



DOWNY MILDEW OF GRAPE

Downy mildew, caused by the oomycete *Plasmopara viticola*, is an important disease of grapes in Illinois. Downy mildew on grapes occurs worldwide wherever the weather during the growing season is humid and rainy, and temperatures are cool to moderate. The optimum temperature for the development of an epidemic of downy mildew is 64 to 76°F (18 to 24°C), a minimum of 54 to 58°F (12 to 13°C), and a maximum of about 86°F (30°C).

Primary damage of downy mildew is through premature defoliation in the middle to late summer that may result in abnormal fruit development. The fruit from vines that are seriously diseased has a low sugar content. From 50 to 75 percent of the fruit crop may be destroyed where the vines are not sprayed, a highly susceptible cultivar is grown, and weather conditions are favorable for infection. Only a few of the older leaves may develop symptoms if the growing season has been hot and dry-unfavorable for the spread and growth of the pathogen - or if the grape cultivar is a resistant one.



Figure 1. Spots of downy mildew on a grape leaf in spring (Courtesy APS, R. Lafon).

The downy mildew pathogen attacks all common species of wild and cultivated grapes (*Vitis* species). The European grape (*V. vinifera*) is more susceptible than cultivated American grapes, which have derived from native species. Other hosts of the pathogen include species of the closely related genus *Parthe nocissus*, which includes Virginia-creeper (*P. quinquefolia*) and Boston-ivy (*P. tricuspidata*).

Loss of leaves may not only affect that season's crop, it may also affect the next season's crop by retarding cane maturation



Figure 2. Downy mildew symptoms on a grape leaf in autumn (Courtesy APS, R. Lafon).

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and decreasing the amount of stored food reserves in the vine. In young vines, this effect may cause death of the plant.

Symptoms

LEAVES

Very young infections are minute, greenish yellow, and translucent "oily" spots that are difficult to see. The lesions enlarge, appearing on the upper surface as angular to irregular, pale yellow to greenish yellow spots with indefinite borders up to about 1/4 inch or more in diameter (Figure 1).



Figure 3. Sporulation of downy mildew pathogen on the underside of diseased grape leaf (Courtesy APS, R. Lafon).

Older leaves in the center of the vine are the first to become infected. Later, the disease spreads toward the young leaves near the ends of the canes. On highly susceptible grape cultivars (see Table 1), even the youngest leaves may die and drop prematurely by autumn (Figure 2).

FRUIT

Two periods of fruit infection may occur during a growing season. The first is when the berries are about the size of small peas. If infected at that stage, the young fruit turns light brown and soft, shatters easily, and in damp weather is frequently covered with the white downy growth of the pathogen. During the hot summer months, little fruit infection normally occurs (Figure 4).

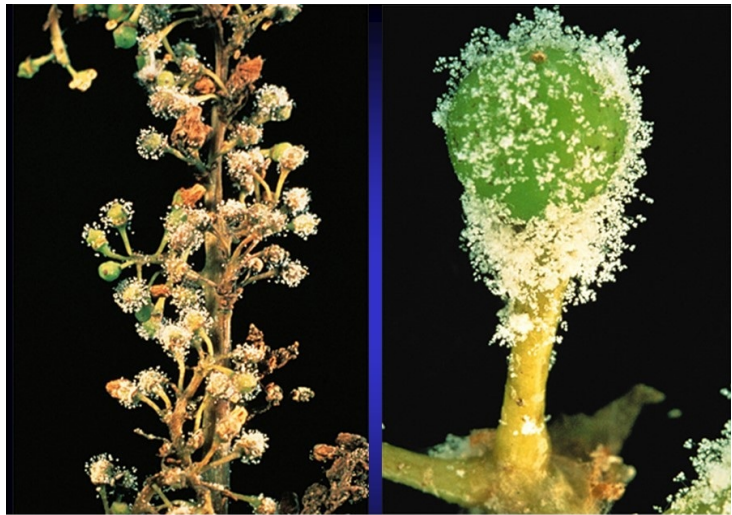


Figure 4. Sporulation of downy mildew pathogen on grape berries [Courtesy APS, R. Lafon (left) W. Gartel (right)].

