A Pocket Guide for Grape IPM Scouting in the North Central and Eastern U.S.
Michigan State University
Michigan State University Extension

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Contents

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Using this scouting guide

This scouting guide was developed as a pocket reference book for easy use in the vineyard. It provides information on the biology of common insect pests and diseases, weather-related disorders, and symptoms of pesticide damage and nutritional disorders. Information on natural enemies is also provided.

Use this guide to learn what to look for while scouting and to guide timing of scouting activities. The guide focuses on grape-growing regions in the eastern half of the U.S. with emphasis on the Great Lakes and the Northeast. This guide is a field supplement to the more detailed publications listed below.

Suggested reading

Compendium of Grape Diseases. 1988. R.C. Pearson and A.C. Goheen. APS Press, St. Paul, Minnesota. 93 pp.

Grape Pest Management. 1992. D.L. Flaherty et al. University of California, Publication 3343. 400 pp.

Natural Enemies Handbook. 1998. M.L. Flint. University of California Statewide Pest Management Project, Publication 3386. University of California Press. 154 pp.

Introduction to scouting

Why scout vineyards?

Regular scouting is the foundation of effective vineyard pest management. Scouting for pests and diseases means looking for them in the vineyard at critical times in their development and recording their incidence. This ensures early detection of pest and disease problems before they reach damaging levels. Regular scouting also helps optimize timing of control measures.

Strategies for scouting

- Know and understand basic pest biology (life cycles) to give you the best information on when pests and their damage can be found.
- Scout for insects and diseases at the right times. See the scouting calendar on page 105.
- Scout with the sun behind you, and be sure to look under the canopy at interior leaves and fruit.
- Look carefully for disease symptoms after prolonged wet periods.
- Develop vineyard history maps with locations of areas most affected by pest and disease outbreaks, and monitor more intensively in these areas.

Tools for scouting

- Monitoring traps to track insect development in vineyards.
- A 20X hand lens to help identify pests and pathogens.
- Collection bags to gather samples for identification.
- Clipboard with scouting forms, waterproof notebook and pencil.
- Vineyard maps to document location of insect, weed and disease pest outbreaks.
- Colored tape or tags to mark vines of interest.
- Waterproof marker to write on tags/tape or on leaves.

Where to monitor

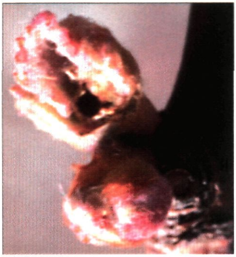
- Check borders and interior areas of the vineyard separately.
- Include areas adjacent to woods.
- Monitor at least 100 vines per vineyard (25 vines along the length of four different rows).
- Look in hotspots with a history of insect or disease problems.
- Inspect and sample both sides of the vine.
- Walk different rows at different times.

Weather monitoring

- Weather information can be used to predict vine phenology, appearance of some insect pests and infection periods of the major diseases affecting grapes.
- Weather information can also be useful in explaining weather-related disorders, such as freeze damage or heat injury.
- Minimum weather monitoring includes measuring rainfall and daily high and low temperatures.
- Disease prediction models, which are built into some weather monitoring equipment, usually require additional information (e.g., relative humidity and duration of leaf wetness within the vineyard).
- Wind speed predictions are useful for determining risk of spray drift.

Insect pests of buds

Climbing cutworms



Cutworm damage to an expanding bud.

Climbing cutworms are large, smooth caterpillars measuring 30 to 40 mm when fully grown. The head capsule is usually dark and the body is dull gray-brown, marked with dots or stripes, and curled when disturbed. The larvae overwinter in the soil of the vineyard floor and become active in spring when vine buds begin to expand. Larvae feed on young buds at night, hiding in the soil beneath the vines during the day. Feeding may injure buds or remove them entirely. Cutworms are mainly a pest in areas with sandy soils and in vineyards with weeds under the vines. Injury is often worse in years when cool temperatures slow bud development.

Vineyards with a history of cutworm damage should be scouted regularly during bud expansion, particularly after warmer nights. Once shoot expansion begins, vines are no longer at risk.

Insect pests of buds

Grape flea beetle

The grape flea beetle (or steely beetle) is a shiny, metallic dark blue color. It may jump when disturbed. The insect overwinters as an adult. This stage feeds directly on young buds, beginning when conditions warm in the spring. Vineyard borders adjacent to woods or other protected areas are most affected. Adults damage swelling buds by hollowing them out. Their damage may be confused with cutworm damage because both species feed during bud swell. The level of injury varies from year to year and is worse when cool temperatures slow bud development.

Adult 5 mm

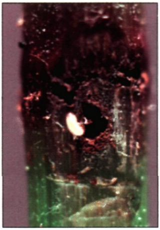
Insect pests of shoots

Grape cane girdler

The grape cane girdler is common in the central and eastern United States. The adult is a black snout beetle. In late spring, the female makes holes encircling the cane and lays her eggs in the holes.

Grape cane girdler – *continued*

After eggs are laid, the female encircles the cane with another series of punctures a few inches below the first girdle, though she places eggs only in the first girdle's holes. The legless grub is white with a brown head. It is similar to the closely related grape cane gall-maker. Grubs feed in the cane pith between the girdles. After larvae complete their development, they pupate. Adults appear in late summer, hibernate over the winter and reappear in late spring. Injury from grape cane girdlers has the greatest impact on vines during establishment.



