



# Grape

June 2017

## PEST MANAGEMENT GUIDELINES FOR AGRICULTURE

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Publication 3448 • Online with photos at <http://www.ipm.ucdavis.edu/PMG/selectnewpest.grapes.html>

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## Acknowledgments for past contributions

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

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

- **Online:** <http://www.ipm.ucanr.edu>
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ANR Communication Services

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**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.

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

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

# Regional Pest Alert



## Grapevine Red Blotch-associated Virus

Red leaf symptoms that differed from other known red leaf diseases affecting grape foliage were first noticed in vineyards planted with red wine grape cultivars in Napa County, California, in 2008. A virus now known as Grapevine red blotch-associated virus (GRBaV) was subsequently identified in grapevines exhibiting red blotch symptoms in 2011. It is now confirmed that red blotch disease is present in many major grape production regions of the United States and Canada.

### Red Blotch Disease Symptoms

Leaf symptoms first appear approximately mid-summer; however, timing of symptom expression differs among grapevine cultivars and year. In red-fruited cultivars, common symptoms include red blotches originating from the leaf margin or within the leaf blade and primary and secondary veins that often turn red. In white fruit cultivars, symptoms appear as pale green to pale yellow patches. Symptoms usually start on basal leaves and progress up the shoot. In some cultivars, such as 'Chardonnay' and 'Zinfandel', marginal burning may occur similar to severe potassium deficiency. In some red-fruited cultivars such as 'Malbec' and 'Mourvèdre', the entire blade may turn red by harvest. Foliar symptoms are generally distinct from those of grapevine leafroll disease (GLD) early in the season, but leaf blade coloration may resemble those of GLD by late fall. At this time, red blotch disease is not known to kill grapevines.

### Effect of Red Blotch Disease on Fruit

The effect of the virus infection on yield and fruit quality parameters appears to vary among cultivars. However, total soluble solids are consistently reduced in juice produced from fruit on diseased grapevines. The effect on pH and titratable acidity is also variable.

### The Virus

GRBaV is a virus similar in genome organization to geminiviruses and is comprised of a single circular DNA molecule with ~3206 nucleotides. The virus can be detected using a laboratory PCR test. The virus appears to have become widely spread through infected



*Grapevine red blotch symptoms on Cabernet franc in mid-September. Note the red veins on infected leaves (left).*



material used for propagation. Commercial testing is available from several plant virus testing laboratories in the USA.

The clustered and/or leading edge patterns of disease incidence in vineyards resemble that of movement by insects not commonly found feeding on grapevines; however, no vector has been identified to date.

## Guidelines for Management

Plant vines produced from GRBaV-tested scion and rootstock source material. In established vineyards, suspect grapevines showing red blotch symptoms should be flagged and tested by a commercial lab to confirm the presence of GRBaV. If positive, a decision on whether to rogue and replant infected vines needs to be made. The epidemiology of GRBaV is not currently known, therefore the decision to rogue will likely be based on the economic impacts of GRBaV on fruit quality. There is no “cure” for a virus infected vine at this time, and there are no chemicals known to control for GRBaV. Because a vector remains unconfirmed, there are no pesticide recommendations that would target a vector at this time.

For more information on Grapevine Red Blotch-associated Virus, please visit [www.ncipmc.org/action/alerts/redblotch.php](http://www.ncipmc.org/action/alerts/redblotch.php)



*Grapevine red blotch symptoms on dry farmed Zinfandel leaves at the end of August.*



*Chardonnay grapevines in early September (left), and again in mid-November (below)*



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Photos provided by the authors.

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## 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.

## 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, ant baits, or with sprays of chlorpyrifos (Lorsban) directed at the soil surface. Chlorpyrifos may only be used for either mealybug control in grapes in a given year or for ant control but not both. 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)
-------------------------------------	----------------------	--------------------	-------------------

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.*

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

- |   |          |    |    |
|---|----------|----|----|
| A. BUPROFEZIN<br>(Applaud)<br>MODE-OF-ACTION GROUP NUMBER: 16<br>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. | 12–24 oz | 12 | 30 |
|---|----------|----|----|

#### LATE SPRING

- |  |                             |          |         |
|--|-----------------------------|----------|---------|
| A. SPIROTETRAMAT<br>(Movento)<br>MODE-OF-ACTION GROUP NUMBER: 23<br>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.   | 6–8 fl oz                   | 24       | 7       |
| B. IMIDACLOPRID<br>(Admire Pro - Soil)<br>(Admire Pro - Foliar)<br>MODE-OF-ACTION GROUP NUMBER: 4A<br>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. | 7–14 fl oz<br>1.0–1.4 fl oz | 12<br>12 | 30<br>0 |
| C. CLOTHIANIDIN<br>(Belay - Soil)<br>(Belay - Foliar)<br>MODE-OF-ACTION GROUP NUMBER: 4A<br>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.   | 6–12 fl oz<br>6 fl oz       | 12<br>12 | 30<br>0 |
| D. DINOTEFURAN<br>(Venom - Soil)<br>(Venom - Foliar)<br>MODE-OF-ACTION GROUP NUMBER: 4A<br>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.  | 6 oz<br>1–3 oz              | 12<br>12 | 28<br>1 |

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

## VINE MEALYBUG (7/15)

**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://ucce.ucdavis.edu/files/filelibrary/2161/27012.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. Chlorpyrifos is also effective on ants, 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 dispensers are 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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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.