When the nights become cooler in the late summer and early autumn, a second infection period may develop. Berries infected at this time generally do not soften or form the downy mildew growth. Instead, they stop growth, become leathery, turn a dull green, then dark brown to brownish purple, wrinkle somewhat, and shatter easily. In severe cases, the entire fruit cluster may decay. The berries do NOT shrivel into "mummies" and turn black and hard as in black rot.

SHOOTS AND TENDRILS

Early symptoms appear as water-soaked, shiny depressions on which a dense growth of whitish mildew appears. Young shoots are stunted, thickened, and may be quite distorted (Figure 5). Such infected shoots and tendrils turn brown and die.

Disease cycle

In the Midwest, the downy mildew pathogen overwinters in infected leaves on the ground, and occasionally in diseased fruit and shoots, as thick-walled resting spores (oospores). Weathering and decomposition of the grape tissues over one or two winters liberate the embedded oospores. During rainy periods in the spring, the oospores germinate at an optimum temperature of 68°F to 77°F (20°C to 25°C) to produce microscopic spores (sporangia) (Figures 3, 4, 5, & 6).



Figure 5. “Shepherd’s crook” symptom of downy mildew on a grape shoot in spring (Courtesy APS, R. Lafon).

The sporangia are disseminated by wind, rain-splash, and by handling wet plants. In a film of moisture, a sporangium may rarely form a germ tube; more commonly its contents divide up to form motile spores (zoospores or swarm spores).

After swimming about for a few minutes to half an hour, zoospores come to rest and encyst; and in about 15 minutes, they produce germ tubes that penetrate the lower surface of young leaves, shoots, tendrils, and blossom clusters resulting in primary infections.

The pathogen spreads through grape tissue by growing between the cells. Food and water are obtained by globular structures

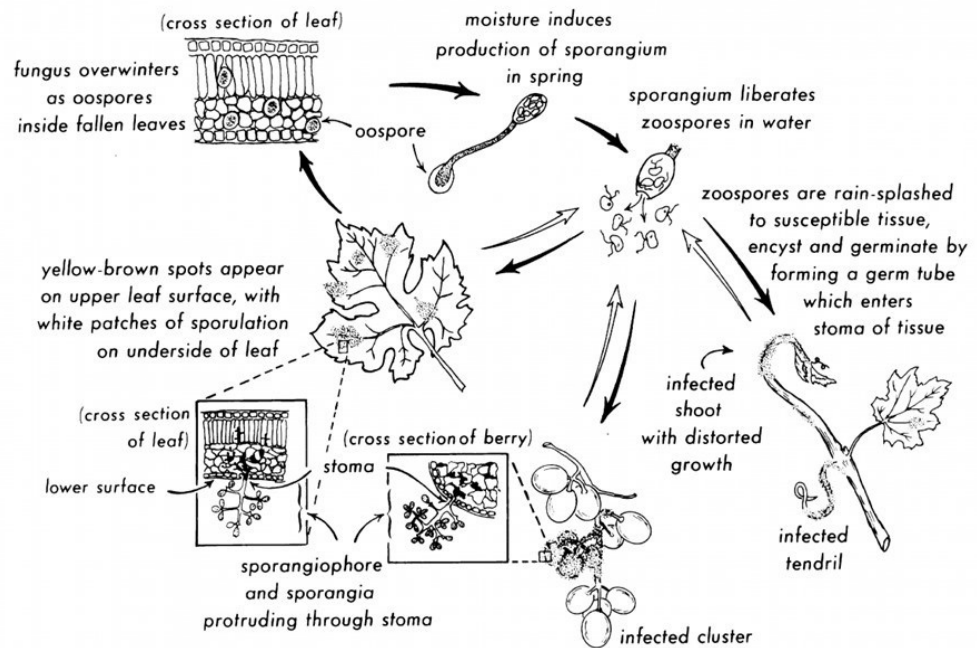


Figure 6. Disease cycle of downy mildew of grape (Courtesy New York State Agricultural Experiment Station).