Above left, female adult drilling ring of holes into a shoot. Above right, white larvae are found near punctures.

Girdled shoots break easily.

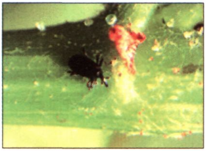
Insect pests of shoots

Grape cane gallmaker

Obvious red galls produced after the beetle lays eggs.

The grape cane gallmaker is a sporadic pest of grapes in the eastern United States. This insect produces noticeable red galls on new shoot growth just above nodes. The majority of galls are beyond the fruit clusters and cause no serious yield loss. Canes with galls can still produce a crop the following year.

Adult beetle 4 mm



The adult is a dark brown snout beetle about 1/8 inch (4 mm) long that looks like the grape cane girdler (see page 5). The legless grub is white with a brown head and slightly larger when full grown.

Evidence of damage on old wood.

Insect pests of leaves

About leafhoppers

Several leafhopper species feed on grape foliage in the eastern United States (see page 12 for a comparison). All feed on the undersides of leaves, puncturing cells and sucking out the contents. In general, juice grape (labrusca) varieties are much more tolerant of leafhoppers than hybrid or vinifera varieties.

Insect pests of leaves

Potato leafhopper

The adult leafhopper is pale to bright green and about 1/8 inch long. Adults are very active, jumping, flying or running when disturbed. The immature forms, or nymphs, are pale green and wingless. They run forward, backward or sideways when disturbed. The potato leafhopper does not overwinter north of the Gulf states. Adults migrate north each spring on southerly winds and are deposited during May and June in spring rains.

Adult potato leafhopper

3 mm

Potato leafhopper – *continued*

Potato leafhoppers can be very destructive on hybrid or vinifera varieties that are sensitive to the toxins they inject while feeding. Feeding is concentrated on young tissues near the shoot tips. On sensitive varieties, only a few adults are needed to cause leaf yellowing and cupping or shortened shoot internodes. This insect is typically a minor pest in labrusca grapes.

Sensitive varieties can display yellowed leaves and "cupping" after potato leafhopper feeding.

Grape leafhopper

Grape leafhopper adult 3 mm

Grape leafhopper adults are orange-yellow with some dark spots and yellow lines on the wings and are about 1/8 inch long. Grape leafhopper has 1.5 to 2 generations per year, with peak abundance of adults occuring in late July and again in late August. Adults overwinter in leaf litter in or around vineyards and feed on weeds as temperatures exceed 60° F (16° C) in the spring. After mating, they move to young grape foliage in late May and early July to lay clear, crescent-shaped eggs inside the leaves. First generation eggs hatch in mid- to late June, and the flightless nymphs take a month to develop into adults. Cold, wet springs and winters are damaging to leafhoppers.

Grape leafhopper nymph

Sampling for grape leafhopper

In labrusca vines, growers can sample for grape leafhopper in the third week of July to determine the need for management. Examine 100 leaves across two edge and two interior vineyard sites. At each site, inspect five leaves (leaves 3 to 7) on one shoot of five vines to determine whether the leaves are showing any white/yellow stippling on the upper leaf surface. If more than 10 leaves of the 100 show damage, apply an appropriate control for the leafhoppers. If populations are only at the vineyard edges, consider area-specific management. Insecticides applied for grape berry moth may control grape leafhopper as well.

Early signs of damage include stippling along leaf veins.

Severe damage includes necrosis on leaves and premature water stress.

Comparison of grape and potato leafhoppers

Character	Grape leafhopper	Potato leafhopper
Color	Light yellow	Green-yellow
Behavior	Walks forward	Walks sideways
Position on vine	On inner canopy leaves	On leaves on ends of shoots
Most susceptible	Labrusca grapes	Vinifera and hybrid grapes
Damage symptoms	Stippling on leaf surface, becoming red/brown when severe.	Leaf yellowing and cupping on wine grapes. Stippling on juice grape leaves.

Other leafhoppers

Threebanded leafhopper, *Erythroneura tricincta,* and Virginia creeper leafhopper, *Erythroneura ziczac,* can both be found in eastern U.S. vineyards. Their biologies are similar to that of grape leafhopper. The threebanded leafhopper adult is brown and black with some orange flecks on the wings. The Virginia creeper leafhopper adult is pale yellowish or white with a zigzag stripe down each wing and distinctly red cross-veins.

Insect pests of leaves

Rose chafer

The rose chafer is a light tan beetle with a darker brown head and long legs. It is about 12 mm long. There is one generation per year. Adults emerge from the ground during late May or June, near grape bloom time, and live for three to four weeks. Females lay groups of eggs just below the surface in grassy areas of sandy, well-drained soils. The larvae (grubs) spend the winter underground, move up in the soil to feed on grass roots and then pupate in the spring. A few weeks later, they emerge from the soil and disperse by flight. Male beetles are attracted to females and congregate on plants to mate and feed.

Feeding damage is most obvious on the leaves, though the greatest impact can be on young clusters when adult beetles remove the developing berries.