**DELAYED DORMANT**

- |   |                            |                     |                     |
|---|----------------------------|---------------------|---------------------|
| A. CHLORPYRIFOS*<br>(Lorsban Advanced)<br>MODE-OF-ACTION GROUP NUMBER: 1B<br>... PLUS ... (optional)<br>NARROW RANGE OIL<br>(Superior, Supreme) | Label rates<br><br>1–2 gal | 24<br><br>See label | 35<br><br>See label |
|---|----------------------------|---------------------|---------------------|
- MODE OF ACTION: Contact including smothering and barrier effects.  
 COMMENTS: In spring, ants in southern California and the Central Valley move the female mealybugs from the roots to plant parts above ground. Spray to obtain thorough coverage of all aboveground plant parts, especially the trunk and cordons where mealybugs are located. Insecticide residues at the base of the vine will help control vine mealybugs in spring when they are being transported up the vine. Most effective when applied during warm weather (60°F or higher) because mealybugs are most active at this time. Apply during January for grapes harvested in June in the Coachella Valley. Do not apply in the North Coast; mealybugs are hidden under the bark at the graft union at this time of the year. Use allowed under a 24(c) registration (SLN CA-080009). Use chlorpyrifos for either ant control or mealybug control, but not for both pests on the same grape crop. Do not apply chlorpyrifos more than twice a year for the control of both vine mealybug and *Pseudococcus* mealybugs. Do not apply it between budbreak and harvest. Avoid drift and runoff into surface water. Chlorpyrifos has been found in surface waters at levels that violate federal and state water quality standards.

**MATING DISRUPTION**

- |  |                   |    |    |
|--|-------------------|----|----|
| A. MATING DISRUPTANT DISPENSERS<br>(CheckMate VMB-XL)# | 250<br>dispensers | NA | NA |
|--|-------------------|----|----|
- 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.

**EARLY SPRING**

- |   |       |    |    |
|---|-------|----|----|
| A. BUPROFEZIN<br>(Applaud)<br>MODE-OF-ACTION GROUP NUMBER: 16 | 12 oz | 12 | 30 |
|---|-------|----|----|
- 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. Use allowed under a FIFRA 2(ee) Recommendation.

**BLOOM**

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

Common name (Example trade name)	Amount per acre**	R.E.I.‡ (hours)	P.H.I.‡ (days)
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/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/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 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.	12–24 oz	12	30

- |    |  |            |    |    |
|----|--|------------|----|----|
| 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.                         |            |    |    |
| D. | THIAMETHOXAM<br>(Platinum)   | 8-17 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. |            |    |    |
| E. | DINOTEFURAN<br>(Venom - Soil)  | 6 oz       | 12 | 28 |
|    | 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.             |            |    |    |
| F. | ACETAMIPRID<br>(Assail 30SG)   | 2.5 oz     | 12 | 3  |
|    | (Assail 70WP)  | 1.1 oz     | 12 | 3  |
|    | 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.  |            |    |    |

**POSTHARVEST**

- |    |  |             |    |    |
|----|--|-------------|----|----|
| 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. | CHLORPYRIFOS*<br>(Lorsban Advanced)  | Label rates | 24 | NA |
|    | MODE-OF-ACTION GROUP NUMBER: 1B  |             |    |    |
|    | COMMENTS: Apply in a minimum of 150 gal water/acre. Treat infested vineyards immediately after harvest to minimize the movement of live mealybugs. Use allowed under a Special Local Needs registration (SLN CA-080009). Growers may apply this material under SLN CA-080009 or under SLN CA-080010 but not both. Avoid drift and runoff into surface waters.                                |             |    |    |

\*\* 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/>.

NA Not applicable.

## 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 (*Carneiocephala 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.

## SHARPSHOOTERS (7/15)

**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 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://www.cnr.berkeley.edu/xylella/control/PDNorthCoast/info.htm>.

**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. Systemic insecticides (imidacloprid) are currently the most effective materials for control of glassy-winged sharpshooter in vineyards.

**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)
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. IMIDACLOPRID (Admire Pro - Soil)	7–14 fl oz	12	30
(Admire Pro - Foliar)	1.0–1.4 fl oz	12	0
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.			
B. CLOTHIANIDIN (Belay - Soil)	12 fl oz	12	30
(Belay - Foliar)	4–6 fl oz	12	0
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.			
C. ACETAMIPRID (Assail 70WP)	1.1 oz	12	3
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.			
D. DINOTEFURAN (Venom - Soil)	5–6 oz	12	28
(Venom - Foliar)	1–3 oz	12	1
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.			
E. THIAMETHOXAM (Platinum)	8–17 oz	12	60
MODE-OF-ACTION GROUP NUMBER: 4A COMMENTS: Soil moisture is important for effectiveness; follow label instructions carefully.			
F. FENPROPATHRIN* (Danitol 2.4EC)	5.33–10.66 fl oz	24	21
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.			
G. PYRETHRIN# (Pyganic EC5.0II)	4.5–17 fl oz	12	0
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.			
H. KAOLIN CLAY# (Surround WP)	12.5–37.5 lb	4	0
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.			

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.irac-online.org/">http://www.irac-online.org/</a> .			