
POWDERY MILDEW ON VEGETABLES

Integrated Pest Management for Home Gardeners

Powdery mildew is a common disease on many types of plants. There are many different species of powdery mildew fungi (such as *Erysiphe* species, *Sphaerotheca* species) and each species only attacks specific plants. A wide variety of vegetable crops are affected by powdery mildews, including artichoke, beans, beets, carrot, cucumber, eggplant, lettuce, melons, parsnips, peas, peppers, pumpkins, radicchio, radishes, squash, tomatillo, tomatoes, and turnips (Table 1). Powdery mildews generally do not require moist conditions to establish and grow, and normally do well under warm conditions; thus they are more prevalent than many other leaf-infecting diseases under California's dry summer conditions.

IDENTIFICATION AND DAMAGE

Powdery mildew first appears as white, powdery spots that may form on both surfaces of leaves, on shoots, and sometimes on flowers and fruit (Fig. 1). These spots gradually spread over a large area of the leaves and stems. An exception is one of the powdery mildews that affects artichokes, onions, peppers, and tomatoes: it produces yellow patches on leaves but little powdery growth.

Leaves infected with powdery mildew may gradually turn completely yellow, die, and fall off, which may expose fruit to sunburn. On some plants, powdery mildew may cause the leaves to twist, buckle, or otherwise distort. Powdery mildew fungal growth does not usually grow on vegetable fruits, although pea pods may get brownish spots. Severely infected plants may have reduced yields, shortened production times,

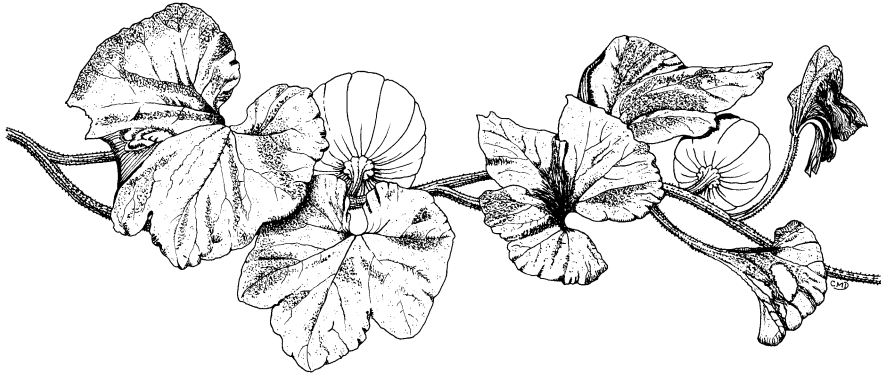


Figure 1. Powdery mildew on pumpkin vine.

and fruit that has little flavor.

LIFE CYCLE

All powdery mildew fungi require living plant tissue to grow. Year-round availability of crop or weed hosts is important for the survival of some powdery mildew fungi. Special resting spores are produced, allowing overwinter survival of the species that causes the disease in cucurbits, lettuce, peas, and certain other crops.

Most powdery mildew fungi grow as thin layers of mycelium (fungal tissue) on the surface of the affected plant part (Fig. 2). Spores, which are the primary means of dispersal, make up the bulk of the white, powdery growth visible on the plant's surface 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.

Powdery mildew spores are carried by wind to new hosts. Although humidity requirements for germination vary, all powdery mildew species can germinate and infect in the absence of free water. In fact, spores of some powdery

mildew fungi are killed and germination is inhibited by water on plant surfaces for extended periods. Moderate temperatures (60° to 80°F) and shady conditions generally are the most favorable for powdery mildew development. Spores and fungal growth are sensitive to extreme heat (above 90°F) and direct sunlight.

MANAGEMENT

The best method of control is prevention. Planting resistant vegetable varieties when available, or avoiding the most susceptible varieties, planting in the full sun, and following good cultural practices will adequately control powdery mildew in many cases (Table 1). However, very susceptible vegetables such as cucurbits (cucumber, melons, squash, and pumpkins) may require fungicide treatment. Several least-toxic fungicides are available but must be applied no later than the first sign of disease.