12 mm

Insect pests of leaves

Japanese beetle

Japanese beetles can be present from June through September. They feed on the upper leaf surfaces, leaving a lacelike skeleton. Injured leaves may turn brown and die if feeding is severe, but clusters are not attacked. Juice grape vines are resistant and tolerate some damage, but vinifera and hybrids are more susceptible.

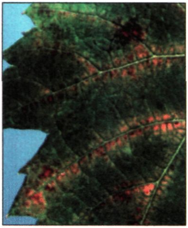
This pest can be a problem particularly in new vineyards using grow tubes. Frequent monitoring is required to reduce the risk of severe damage. Japanese beetle traps may attract beetles to vineyards, so their use is discouraged.

Beetles lay eggs underground in grassy areas near vineyards, preferring soil with moisture. The white, C-shaped larvae (grubs) feed on grass and weed roots and overwinter underground in these areas. Cultural and biological controls of grubs may reduce subsequent abundance of adults.

Twospotted spider mite

Twospotted spider mites can be seen with a 20X hand lens.

This mite can cause severe damage to wine grapes if populations reach high densities. The mite's feeding removes leaf tissue, causing yellowing and then bronzing. Thin-leaved varieties are most susceptible. These mites overwinter in leaf litter, develop on weeds in spring and move onto the vine as ground cover dries in summer. Water-stressed vines are most at risk. The most effective method of control is to protect predatory mites. Biological control is achieved with one predatory mite per 10 twospotted mites (see page 30).

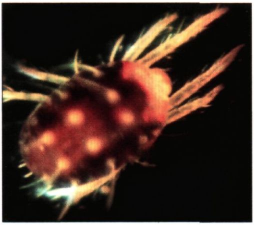


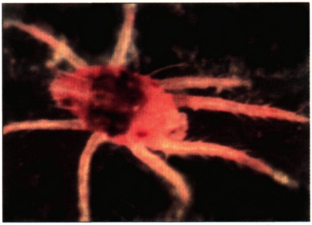
Bronzing on the upper side of the leaf is a symptom of mites feeding below.

Mite pests of leaves

European red mite

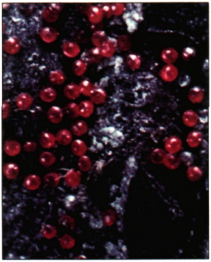
Adult female European red mites are less than 0.5 mm and dark red with eight legs. Adult males are smaller than the females and have a pointed abdomen. Males are usually dull green to brown.





Above left, adult female; right, adult male

Mites hatch in the spring from tiny, spherical eggs laid around cane nodes and under loose bark. These eggs can be detected by scouting in early spring. Although several generations can occur each season, populations rarely increase enough to cause significant damage because predatory mites usually prevent their growth.



Mite eggs

Mite pests of leaves

Grape erineum mite

This very small mite cannot be seen without magnification. It overwinters under the bark of one-year-old canes. In spring, the mites move to leaves, causing raised bumps, called "erineum," on the upper surface. These have densely curled leaf hairs on the lower surface, in which the mites feed and reproduce.

White patches on the undersurface of the leaf house the erineum mite.

About gallmakers

Many galls of various shapes occur on grapevines as a result of attack by small flies (gall midges). Galls can occur on leaves, tendrils and blossom buds. Numerous species of gall midges attack grape. No practical control for these galls is known, though removing the galls by hand and destroying them would reduce future populations.

Gallmakers on leaves

Galls are formed by larvae of small cecidomyiid flies, which lay their eggs into the leaf. Infestations are generally spotty, both within vineyards and within infested vines, and they rarely cause significant economic damage. There may be one to three generations per year. The life cycle begins with eggs laid within the unfolding buds or shoot tips. Orange, maggotlike larvae hatch from these eggs and enter the vine tissue. As the larvae feed, galls form around them.

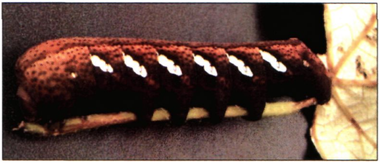
Galls are formed by various fly species. Each makes a characteristically shaped gall. Above are tumid galls and below, pointed galls.

■ **2 mm** Larvae in galls

Insect pests of leaves

Hornworms

Hornworms (sphingid larvae) are found feeding on leaves in vineyards. Larvae may be brown or green with spots on the sides of the body and a distinctive "horn" on the rear end. The larvae can grow to 5 inches (12 cm) long, and they feed voraciously during development. Because of this, hornworms are more of a concern in young vineyards with limited leaf area. Larger vines can usually tolerate some leaf area loss from their feeding.



The coloration of hornworms makes them hard to see, so feeding damage and droppings are usually the first sign of their presence.

Pests of fruit

Grape berry moth

Grape berry moth is common in commercial and backyard vineyards in eastern North America. It is a native insect with wild grape as its historical host. There are two or more generations of larvae per year.

Adult 6 mm

Grape berry moth spends the winter as a pupa in leaf litter in and around vineyards. First generation adults emerge from the pupae before bloom. Male and female moths mate and then females lay circular, flat eggs directly onto the cluster around bloom. The eggs can be difficult to find because of their small size (approximately 1 mm diameter). Their shiny exterior can be used to detect them, especially with a hand lens. Eggs parasitized by wasp parasites turn black.

