultural Control

##### *Exclusion*

Fencing is the most effective method for excluding deer from a field. Fencing also substantially reduces crop theft and vandalism from humans. Fencing is costly, but if you are planting where deer and uninvited people are likely to present continuing problems, it will likely pay for itself in the long run.

Check deer fences periodically to be sure they remain intact; damaged wire, broken gates, soil washout beneath fences, etc., permit access and must be repaired immediately. Deer that manage to circumvent the fence and get inside may have to be removed by shooting if they cannot be driven out.

##### *Woven Wire Fences*

A fence made of woven wire exclude deer if the fence is tall enough. Use a 6-foot (1.8 m) fence of woven wire with several strands of smooth or barbed wire along the top to extend the height to 7 or 8 feet. Be sure the fence is tight to the ground or deer will crawl under.

Wire mesh cylinders around individual trees may be effective where only a few new trees are being planted in a location subject to deer damage. Make the cylinders at least 6 feet tall and large enough in diameter to keep deer from reaching over them to eat the foliage. Secure the cylinders with stakes so they cannot be tipped over.

***Electric Fences***

Electric fencing is less expensive to install than woven mesh fencing but it costs more to maintain. High-tensile wire is the best choice, as it is more resilient than other types; it can absorb the impact of deer, falling limbs, and farm equipment without stretching or breaking. Use a high-voltage, low-impedance power source that provides sufficient voltage to repel deer while being less likely to short out when vegetation touches the wires. Control vegetation around the base of the fence; in wet weather, contact with wet foliage can drain enough voltage from the fence to render it ineffective.

***Habitat modification***

Eliminating suitable cover for bedding and other survival needs rarely results in less crop damage. Deer are highly mobile and many travel 1/2 mile or more to reach a desired area, especially when they have become accustomed to feeding there.

**Monitoring and Treatment Decisions**

In brushy areas, deer usually stay out of sight during the daytime. They move into vineyards or orchards at night to browse, although in areas where hunting is not allowed, deer can habituate to humans; consequently, they are often seen in the daytime in these areas. Feeding evidence and hoof prints indicate their presence. In areas where deer are not visible, you may also use spotlights to check for deer at night.

***Repellents***

Growers can use chemical repellents for tree and vine crops over relatively small areas. Repellents are not always effective for a variety of reasons including:

1. lack of alternative food sources for deer
2. habituation to the field
3. need for frequent reapplication after rainfall or irrigation events
4. need to reapply to new vegetative growth

As such, repellents should not be relied upon to eliminate damage, but rather to reduce damage to acceptable levels.

Depending on the active ingredient, chemical repellents elicit a fear, pain, or discomfort response in deer. Those repellents that elicit a fear response (e.g., repellents based on rotten egg formulations, dried blood, etc.) are typically most effective. Repellents that elicit a pain response (e.g., those containing capsaicin) are also effective if applied at high concentrations. Efficacy from urine and fecal matter from predators tends to be highly variable; more effective options are available.

***Frightening devices***

Noise-making devices such as propane exploders and electronic distress calls are not often reported to be effective for more than a day or so because deer rapidly habituate to frightening devices. A relatively new electronic distress call (<http://www.birdgard.com/deer-shield/DeerShield>; <http://www.birdgard.com/deer-shield/>) is effective for white-tailed deer (*Odocoileus virginianus*). This product has not been sufficiently tested on mule deer in California, but may work given its reported success on white-tailed deer.

If only a few deer are involved, having someone patrol newly planted areas at night with a spotlight to frighten deer away may prove effective, though expensive.

For small fields (less than 80 acres), dogs can be effectively used to frighten deer away. Dogs must be fenced in to keep them from roaming away from the target area. Options for fencing include a woven wire fence, electric fencing, or invisible fencing. Effective breeds will vary but could include retrievers and other medium-sized active dogs. The dogs do not require extensive training, but not all dogs are appropriate for field protection; they must be out in the elements at all times, and must show an interest in chasing offending animals away.

