How to Manage Pests
UC Pest Management Guidelines

Grape

Powdery Mildew
Pathogen: *Erysiphe necator*
(Reviewed 12/14, corrected 2/16)

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SYMPTOMS

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 cordon 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](https://www.ucdavis.edu) 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**

<table>
<thead>
<tr>
<th>Index</th>
<th>Disease</th>
<th>Pathogen</th>
<th>Sulfur</th>
<th>Demethylation-</th>
<th>Strobilurins and</th>
</tr>
</thead>
</table>
### 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).

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount per acre**</th>
<th>R.E.I.‡ (hours)</th>
<th>P.H.I.‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UPDATED: 12/14</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>**When choosing a pesticide, consider <strong>efficacy and the general properties of the fungicide as well as information relating to environmental impact.</strong></td>
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<tr>
<td><strong>Note:</strong> Treatments can be made in conjunction with plant growth regulators and other applications.</td>
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</tbody>
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### DEMETHYLATION INHIBITORS (DMI)

**A. TEBUCONAZOLE**  
(Elite 45WP)  
4 oz  
MODE-OF-ACTION GROUP NAME (NUMBER¹): Demethylation inhibitor (3)  
COMMENTS: Do not apply more than 2 lb of product/acre per season.

**B. TRIFLUMIZOLE**  
(Viticure)  
4–8 fl oz  
MODE-OF-ACTION GROUP NAME (NUMBER¹): Demethylation inhibitor (3)  
COMMENTS: Do not apply more than 32 fl oz of product/acre per season.

**C. MYCLOBUTANIL**  
(Rally 40WSP)  
4–5 oz  
more gal water/acre  
MODE-OF-ACTION GROUP NAME (NUMBER¹): Demethylation inhibitor (3)  
COMMENTS: Do not apply more than 1.5 lb of product/acre per season.

**D. FENARIMOL**  
(Vintage)  
3–6 oz  
MODE-OF-ACTION GROUP NAME (NUMBER¹): Demethylation inhibitor (3)  
COMMENTS: Do not apply more than 21 fl oz of product/acre per season.
### E. Tetracnazole (Mettle 125ME)
- **3–5 fl oz**
- **MODE-OF-ACTION GROUP NAME (NUMBER):** Demethylation inhibitor (3)
- **COMMENTS:** Do not apply more than 10 fl oz of product/acre per season.

### F. Flutriafol (Rhyme)
- **4-5 fl oz**
- **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**
- **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**
- **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**
- **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**
- **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**
- **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.)**
- **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**
- **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.

B. FLUOPYRAM + PYRIMETHANIL  
(Luna Tranquility)  
16–24 fl oz  
12  
7  
MODE-OF-ACTION GROUP NAME (NUMBER¹): Succinate dehydrogenase inhibitor (7) and Anilinopyrimidine (9)  
COMMENTS: For use on wine grapes only. Do not apply more than 54.7 fl oz of product/acre per season.

C. DIFENOCONAZOLE + CYPRODINIL  
(Inspire Super)  
14–20 fl oz  
12  
14  
MODE-OF-ACTION GROUP NAME (NUMBER¹): Demethylation inhibitor (3) and Anilinopyrimidine (9)  
COMMENTS: Do not apply more than 80 fl oz of product/acre per season.

D. DIFENOCONAZOLE + AZOXYSTROBIN  
(Quadris Top)  
10–14 fl oz  
12  
14  
MODE-OF-ACTION GROUP NAME (NUMBER¹): Demethylation inhibitor (3) and Quinone outside inhibitor (11)  
COMMENTS: Do not apply more than 56 fl oz/acre per season.

E. PYRACLOSTROBIN + BOSCALID  
(Pristine)  
8–12.5 fl oz  
12  
14  
MODE-OF-ACTION GROUP NAME (NUMBER¹): 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#  
Label rates  
See comments  
See label  
(dust, wettable, flowable, or micronized)  
MODE-OF-ACTION GROUP NAME (NUMBER¹): 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.

CONTACT MATERIALS

A. NARROW RANGE OIL#  
(JMS Stylet Oil, Saf-T-Side, etc.)  
1–2%  
4  
0
**MODE-OF-ACTION GROUP NAME (NUMBER)¹**: 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.

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**B. POTASSIUM BICARBONATE#**

| (Kaligreen) | 2.5–5 lb | 4 | 1 |
| (MiStop)    | 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.

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**C. FUNGICIDAL SOAP#**

| (M-Pede) | 1.5–2% | 12 | 0 |

**MODE-OF-ACTION GROUP NAME (NUMBER)¹**: 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 Calamaria or Italia varieties of grapes. Do not apply past veraison.

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**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 *Phomopsis* and *Botrytis*. Sprays should be directed to the cordon and fruiting wood to ensure drenching occurs.

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**Precautions**

**PUBLICATION**

**UC IPM Pest Management Guidelines: Grape**

**UC ANR Publication 3448**

**Diseases**

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Unfortunately, we cannot provide individual solutions to specific pest problems. See our Home page, or in the U.S., contact your local Cooperative Extension office for assistance.