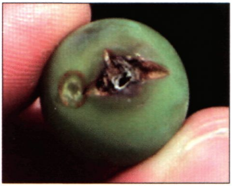
The dark head capsules indicate that these eggs are close to hatching into larvae.

Grape berry moth – *continued*

Larvae hatch from the eggs in three to six days, depending upon temperature, and feed on the cluster until they have developed to full size.

Webbing and frass with discoloration of berries from grape berry moth larva

Larvae of the first generation feed on young grape clusters and may remove sections of clusters. Then, when berries are formed, the young larvae burrow into the fruit. Webbing and larvae are visible in the small clusters during and after bloom. Damage from redbanded leafroller can be mistaken for grape berry moth at this time, so it is important to identify the larvae to determine the appropriate management strategy.



Second generation larvae feed on the expanding berries, and feeding sites are visible as holes. Larvae may web together multiple berries.

Grape berry moth – *continued*

Larvae of the third generation feed inside berries before and after veraison. Berries may be hollowed out by feeding, and larvae at this time may contaminate harvested fruit. Damage by grape berry moth after veraison predisposes berries to infection by Botrytis and sour rots and can attract fruit flies, wasps and ants.

In Michigan, Pennsylvania, northern Ohio and New York, it is important to scout in mid- to late July for eggs and larvae. Detecting egg laying and egg hatch helps accurately time insecticide controls. In high-pressure vineyards, egg laying may continue over many weeks late in the season. Infestation is often greater on the border than the interior of vineyards, particularly near woods or hedgerows.

Regular cluster sampling in the vineyard interior and at the borders (particularly next to woods) can help to assess berry moth infestation levels and determine management needs.

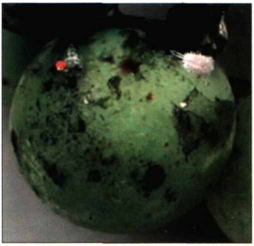
9 mm Mature larva

Grape mealybug

Adult female 3 mm

Mealybugs are a sporadic pest of grapes in the eastern United States. Adults are soft, oval, flat, distinctly segmented and covered with a waxy layer that extends into spines along the body margin and the posterior end. The pinkish body is visible through the powdery wax. Mealybugs are most commonly found in the crevices of foliage or where berries meet the rachis.

Mealybug damage is primarily cosmetic and occurs when honeydew produced by the feeding insects drops onto nearby leaves and fruit. The honeydew acts as a substrate for sooty molds that can spoil fruit quality.



Sooty mold developing on mealybug honeydew.

Banded grape bug

The banded grape bug has piercing-sucking mouthparts that it inserts into plant tissue to suck out plant sap. It completes one generation per year on grapes and is active in vineyards from shortly after bud break to early July. It spends most of the year as an egg, which is the overwintering stage. Eggs are laid in crevices on second-year wood and vine trunks. They hatch when shoots are approximately 2 to 5 inches (5 to 13 cm) long. The nymphs then begin feeding on shoot tips and newly emerged leaves. Feeding is concentrated in the stalks of individual florets, the buds and the cluster stem. Nymph development takes about 3 weeks, with adults appearing in early June.

As few as one nymph per 10 shoots can cause economic damage. Adults are predators and therefore do not damage grapes. A smaller green-colored plant bug, *Lygocoris inconspicuous*, has similar timing and damage potential.

Pests during harvest

Yellowjackets


Yellowjacket feeding on ripe berry.

Yellowjackets and other wasps may break open grape berry skins during late summer. Early in the growing season, wasps are mainly predatory, but late in the season they begin to search for sugar, including ripened fruit. Destruction of nearby nests is effective but difficult because nests are often underground.

Pests during harvest

Fruit flies

Fruit flies lay eggs near the surface of fermenting berries. Eggs take only 30 hours to hatch, and larvae develop in fermenting material. They feed near the surface, mostly on yeast, for 5 to 6 days and go to drier places to pupate. The life cycle may be completed within 8 to 10 days at 85° F (29° C). Timely harvesting can help prevent fruit fly outbreaks in the vineyard.

Pests during harvest

Ants

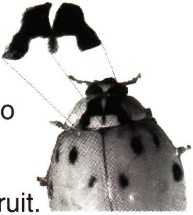
A column of ants on a vine during the summer may be tending mealybugs because ants feed on the secreted honeydew. Ants can become pests during harvest, when ripe berries are a source of sugar, and they can become a hazard for hand-pickers. They rarely require control and typically affect a small area of a vineyard.

Many species of ant feed on ripe berries.

Pests during harvest

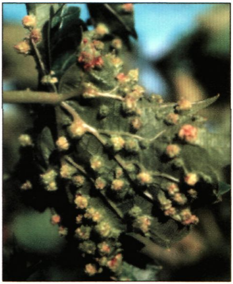
Multicolored Asian ladybeetle

This insect searches for sugar resources and tight spaces to prepare for overwintering. These characteristics may attract them to ripe grape clusters during harvest. Grapes or juice may be contaminated if beetles are crushed with fruit.

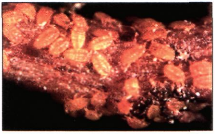


Asian ladybeetle can be distinguished from others by the black W or M (depending on the viewing direction) on the body between the head and abdomen.