(haustoria) that invade the host cells in large numbers. The pathogen masses within the grape tissue; and when the nights are cool and damp, structures form on the underleaf surfaces and on stems that are delicate, branched, miniature, and treelike, called sporangiophores (Figures 3, 4, 5, & 6). They grow out singly or, more often, in clusters of 4 to 6 (but up to 20) through natural openings (stomates)

or, rarely, by pushing directly through the epidermis. On the young fruit the sporangiophores emerge through lenticels. Each sporangiophore produces four to six branches at nearly right angles to the main stem, and each side branch produces two, sometimes three, secondary branches. Single, lemon-shaped sporangia are formed at the tips of the secondary branches. The sporangia are easily disseminated by wind, rain, and by handling infected plants.

The sporangiophores, with their large numbers of terminally borne sporangia, make up the downy mildew growth. If water is present on grape tissue, the sporangia quickly germinate to produce large numbers of motile zoospores that can result in secondary infections throughout a vineyard and thus rapidly spread the disease. Young lesions can be seen 4 to 12 days after infection on susceptible grape cultivars while it takes up to 18 or 20 days on a resistant plant. Spore germination, penetration, and infection can occur in 30 minutes to 2 hours at an optimum temperature of 50°F to 60°F (10°C to 16°C) with a minimum of about 40°F (4°C). The sporangiophores and sporangia of the downy mildew pathogen are usually formed at night and are most visible in early morning while the leaves, fruit, and other infected parts are still damp.

Toward the end of the growing season, oospores are formed in the old diseased leaves. To a lesser extent, oospores are also formed in infected fruit and shoots. The formation of the overwintering oospores completes the disease cycle.

Disease management

Downy mildew can be effectively managed by effective cultural practices and fungicide applications. Fungicide application should be considered as preventive of disease development.

1. Properly space vines, and choose a planting site where the vines will be exposed to all-day sun and good air circulation. Keep the vines off the ground and properly tied.
2. Drain soil to minimize spore production of the pathogen.
3. Prune vines each year during the dormant period. Remove the prunings, excess growth, overwintering berries, leaves, and tendrils from the vineyard and, where possible, burn them.
4. Keep the fruit planting and surrounding areas free of weeds and tall grass.
5. Grape cultivars differ in their susceptibility to downy mildew and several other diseases. The reactions of commonly grown grape cultivars to downy mildew and other major diseases are given in Table 1.
6. Fungicide use is the most important control on susceptible cultivars. Protectant fungicides, such as copper compounds, can be used as preventive treatments. Systemic fungicides, such as fosetyl aluminum and metalaxyl. Follow recommendations in the Midwest Fruit Pest Management Guide, University of Illinois Extension - ICSG (<https://ag.purdue.edu/hla/hort/documents/id-465.pdf>).

Table 1. Relative Susceptibility and Sulfur and Copper Sensitivity of Grape Cultivars