***Shooting***

In some circumstances depredation permits may be obtained from the California Department of Fish and Wildlife, but shooting is rarely a successful solution to a significant deer problem. Encouraging deer hunting in the area can lower the overall deer population and thus reduce damage from deer.





# 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 pincher 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

Jackrabbits, cottontails, and brush rabbits may damage young trees and vines. Rabbits may chew and remove bark and clip off branches within their reach to eat buds and young foliage. Trunk girdling is usually higher on the trunk than damage caused by meadow voles. The damage appears as vertical lines or grooves in the bark. Rabbits usually do not present a serious problem for older trees and vines. Rabbits may also gnaw on drip irrigation lines. They often live outside of orchards, vineyards, and crop fields, moving in to feed from early evening to early morning. They damage plants primarily in winter and early spring, when other sources of food are limited.

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

Rabbits are active all year but damage trees and vines primarily in winter and early spring when other sources of food are limited. 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. Unless you are already building a deer fence, the cost of a rabbit fence may be prohibitive for a large orchard or vineyard when you are only going to need it for a few years. Individual tree guards are a good alternative, particularly if damage to vines and trees is focused on the perimeters of orchards and vineyards.

#### *Tree Guards*

Tree guards are useful when planting new orchards or vineyards or replanting trees or vines in established areas. Cylinders made from wire mesh or some hard plastics provide the best protection against rabbits. Cardboard or heavy paper can also be used, but rabbits may chew through these.

1. Make the cylinders at least 2.5 feet tall to keep jackrabbits from reaching foliage and limbs by standing on their hind legs.
2. Secure the tree guards with stakes or wooden spreaders.

Use smaller-mesh wire and bury the bottom few inches of the cylinder if you also need protection against voles.

#### *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):

- Inspect young trees and vines periodically for feeding on bark to catch a problem early.
- Look for clipping of small, low branches and leaves as tree breaks dormancy.

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.

## VOLES (MEADOW VOLE, MEADOW MICE) (7/16)

**Scientific Name:** *Microtus* spp.

### DESCRIPTION OF THE PEST

Voles are also called meadow mice. Adults:

- Larger than house mice but smaller than rats
- Blunt-nosed stocky rodents
- Full grown length is 4 to 6 inches
- Small ears and eyes
- Short legs
- Short tails
- Coarse fur is usually dark gray or grayish brown

Compared to deer mice, voles have a more robust body, less obvious ears, and a relatively shorter tail. Vole ears are at least partly obscured by the hair in front of them and their tails are about one-half to one-quarter the length of their head and body combined. Deer mice have relatively large and prominent, fleshy ears, white belly and feet, and their tail is bi-colored and more than 70% the length of their head and body.

Voles live in colonies and are active both day and night, all year round. Females bear 5 to 10 litters per year, with peaks of reproduction in spring and fall. Because voles mature rapidly and bear multiple litters yearly, numbers can increase quickly reaching as high as hundreds of voles per acre. In many areas, populations peak every 4 to 8 years, and then decline fairly rapidly. Voles live in areas such as irrigated pastures, fencerows, or weedy ditchbanks, where the soil is suitable for burrowing and where vegetation provides cover. Grasses and other dense ground cover provide food and shelter that favor the buildup of vole populations. They usually avoid sandy soils. The soil of the Tulelake Basin of Northern California is a location that is highly favorable for voles.

You can recognize vole activity by the narrow runways in grass or other ground cover, connecting numerous shallow burrows with openings about 1-1/2 inches in diameter. Voles seldom travel far from their burrows and runways, usually less than 10 feet (3 m) from the nest. Droppings are about 0.18 inch (4.5 mm) long and greenish when fresh, turning brown or gray with exposure to the environment. Sometimes fresh leaves or other cuttings are found in these trails.

Five species of voles, genus *Microtus*, occur in California. The most widespread species in the state is the California vole (*Microtus californicus*), which occurs in the Central Valley and throughout the length of the coast range. In potatoes, most damage occurs in the Klamath Basin, where the montane vole (*M. montanus*) is found.