Grape phylloxera



Phylloxera are small, yellow, aphidlike insects that live on vine roots and leaves. The root form stunts growth of susceptible vines and can kill them. This pest is effectively managed by using resistant or tolerant rootstocks. In the eastern United States, foliar damage is seen on wild grape, labrusca and some vinifera vineyards as raised galls on the undersides of leaves (see photo above). The root form of this pest prefers vines growing in heavy clay soils. Phylloxera damage the roots of vines by feeding on growing rootlets, which then swell and turn yellowish. The swellings are often hard to see on mature roots. Necrotic spots (dead areas) develop at the feeding sites. Labrusca grapes can tolerate phylloxera feeding on roots, particularly in well-watered vineyards.



Phylloxera nymphs on a root

Insect pests of roots

Grape root borer

Adult grape root borers are clearwing moths with a dark brown body and yellow-orange bands on the abdomen. Moths are active during the day and are seen on vines in July. The female moths lay up to 300 eggs on or near the vine, and newly hatched larvae crawl into the soil and vine roots.

Adult root borer moths mimic wasps for protection.

Larvae feed on the roots for up to two years (perhaps longer), moving to larger roots as they grow. Damaged vines have reduced vigor and may eventually die. This species is found in much of the eastern United States but is more damaging in southern states.

Larvae spend two years feeding on roots and can reduce vine vigor or kill vines.

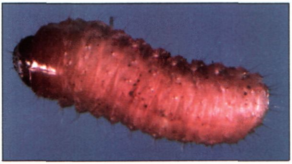
Insect pests of roots

Grape rootworm

This beetle is 6 mm long and light brown with yellow hairs. It feeds on grape foliage as an adult, making a chainlike damage pattern. Immature stages feed on grape roots. Infestations that go untreated for many years can lead to vineyard decline. Grape rootworm adults begin appearing in vineyards in mid- to late May and then lay eggs on the vine trunks.

Adult grape rootworm 6 mm

Larvae later crawl into the soil and attach themselves to grape roots, remaining there for one to two years while completing their development. Larvae eat small roots and bore into larger ones.



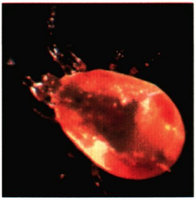
Grape rootworm larvae (left) are found underground.

About natural enemies

Beneficial organisms (natural enemies) can enhance pest control, often providing good suppression of many indirect pests, such as mites and leafhoppers. The best way to conserve beneficial insects is to use caution when selecting pesticides and timing applications, and restricting use of predator-toxic products, particularly later in the season. Keeping flowering plants in and around the vineyard also helps conserve beneficials because adults of many predators and parasites feed on nectar and pollen.

Predatory mites

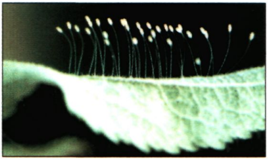
Predatory mites can be distinguished from pest mites by observing their movement. When disturbed, predators generally move more quickly than pest mites. A ratio of one predator to 10 pest mites is often sufficient for effective biological control.



Amblyseius fallacis adults are tear-shaped and fast moving.

12 mm

Green lacewing adults (10 to 12 mm) have net-veined wings and gold-colored eyes. They feed on nectar, pollen and aphid honeydew.



Lacewing eggs are suspended at the tips of long, erect stalks.

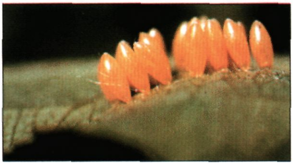
Lacewing larvae are alligator-shaped with long, piercing mandibles. They are active predators on the leaf surface.

15 mm

Predators – *continued*

Several species of **lady-beetles** are active in vine-yards. They are generally oval and red to orange with varying numbers of dark spots. Pollen is an important compo-nent of the diet of some species.

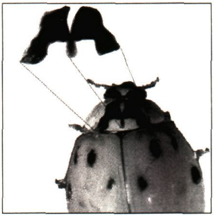
Ladybeetle eggs are yellow and barrel-shaped and laid in clusters.



5 mm

Larvae have dark, elongated bodies with orange markings and well developed legs.

The **multicolored Asian ladybeetle**, an introduced species, feeds on pests during summer. This insect can be distinguished from other ladybugs by the black M or W (depending on the viewing direction) between the head and abdomen (see photo). See page 26 for details of its pest status.

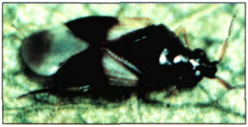


Predators – *continued*

Syrphid fly adults (below left) resemble bees but have only one pair of wings. They can be seen hovering in the air.

Syrphid fly larvae (above right) are usually light green, legless maggots, rounded at the rear and tapering to a point at the head. 2 mm

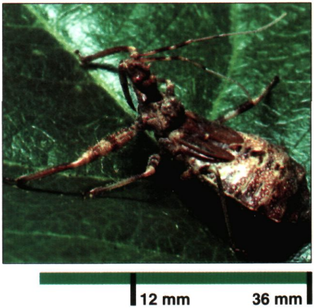
Damsel bugs have long bodies that narrow slightly toward the head. They have stout beaks and large front legs for grasping prey. 8 mm



Adult **minute pirate bugs** are black with white markings. 5 mm

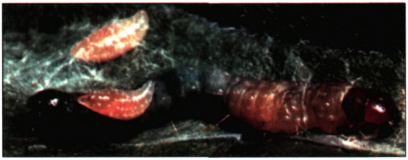
Predators – *continued*

Adult **assassin bugs** are medium to large insects, and their color ranges from brown to green. They have long heads with a groove between the eyes and curved beaks. The nymphs are also important predators.