Cultivar	Susceptibility								Sensitivity	
	BR	DM	PM	Bot	Phom	Eu	CG	ALS	Sulfur ¹	Copper ²
Aurora	+++	++	++	+++	+	+++	++	+++	No	++
Baco Noir	+++	+	++	++	+	++	+++	++	No	?
Cabernet Franc	+++	+++	+++	+	?	?	+++	?	No	?
Cabernet Sauvignon	+++	+++	+++	+	+++	+++	+++	?	No	+
Candice	+++	++	+	++	?	?	++	++	?	?
Cascade	+	+	++	+	++	++	+	?	No	?
Catawba	+++	+++	++	+	+++	+	+	+	No	++
Cayuga White	+	++	+	+	+	+	++	++	No	+
Chambourcin	+++	++	+	++	?	?	++	?	Yes	?
Chancellor	+	+++	+++	+	+++	+	+++	+++	Yes	+++
Chardonnay	++	+++	+++	+++	+++	++	+++	++	No	+
Chelois	+	+	+++	+++	+++	+++	++	+++	No	+
Concord	+++	+	++	+	+++	+++	+	+	Yes	+
Cynthiana/Norton	+	++	+	+	+	?	+	?	Yes	?
DeChaunac	+	++	++	+	+++	+++	++	+++	Yes	+
Delaware	++	+++ ³	++	+	+++	+	+	+	No	+
Dutchess	+++	++	++	+	++	+	++	+	No	?
Elvira	+	++	++	+++	+	+	++	++	No	++
Einset Seedless	+++	++	+++	+	?	?	+	?	?	?
Foch	++	+	++	+	?	+++	+	+	Yes	?
Fredonia	++	+++	++	+	++	?	+	+	No	?
Frontenac	++	+	++	++	+	?	?	?	No	?
Gewüztraminer	+++	+++	+++	+++	?	?	+++	+	No	+
Himrod	++	+	++	+	?	?	?	+	No	?
Ives	+	+++	+	+	?	++	+	+	Yes	?
Jupiter	++	+	+++	+	+	?	?	?	?	?
LaCrosse	+++	++	++	+++	++	?	?	?	?	?
Leon Millot	+	++	+++	+	+	+	?	?	Yes	?
Limberger	+++	+++	+++	+	?	+++	+++	?	No	?
Marechal Foch	++	+	++	+	?	+++	?	+	Yes	?
Marquis	+	+++	+	+	+++	?	?	?	?	?
Mars	+	+	+	+	+	?	+	?	?	?
Melody	+++	++	+	+	?	?	?	?	No	?
Moore's Diamond	+++	+	+++	++	?	++	?	?	No	++
Muscat Ottonel	+++	+++	+++	++	?	+++	+++	?	No	?
Niagara	+++	+++	++	+	+++	+	++	+	No	?
Pinot Blanc	+++	+++	+++	+++	+++	+++	+++	+++	No	+
Pinot Gris	+++	+++	+++	++	?	+++	+++	?	No	?

Table 1. Relative Susceptibility and Sulfur and Copper Sensitivity of Grape Cultivars - Continued

Cultivar	Susceptibility								Sensitivity	
	BR	DM	PM	Bot	Phom	Eu	CG	ALS	Sulfur ¹	Copper ²
Pinot Meunier	+++	+++	+++	+++	?	+++	+++	?	No	?
Pinot Noir	+++	+++	+++	+++	?	?	+++	+	No	+
Reliance	+++	+++	++	+	++	?	?	?	No	?
Riesling	+++	+++	+++	+++	++	++	+++	+	No	+
Rosette	++	++	+++	+	++	++	++	++	No	+++
Rougeon	++	+++	+++	++	+++	+	++	+++	No	+++
Saint Croix	?	++	++	++	?	?	?	?	?	?
Sauvignon Blanc	+++	+++	+++	+++	?	?	+++	?	No	+
Seyval	++	++	+++	+++	++	+	++	++	No	+
Steuben	++	+	+	+	?	?	+	++?	No	?
Traminette	+	++	+	+	?	?	++	?	?	?
Vanessa	+++	++	++	+	+	?	+	?	?	?
Ventura	++	++	++	+	+	?	+	+++	No	?
Vidal Blanc	+	++	+++	+	+	+	++	+	No	?
Vignoles	+	++	+++	+++	++	++	++	++	No	?
Villard Noir	?	+	+++	+	?	?	?	?	?	?

Key to susceptibility: BR = Black rot; DM = Downy mildew; PM = Powdery mildew; Bot = Botrytis; Phom = Phomopsis; Eu = Eutypa; CG = crown gall; ALS = angular leaf scorch.

Key to rating: + = slightly susceptible or sensitive; ++ = moderately susceptible or sensitive; +++ = highly susceptible or sensitive; No = not sensitive; Yes = sensitive; and ? = relative susceptibility or sensitivity not established.

¹ Slight to moderate sulfur injury may occur even on tolerant cultivars when temperatures are 85°F (30°C) or higher during or immediately following the application.

² Copper applied under cool, slow-drying conditions is likely to occur injury.

³ Berries not susceptible.