POWDERY MILDEW ON FRUITS AND BERRIES

Integrated Pest Management for Home Gardeners and Landscape Professionals

Powdery mildew is a common disease on many types of plants. Several powdery mildew fungi cause similar diseases on different plants (such as *Podosphaera* species on apple and stone fruits; *Sphaerotheca* species on berries and stone fruits; *Erysiphe necator* on grapevines, see Table 1). Powdery mildew fungi generally require moist conditions to release overwintering spores and for those spores to germinate and infect a plant. However, no moisture is needed for the fungus to establish itself and grow after infecting the plant. Powdery mildews normally do well in warm, Mediterranean-type climates. Thus powdery mildews are more prevalent than many other diseases in California's dry summer and fall seasons.

IDENTIFICATION AND DAMAGE

Powdery mildew can be recognized easily on most plants by the white to gray powdery mycelium and spore growth that forms on both sides of leaves, sometimes on flowers and fruit, and on shoots (Figs. 1 and 2).

The disease can be serious on woody plants such as grapevines, caneberries, and fruit trees where it attacks new growth including buds, shoots, and flowers as well as leaves. New growth is dwarfed, distorted, and covered with a white, powdery growth. On apple and grape and to a lesser extent apricot, nectarine, and peach, infected young fruits develop weblike, russetted scars. On tree fruits a rough corky spot on the skin will develop where infection occurred. Grapes with a severe infection may also crack or split and fail to grow and expand.

On strawberry, affected leaf edges curl upward. Infected leaves later develop dry, brownish patches along with nondescript patches of white powdery fungus on the lower surface and reddish discoloration on the upper surface. When foliage infections are severe, flowers and fruit may also be infected.

LIFE CYCLE

All powdery mildew fungi require living plant tissue to grow. On deciduous perennial hosts such as grapevine, raspberry, and fruit trees, powdery mildew survives from one season to the next in infected buds or as fruiting bodies called chasmothecia, which reside on the bark of cordons, branches, and stems. On strawberry the fungus can survive on leaves that remain on the plants through winter.

Figure 1. Powdery mildew on a grape leaf.

Figure 2. Severe powdery mildew infection on Thompson Seedless grapes.

Most powdery mildew fungi grow as thin layers of mycelium on the surface

Table 1.

Host Plants and Control Measures for Powdery Mildew Species.

Hosts	Fungus Species	Controls
apple, nectarine, peach, quince	*Podosphaera leucotricha*	tolerant varieties; prune out infections in apple trees during dormant season; fungicides if necessary
cherry	*Podosphaera clandestina*	fungicides if necessary
apricot, plum, prune	*Podosphaera tridactyla*	tolerant varieties; fungicides if necessary
strawberry (a different strain infects caneberries)	*Sphaerotheca macularis*	resistant varieties; removing infected tissue; fungicides if necessary
apricot, nectarine, peach, plum, roses	*Sphaerotheca pannosa*	fungicides if necessary; remove or treat roses
grape	*Erysiphe necator*	tolerant varieties; water sprays; prune during dormancy; fungicides

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of the affected plant part (Fig. 3). Spores, which are the primary means of dispersal, make up the bulk of the powdery growth and are produced in chains that can be seen with a hand lens. In contrast, spores of downy mildew grow on branched stalks that look like tiny trees. Also downy mildew colonies are gray instead of white and occur mostly on the lower leaf surface.

Powdery mildew spores are carried by wind to host plants. Although humidity requirements for germination vary, many powdery mildew species can germinate and infect in the absence of water. In fact, spores of some powdery mildew fungi are killed and germination and mycelial growth are inhibited by water on plant surfaces. Moderate temperatures and shade are generally the most favorable conditions for powdery mildew development, since spores and mycelium are sensitive to extreme heat and direct sunlight.