Most **parasitic wasps** are tiny and they often develop inside their hosts, so detecting them can be difficult. Some recognizable signs of parasitism include unusual host (pest) behavior, host body darkening, and the presence of emergence holes or cocoons.

Tachinid fly adults are hairy and bristly. Their larvae feed on moth, beetle and stinkbug larvae.



Tachinid fly larvae emerge from moth larva.

Predators – *continued*

Trichogramma wasps are egg parasites of many insects, including grape berry moth. Parasitized eggs are dark black rather than the yellow-cream of healthy eggs.

Braconids and **ichneumonids** are small black, orange or yellow wasps that prey on immature insects such as grape berry moth larvae. Adults are less than 10 mm long, and many species are found in vineyards.

Shield bug on a leaf

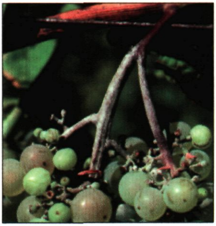
Many **shield bugs** (pentatomids) are predatory and can attack beetles and caterpillars.

Spiders live in the vine canopy and can eat leafhoppers and other small pests.

Powdery mildew

Uncinula necator

Powdery mildew can infect all green tissues and give them a whitish gray, powdery appearance. Colonies occur mostly on the upper leaf surface. Early berry infections can result in split berries, secondary rots and undesirable flavors in wine. Late diffuse infections are largely invisible but can still predispose the berries to rots.

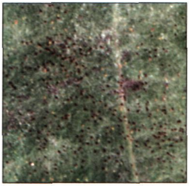


Rachis infection

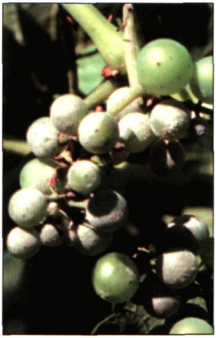
Infected shoots show dark gray, feathery patches (above, left), which appear reddish brown on dormant canes (above, right).

Powdery mildew – *continued*

In late summer, the fungus produces small, golden-brown to black fruiting bodies (cleistothecia) on infected plant parts. Cleistothecia overwinter in bark crevices. The cleistothecia release ascospores during rains of 0.1 inch (2.5 mm) or more between bud break and fruit set. In regions with mild winters, the fungus can also survive in dormant buds, which develop into "flag shoots." Powdery mildew is favored by high humidity and temperatures of 68 to 81°F (20 to 27°C). Wetness is not required for infection. Temperatures above 95°F (35°C) inhibit new infections. Begin monitoring at immediate prebloom, checking leaves inside the canopy closest to the trunk. On Concord vines, the disease appears first on the rachis around bloom and is rarely seen on foliage until later in summer.



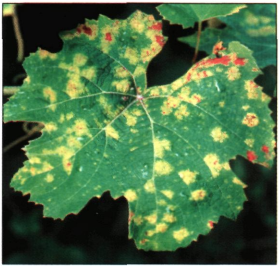
Cleistothecia



Berry infection

Downy mildew
Plasmopara viticola

Downy mildew is a widespread, serious disease of grapevines. Initial leaf symptoms are light green or yellow spots, sometimes called "oil spots" because they may appear greasy. Under humid conditions, white, fluffy sporulation can be seen on the lower leaf surface. The lesions eventually turn brown as the infected tissue dies. Severely infected leaves drop prematurely, which can reduce



Above left, young lesions. Above right, older lesions that have turned brown. At left, white spore masses on the lower surface of the leaf.

Downy mildew – *continued*

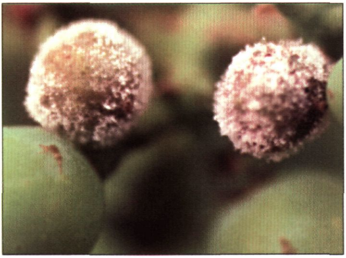
winter hardiness of the vine. Infected flower clusters dry up or become covered with white spores under humid conditions. Infected berries turn a mottled dull-green or reddish purple and readily fall from the cluster. Although berries become resistant to infection within three weeks after bloom, the rachis remains susceptible for several weeks longer.

On older leaves, lesions are smaller and more angular as they are delimited by leaf veins.

Young shoot covered with spores.

Downy mildew – *continued*

The fungus overwinters in leaves on the ground and produces spores in spring. The spores are carried by wind and rain splash to new leaves and require a film of water for infection. Lesions appear 5 to 17 days after infection. The disease can spread rapidly under warm conditions with frequent rain or dew. Use the 10-10-10 rule to decide when to start scouting for downy mildew: at least 10 cm (4 in) of shoot growth, 10 mm (0.4 in) rainfall and temperatures of 10°C (50°F) during a 24-hour period.

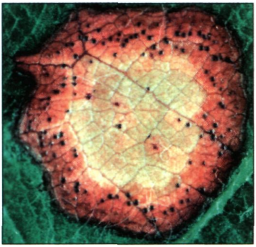


White spore masses develop on infected berries.