### DAMAGE

Voles can cause severe damage in orchards and vineyards by feeding on bark. Characteristic damage is complete or partial girdling of trunks from just below the soil line to usually no more than 5 inches high. In rare situations, voles climb higher on young trees or vines.

In addition to bark, voles also feed around the root crown, and sometimes chew holes in irrigation lines. Young trees or vines are more readily fed upon and most susceptible to being completely girdled and killed by voles. Large trees or vines can be damaged, but this is uncommon and rarely ends in death. For instance, after severe pruning, sufficient light penetrates the canopy for vegetation to grow near trunks, providing cover and food for voles. Voles live in areas where grass or other permanent vegetative cover remains year-round. Orchards or vineyards that have cover crops or those in which grass and herbaceous plants are left to grow next to trunks are most susceptible to damage.

### MANAGEMENT

The best management programs for voles keep numbers at low levels; once vole numbers reach high levels, control becomes much more difficult and costly. Vegetation management and the proper use of exclusion keep damage to a minimum. Poisonous bait (either multiple-dose anticoagulants\* or zinc phosphide\*) can control voles that reach harmful numbers. All field-use rodenticides for voles are restricted use materials that require the applicator to be a private or commercial certified applicator or to be under the supervision of a certified applicator. Some require a permit from the county agricultural commissioner for purchase or use.

## Biological Control

Predators such as coyotes, foxes, badgers, weasels, owls, and hawks feed on meadow voles; however, predation is rarely, if ever, a major factor in controlling a rapidly increasing vole population.

## Cultural Control

### *Habitat Management*

Cultural practices can significantly affect meadow vole numbers. Because voles travel only a few feet from their burrows to obtain food, any destruction of vegetation will make the area less favorable to them and results in burrow abandonment and/or mortality. Physically removing vegetation, using herbicides or other methods to keep an area about 3 feet out from the trunks free of vegetation, has been proven to reduce damage. If you maintain ground cover or resident weeds in the row middles, keep it mowed fairly short (< 2 inches) to be less attractive to voles.

Maintaining weed-free fencerows, roadsides, and ditch banks is also an important preventive measure. A vegetation-free zone 30 to 40 feet wide between a field and adjacent areas helps reduce the potential for invasion by voles, but such a wide area is rarely practical; bare soil borders may be undesirable where off-site movement of contaminated soil and water must be prevented with a vegetative border to filter runoff.

### *Exclusion*

Cylindrical wire or plastic trunk guards to protect young trees or vines from voles are widely used. An effective guard can be a 24-inch-tall cylinder made of ¼ - or ½ -inch mesh hardware cloth that is of sufficient diameter to allow several years' growth without crowding the tree or vine. Bury the guards' bottom edge at least 6 inches below the soil surface, but note that voles may dig beneath them.

Plastic, heavy cardboard, or other fiber materials, such as milk cartons, can also be used to make trunk guards. These materials are less expensive, also provide sunburn protection, and are more convenient to use; however, they provide less protection against vole damage since the voles can chew through them and sometimes use them as a harborage.

Regularly check beneath tree guards for evidence that voles are burrowing underneath them to gnaw on the tree trunk, looking also for the presence of other pests such as snails. If voles take up residence inside the cover, the damage is often greater than if the covers were not used. Good weed control around trunks improves the effectiveness of trunk guards.

Exclusionary fencing consisting of aluminum flashing can be used along field borders. The fencing should be buried at least 6 inches below ground and should extend 12 inches above ground. Drive rebar or wooden stakes into the ground every 15 feet to provide support for the fencing. The efficacy of such fencing is greatly increased if bare soil is present around the base of the fence. Be aware that equipment must frequently move in and out of fields, thereby limiting sites where fencing is practical. Fencing is expensive, so significant damage should be expected to justify the cost of installation.