Resistant Varieties

In some cases, varieties resistant to powdery mildew may be available. If available, plant resistant varieties of cantaloupe, cole crops, cucumber,

Hosts	Fungus species	Controls
cucumbers, endive, lettuce, melons, potato, pumpkin, squash	<i>Erysiphe cichoracearum</i>	resistant varieties of lettuce, cucumber; water sprays; fungicides if necessary on squash and pumpkin
broccoli, Brussels sprouts, cauliflower, and other cole crops; radicchio, radishes, turnips	<i>Erysiphe cruciferarum</i>	not usually required
tomatoes	<i>Erysiphe lycopersici</i>	fungicides if necessary
peas	<i>Erysiphe pisi</i>	resistant varieties; sprinkler irrigation
carrots, parsley, parsnips	<i>Erysiphe heraclei</i>	tolerant varieties
beets	<i>Erysiphe polygoni</i>	tolerant varieties
artichoke, eggplant, peppers, tomatillo, tomatoes	<i>Leveillula taurica</i>	rarely required; fungicides if necessary
beans, black-eyed peas, cucurbits, okra	<i>Sphaerotheca fuliginea</i>	resistant varieties for some; fungicides if necessary

melons, peas, pumpkins, and squash. If you plant more susceptible varieties, you may need to take control measures.

Cultural Practices

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. Overhead sprinkling may help reduce powdery mildew because spores are washed off the plant. However, overhead sprinklers are not usually recommended as a control method in vegetables because their use may contribute to other pest problems.

Fungicide Application

In some situations, especially in the production of susceptible cucurbits, fungicides may be needed. Fungicides function as protectants, eradicants, or both. A protectant fungicide prevents new infections from occurring whereas an eradicant can kill an existing infection. Apply protectant fungicides to highly susceptible plants before the disease appears. Use eradicants at the earliest signs of the disease. Once mildew growth is extensive, control with any fungicide becomes more difficult. The products listed here are for home garden use. Commercial growers should consult the UC Pest Management Guidelines, which are available online at the following address: <http://www.ipm.ucdavis.edu/PMG/crops-agriculture.html>.

Fungicides. Several least-toxic fungicides are available, 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

have some protectant activity.

Oils. To eradicate mild to moderate 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