Black rot

Guignardia bidwellii

Black rot can be very destructive to grape fruit clusters. It can attack all new growth – leaves, petioles, shoots, tendrils and berries.

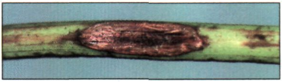


On the leaves, light brown, roughly circular spots appear in the spring and summer (above left). These can be distinguished from herbicide damage by a ring of small black fruiting bodies (above right), visible with the naked eye or a hand lens.

Fruit infections occur from bloom until the berries become naturally resistant (about 3 to 5 weeks after bloom). The first symptom, a whitish dot within a rapidly expanding brown area, appears 10 to 14 days after infection. Within a few days, the berry starts to shrivel and becomes a hard, blue-black mummy.

Black rot – *continued*

Above, initial berry lesion, which may expand to show growth rings (right).



If berries are infected close to the onset of natural resistance, lesions remain localized. The fungus overwinters in mummies within the vine or on the ground. Ascospores are released shortly after bud break until about 2 weeks after bloom and are dispersed by wind and rain.

Above, mummified berries on a cluster.

Black rot – *continued*

Leaf spots and infected berries can also yield conidia, which are dispersed by rain splash and cause secondary infections.

The optimum temperature for disease development is 27°C (80°F). At that temperature, the wetness period required for infection is only 6 hours (see table below).

Environmental conditions conducive to black rot disease development

Ave. temperature (F)	Hr. of leaf wetness
50	24
55	12
60	9
65	8
70	7
75	7
80	6
85	9
90	12

Approximate number of hours of wetting required for infection by the grape black rot fungus at various temperatures.

Source: R.A. Spotts, Ohio State University.

Phomopsis cane and leaf spot

Phomopsis viticola

Phomopsis cane and leaf spot is common in Northeastern and Midwestern grape-growing regions. Infected leaves have small, yellowish spots with dark centers and may be puckered. On petioles, shoots and rachises, elongated black spots or streaks develop that make the tissue brittle. Most shoot lesions occur on the basal three to six internodes. Rachis and berry infections become apparent later in the season. Infected rachises wither, causing berries or entire clusters to drop prematurely.

Below, an infected leaf, and left, lesions on rachis and shoot.

Phomopsis – *continued*

Berries get infected directly through the skin or via the berry stem and turn brown and rubbery. Prolonged rainy, cold weather in spring, especially during bloom and fruit set, promotes rachis infections and fruit losses. At least 6 hours of wetness are needed for infection at 59° to 68°F (15° to 20°C). Actively growing tissues are most susceptible, and symptoms appear 21 to 30 days after infection. The fungus overwinters in bark of infected canes.

Fruiting bodies develop in bleached area on cane stub.

Above, fruiting bodies appear as numerous black specks on the berry surface.

Anthracnose

Elsinoë ampelina, Colletotrichum acutatum

Anthracnose is a southern disease that also occurs in northern regions. Some table grape varieties are particularly susceptible. Symptoms occur on all aboveground parts of the vine, particularly on young tissues. Leaves develop numerous dark brown spots, 1/25 to 1/5 inch (1 to 5 mm) in diameter. As the centers fall out, lesions take on a "shot-hole" appearance. Severe infections curl and distort leaves. Lesions on shoots are sunken and dark brown with grayish centers.

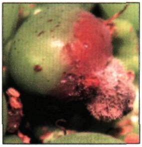
Entire shoot tips may be blighted.

Anthracnose – *continued*

On green berries, "bird's-eye" spots are purplish brown or may look bleached with a dark edge. Berries remain firm for some time, then crack or shrivel. The causal fungi overwinter in infected parts of the vine, and spores are dispersed by wind and rain splash in the spring. Anthracnose can be severe in years with heavy rainfall early in the season.

Bird's eye spots on berries.

Botrytis bunch rot
Botrytis cinerea



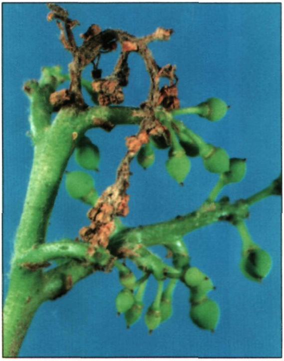
Grayish mold develops on infected berries. Right, berry becoming infected from moldy blossom.

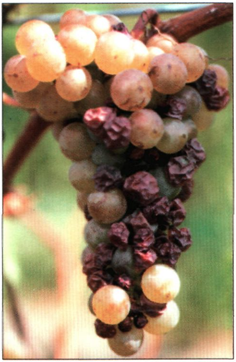
Botrytis bunch rot is a fruit rot, but it also can affect other plant parts. In spring, buds and young shoots may be infected and turn brown. In late spring, V-shaped or irregular brown patches may appear on leaves. Inflorescences may become blighted and wither away. Some flower infections remain latent until veraison. From veraison onward, the fungus can infect grape berries directly through the epidermis or through wounds. Compact clusters, powdery mildew infection, hail and insect damage (e.g., grape berry moth) can predispose grapes to infection. Infected white grapes turn brown; purple grapes become reddish.