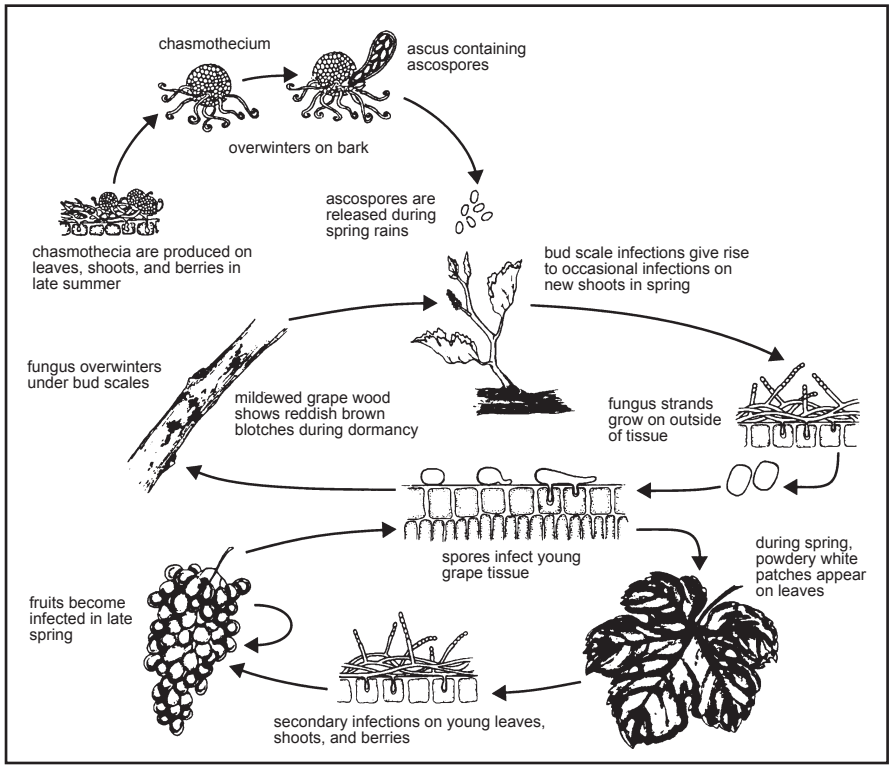

Figure 3. Powdery mildew life cycle on grape.

MANAGEMENT

The best method of powdery mildew control is prevention. Avoiding the most susceptible varieties and following good cultural practices will adequately control powdery mildew in many situations. However, where conditions are favorable, susceptible fruit trees and berries may require protection with fungicide sprays. Fungicide applications are most often needed on susceptible varieties of apple and on almost all grape and strawberry varieties.

Resistant Varieties

Where possible, choose resistant varieties that meet your growing requirements and personal preferences. Be aware that control actions will probably be necessary when planting more susceptible varieties.

Apple. The most resistant varieties are Red Delicious and Stayman Winesap. Moderately susceptible varieties include Braeburn, Golden Delicious, Granny Smith, Jonagold, and McIntosh. The most susceptible varieties include Gravenstein, Jonathan, Rome Beauty, and Yellow Newtown.

Caneberries. Blackberry is not affected by powdery mildew. Resistant raspberry varieties include Chief, Marcy, Malling Orion; the variety Logan is immune. Highly susceptible raspberry varieties include Glen Clova, Latham, Ottawa, and Viking.

Cherry. The most susceptible varieties are Bing, Black Tartarian, and Rainier.

Grapevines. Most varieties are susceptible.

Nectarine. Most varieties are susceptible.

Peach. Freestone varieties such as Crest, Flame Crest, Flavor Crest, and O'Henry are less susceptible than varieties such as Elegant Lady, Fairtime, Fay Elberta, and Summerset.

Plum. Some highly susceptible varieties of plum that may need protection are Black Beaut, Gaviota, Kelsey, and Wickson.

Strawberry. Day-neutral (everbearing) varieties such as Fern, Seascape, Sequoia, and Yolo are more susceptible than short-day varieties (those that fruit in May and June only) such as Chandler.

Cultural Practices

Shade and moderate temperatures favor most powdery mildews. Plant in sunny areas as much as possible, provide good air circulation, and avoid applying excess fertilizer. A good alternative is to use a slow-release fertilizer. Long duration overhead sprinkling may actually reduce active powdery mildew infections because spores are washed off the plant. However, spores can be disseminated in water to new noninfected leaves if watered only briefly.

As new shoots begin to develop on perennial plants, watch closely for the appearance of powdery mildew. Where infection is limited, prune out and bury or discard diseased tissue as soon as it appears. Infected tissue can be recog-

nized by the young emerging leaves being deformed or showing a puckered condition. Soon after emergence infected leaves begin to exhibit white mycelial growth on the leaf surface. This combination of symptoms is characteristic of early season mildew onset. If powdery mildew has been present during the season on woody species, prune out infected tissue during the dormant season.

Prune grapevines during dormancy and position shoots during the growing season to allow exposure of fruit to sunlight and good air flow through the canopy. Pruning and training are also helpful in controlling Botrytis bunch rot.

Because one common powdery mildew fungus, *Sphaerotheca pannosa*, often spreads disease from roses to stone fruits, try to avoid planting apricot or plum trees near highly susceptible rose bushes. If roses are nearby and can't be removed, control powdery mildew infections on them.

On apple trees, look carefully for infected shoots and buds in the dormant season and remove them. Infected buds are flattened or shriveled compared to normal buds. The buds and infected shoots have a thin layer of fuzzy white fungus on their surfaces that usually is easy to see. Where practical, remove and dispose of overwintering leaves on strawberry plants that are infected. If raspberry canes develop powdery mildew, remove the canes down to the roots during the dormant season. Infected canes of berries and grapevines have distinctive weblike russetting. Remove infected prunings from the garden area and destroy them.