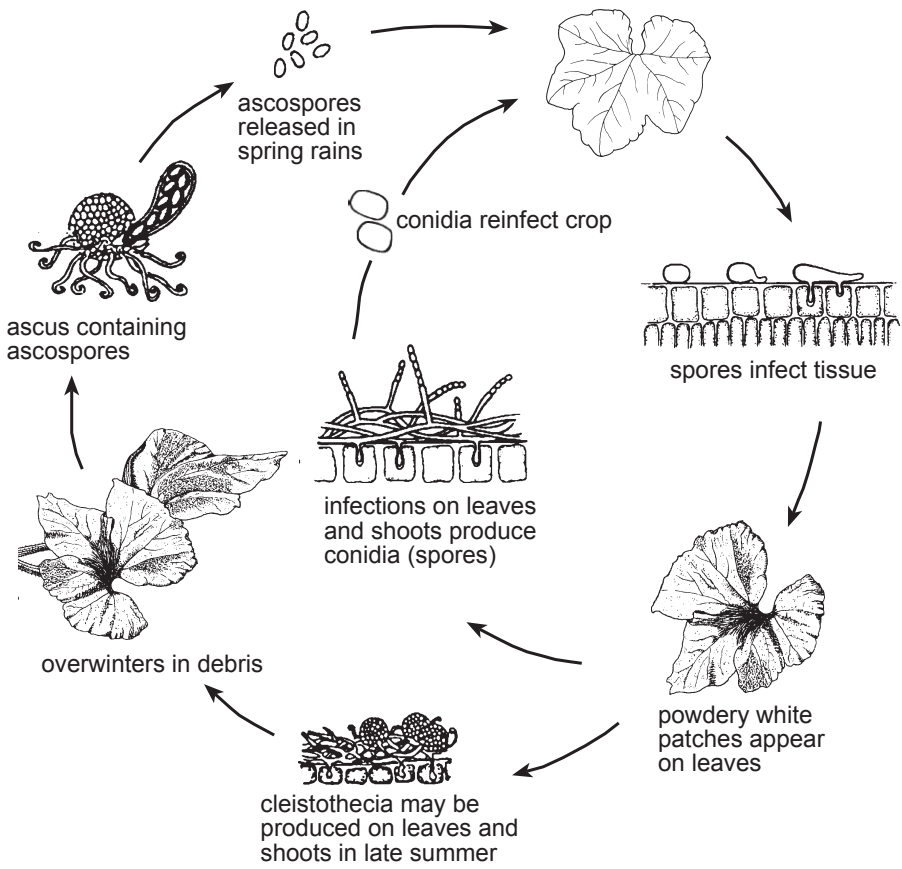


Figure 2. Powdery mildew life cycle on squash.

neem oil or jojoba oil (such as E-rase). *Be careful, however, to never apply an oil spray within 2 weeks of a sulfur spray or plants may be injured. Also, oils should never be applied when temperatures are above 90°F or to drought-stressed plants.* 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.

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). However, sulfur can be damaging to

For more information contact the University of California Cooperative Extension in your county. See your telephone directory for addresses and phone numbers.

AUTHORS: R. M. Davis, Plant Pathology, UC Davis; W. D. Gubler, Plant Pathology, UC Davis; S. T. Koike, UCCE Monterey Co.
TECHNICAL EDITOR: M. L. Flint
COORDINATION & PRODUCTION: P. N. Galin
ILLUSTRATIONS: Fig. 1: C. M. Dewees;
Fig. 2: adapted from *Grape Pest Management*, Oakland: Univ. Calif. Agric. Nat. Res. Publ. 3343. Leaves by C. M. Dewees.

Produced by UC Statewide IPM Program, University of California, Davis, CA 95616

This Pest Note is available on the World Wide Web (www.ipm.ucdavis.edu)



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 Urban Pest Management.

To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.

This material is partially based upon work supported by the Extension Service, U.S. Department of Agriculture, under special project Section 3(d), Integrated Pest Management.

some squash and melon varieties. *To avoid injuring any plant, do not apply sulfur when air temperature is near or over 90°F and do not apply it within 2 weeks of an oil spray.* Other sulfur products, such as sulfur dust, are much more difficult to use, irritating to skin and eyes, and limited in terms of the plants they can safely be used on. Copper is also available to control powdery mildew but is not very effective.

Biological Fungicides. Biological fungicides (such as Serenade) are commercially available beneficial microorganisms formulated into a product that, when sprayed on the plant, destroys 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, such as wettable sulfur, to susceptible plants before or in the earliest stages of disease development. 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.

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 to reduce or eliminate the infection.

REFERENCES

- Flint, M. L. 1998. *Pests of the Garden and Small Farm: A Grower's Guide to Using Less Pesticide*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 3332.
- Gubler, W. D., and D. J. Hirschfeld. 1992. Powdery Mildew. In *Grape Pest Management*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 3343. pp 57-63.
- McCain, A. H. 1994. *Powdery Mildew*. HortScript #3, Univ. Calif. Coop. Ext. Marin County. ❖

WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Pesticides applied in your home and landscape can move and contaminate creeks, rivers, and oceans. Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash or pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

The University of California prohibits discrimination or harassment of any person on the basis of race, color, national origin, religion, sex, gender identity, pregnancy (including childbirth, and medical conditions related to pregnancy or childbirth), physical or mental disability, medical condition (cancer-related or genetic characteristics), ancestry, marital status, age, sexual orientation, citizenship, or service in the uniformed services (as defined by the Uniformed Services Employment and Reemployment Rights Act of 1994: service in the uniformed services includes membership, application for membership, performance of service, application for service, or obligation for service in the uniformed services) in any of its programs or activities. University policy also prohibits reprisal or retaliation against any person in any of its programs or activities for making a complaint of discrimination or sexual harassment or for using or participating in the investigation or resolution process of any such complaint. University policy is intended to be consistent with the provisions of applicable State and Federal laws. Inquiries regarding the University's nondiscrimination policies may be directed to the Affirmative Action/Equal Opportunity Director, University of California, Agriculture and Natural Resources, 1111 Franklin Street, 6th Floor, Oakland, CA 94607, (510) 987-0096.