### *Flood irrigation*

Where still feasible, flood irrigation can help control vole populations. When a field is flooded, the voles must come to the surface or drown. When at the surface, they can be picked off by a number of predators; growers and their dogs can also actively seek out voles at this time to further reduce population size.

## Monitoring and Treatment Decisions

It is important to monitor for voles carefully. Otherwise, you may not notice damage until it is too late to prevent significant injury.

Make sure to check ditch banks, fencerows, roadsides, and other areas where permanent vegetation favors the buildup of voles. Dense grass is their preferred habitat.

Starting in midwinter, monitor monthly in cover crops, weedy areas, and alfalfa fields looking for:

- Active runways: 1- to 2-inch wide surface paths that lead to silver dollar-sized burrow openings.
- Place snap traps in runways to detect pests. Scatter around the field to identify active areas needing baiting. Use expanded trigger traps to avoid having to use bait.
- Fresh vole droppings and short pieces of clipped vegetation, especially grass stems, in runways.
- Burrow openings around the bases of orchard trees or vines. Burrows frequently have numerous openings to the surface. They are relatively shallow and contain food and nesting chambers.

If you find burrows in orchard or vine crops, remove the soil from around the base of the tree or vine and look for bark damage. Voles usually start chewing on bark about 2 inches below the soil line and then move upward to about 5 inches aboveground.

### *Baiting*

If you find damaging infestations or numbers increasing within orchard, vineyard, or vegetable crops, poison baits can be used during the dormant season to greatly reduce vole numbers. Baiting can also reduce voles in adjacent areas before they have a chance to invade. Single- and multiple-dose baits are available, but there may be baiting restrictions in some areas to protect endangered species. It is imperative that you understand and follow the label directions for use. In particular, please note that poison baits cannot be applied within orchard, vineyard, or vegetable crops from green up (spring) until after harvest occurs.

For small infestations, scatter the bait in or near active vole runways and burrows according to the label directions. For larger areas and where the label permits, you can make broadcast applications using a belly grinder-type seeder or a vehicle with a tailgate seeder. Broadcast application rates vary, depending upon estimated numbers of voles and type of toxicant. Both single-dose (e.g., zinc phosphide\*) and multiple-dose (e.g., first-generation anticoagulants, chlorophacinone\* and diphacinone\*) poisons are used for meadow vole control in orchard, vineyard, and vegetable crops. These are restricted-use pesticides that require a permit from the county agricultural commissioner for purchase or use

In ditchbanks and other non-cropland sites, bait should be applied in fall or spring before the voles' reproduction peaks to slow or prevent populations from expanding into the crop. However, application within an orchard, vineyard, or vegetable field is restricted to the nonbearing season, so timing is key to prevent a population explosion during the growing season. Bait acceptance will depend on the amount and kind of other food available. When baiting for voles with anticoagulants, 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.

### *Trapping*

Trapping is not typically practical as voles often number in the thousands over even relatively small areas.

### *Fumigants*

Fumigation is not typically effective because of the shallow, open nature of vole burrow systems and the large number of voles. However, it is occasionally used in artichokes given the deeper structure of vole burrow systems in the crop.

### *Repellents*

Repellents are not effective in preventing damage.

- \* 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.mrldatabase.com>.

**Processed crops**

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

**Crop injury**

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

**Personal safety**

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

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University policy also prohibits retaliation against any employee or person in any of its programs or activities for bringing a complaint of discrimination or harassment pursuant to this policy. This policy also prohibits retaliation against a person who assists someone with a complaint of discrimination or harassment, or participates in any manner in an investigation or resolution of a complaint of discrimination or harassment. Retaliation includes threats, intimidation, reprisals, and/or adverse actions related to employment or to any of its programs or activities.

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before they are officially promulgated. Inquiries regarding the University's equal employment opportunity policies may be directed to Linda Marie Manton, Affirmative Action Contact, University of California, Davis, Agriculture and Natural Resources, One Shields Avenue, Davis, CA 95616, (530) 752-0495.