Fungicide Applications

Where powdery mildew has been a problem in the past, fungicides may be needed. Fungicides function as protectants, eradicants, or both. A protectant fungicide can only prevent a new infection from occurring, but an eradicant will kill an existing infection. Apply protectant fungicides to highly susceptible plants before the disease appears. Eradicants should be used at the earliest appearance of the disease. Once mildew growth is extensive, control with fungicides becomes more difficult.

Fungicides. Several least-toxic fungicides are available for backyard trees and vines, including horticultural oils, neem oil, jojoba oil, sulfur, and the biological fungicide Serenade. With the exception of the oils, these materials are primarily preventive. Oils work best as eradicants but also work as good protectants. The fungicides listed here are registered for home use. Commercial growers should consult the UC IPM Pest Management Guidelines for fungicides for commercial use. They are available online at http://www.ipm.ucdavis.edu/PMG/crops-agriculture.html.

Oils. To eradicate powdery mildew infections, use a horticultural oil such as Saf-T-Side Spray Oil, Sunspray Ultra-Fine Spray Oil or one of the plant-based oils such as neem oil (such as Green Light Neem Concentrate) or jojoba oil (such as E-rase). *Be careful, however, never to apply an oil spray within 2 weeks of a sulfur spray or plants may be injured.* Some plants may be more sensitive than others, however, and the interval required between sulfur and oil sprays may be even longer; always consult the fungicide label for any special precautions. *Also, oils should never be applied when temperatures are above 90°F or to drought-stressed plants.* Horticultural oils and neem and jojoba oils are registered on a wide variety of crops.

Sulfur. Sulfur products have been used to manage powdery mildew for centuries but are only effective when applied before disease symptoms appear. The best sulfur products to use for powdery mildew control in gardens are wettable sulfurs that are specially formulated with surfactants similar to those in dishwashing detergent (such as Safer Garden Fungicide). *To avoid injury to the plant or tree, sulfurs should not be applied within 2 weeks of an oil spray, used on any plant when the temperature is near or over 90°F (80°F for caneberries and strawberry), and never applied at any temperature to apricot trees.*

Biological Fungicides. Biological fungicides (Serenade) are commercially available beneficial microorganisms formulated into a product that, when sprayed on the plant, inhibit or destroy fungal pathogens. The active ingredient in Serenade is a bacterium, *Bacillus subtilis*, that helps prevent the powdery mildew from infecting the plant. While this product functions to kill the powdery mildew organism and is nontoxic to people, pets, and beneficial insects, it has not proven to be as effective as the oils or sulfur in controlling this disease.

How to Use. Apply protectant fungicides to susceptible plants before disease develops. Once mildew growth is mild to moderate, it is generally too late for protective fungicides to effectively control powdery mildew except for on new plant growth. The protectant fungicides are only effective on contact, so applications must provide thorough coverage of all susceptible plant parts. As plants grow and produce new tissue, additional applications may be necessary at 7- to 10-day intervals as long as conditions are conducive to disease growth. On highly susceptible plants, sulfur can be applied early in the season when temperatures are below 90°F and then to switch to other materials as the season progresses. However, applying oil, which is both a protectant and an eradicant, for the early sprays provides the best control.

If mild to moderate powdery mildew symptoms are present, the horticultural oils and plant-based oils such as neem oil and jojoba oil can be used.

Caneberries and Grapevines. Dormant or delayed dormant sulfur sprays can be used as a preventive measure before canes begin to grow in spring. Fungicides registered for use on caneberries include wettable sulfur and oils including neem oil. Don't apply sulfur when temperatures exceed 90°F.

Strawberry. Treat as soon as symptoms appear. Be sure to spray both upper and lower leaf surfaces. It may help to remove and destroy affected leaves

before treating the rest of the planting. Materials registered to control powdery mildew include sulfur and oils. The sulfur treatments also reduce mite populations, but don't apply sulfur when temperatures exceed 80°F because it damages foliage and fruit.

Apple and Stone Fruit. Sprays are not necessary in many backyard situations. However, if you have had serious powdery mildew damage in past years, treat at 2-week intervals, beginning when buds just start to open (green tip stage), until small, green fruit are present. (Caution: Do not use sulfur on apricot trees.) Sulfur, horticultural oils, neem oil, and Serenade are all registered for powdery mildew on backyard trees.

Grapevines. Powdery mildew is a perennial problem in grapevines. Begin applying treatments when all buds have pushed. Thereafter, repeat at 10-day intervals if disease pressure is high; otherwise, extend intervals when temperatures are above 90°F until the sugar content of the grapes is 12 to 15%, which is when they begin to soften and approach ripeness and are no longer susceptible to infection. You can measure the sugar content with a refractometer, if you have access to one, or you can see if sample berries sink in a 15% sucrose solution. (Prepare the sucrose solution by dissolving 8½ teaspoons of table sugar in a half cup of warm water, then mixing in enough cold water to make the total volume 1 cup.) Sulfur, horticultural oils, neem oil, jojoba oil, and Serenade are registered for controlling powdery mildew in home vineyards.

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