Botrytis bunch rot – *continued*

The disease is favored by temperatures of 59° to 68°F (15° to 20°C) and free water or at least 90 percent humidity, and it spreads rapidly during moist periods, especially close to harvest. In certain cultivars, slow-developing, late-season infections are termed "noble rot" because they contribute to the production of exceptionally sweet wines. The fungus overwinters in mummified fruit and other infected plant parts.

Left, a blighted flower cluster. Right, during dry weather, infected berries dry up.

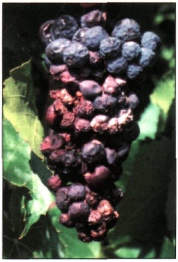




Sour bunch rot

Fungi, yeasts and bacteria

Sour bunch rot is a wet rot that spreads rapidly throughout clusters and causes berries to smell like vinegar. It is caused by a variety of fungi, yeasts and acetic acid bacteria. Unlike Botrytis bunch rot, it usually lacks fungal sporulation. Low-grade powdery mildew infections and grape berry moth or fruit fly infestations can predispose clusters to infection. Insects can also spread the sour rot organisms on their bodies. Some cultivars are more susceptible than others. Prolonged periods of wetness or high relative humidity are conducive to sour bunch rot development.



Bitter rot

Greeneria uvicola

Fruiting bodies

Bitter rot is common in south-eastern growing regions. It gives the berries a bitter taste that is detectable in wine. After flowering, the fungus infects the berry stem and remains latent until the berry is mature. Then the fungus rapidly invades the berry and sporulates in concentric circles, darkening and roughening the surface. Within a couple of days, the berries soften and easily detach. Berries that do not fall off shrivel up, similar to black rot-infected berries. The optimum temperature for infection is 82° to 86°F (28° to 30°C), but infection can occur at temperatures as low as 54°F (12°C). Fruit injury by insects, birds or cracking can cause bitter rot to spread rapidly throughout the cluster. The fungus invades wounds and overwinters in plant debris and bark of one-year-old canes.

Ripe rot

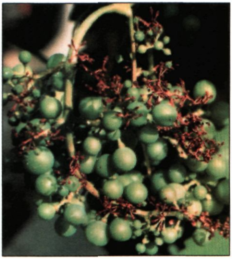
Colletotrichum spp.

Spore masses on infected berries.

Ripe rot occurs in most grape-growing areas but is most common in warm, humid regions. The fungus causes ripe fruit to rot. Initially, berries show circular, reddish brown spots, which enlarge to cover the whole fruit. Salmon-pink spore masses develop in a circular pattern on the fruit surface. The berries shrivel and darken as they decay and then fall to the ground. Berries are susceptible to infection at all stages of development but do not show symptoms until the berries are ripe. Disease development is favored by wet weather at 77° to 86° F (25 to 30° C). The fungus overwinters in mummified fruit and infected pedicels, from which spores are dispersed in spring and early summer. Spores on infected fruit can cause secondary infections of neighboring berries.

Angular leaf scorch

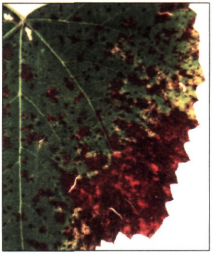
Pseudopezicula tetraspora



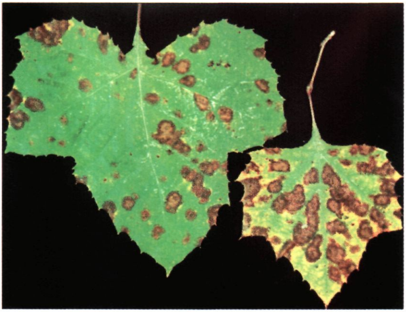
This foliar disease occurs in New York. It is very similar to the European "Rotbrenner" disease. Lesions are initially yellow or reddish and confined by major veins. They later become necrotic and surrounded by yellow or red margins. Late-season infections may look like freckled spots and can cause premature defoliation. Infected flower clusters dry up. Unlike Botrytis blight, this disease infects only the berry stems, not the rachis. The pathogen overwinters in fallen infected leaves. The disease may seem absent in most years but can be severe in years with several prolonged (two- to three-day) rains.

Septoria leaf spot

Septoria ampelina



Septoria leaf spot, also called mélanose, is a minor foliage disease in the eastern and midwestern United States. The disease mainly affects American *Vitis* and muscadine grapes. Angular, reddish brown to black spots that are 1 to 2 mm in diameter appear after midseason. Nearing veraison, lesions become larger with diffuse margins. Fruiting bodies may be seen with a hand lens. The area surrounding the spots may be yellow. The fungus overwinters in infected leaf debris.



Leaf blotch

Briosia ampelophaga

Leaf blotch is present throughout the eastern United States. It can affect many types of grapes but is most often found on leaves of American rootstock cultivars. Leaf lesions appear after midseason. Lesion size ranges from 1/25 to 2 inches (1 to 50 mm). Small lesions have dark margins, and large lesions have light-colored, zonate rings. Stalked fruiting structures are produced within 3 to 4 days of the appearance of the lesion, usually on the lower leaf surface. The fungus may also sporulate on overripe berries. The fungus overwinters in infected plant debris.

Tar spot

Rhytisma vitis

Tar spot is a minor disease that occurs mostly on wild grapevines. This fungal disease is characterized by black, slightly raised spots about 1/10 to 1/5 inch (2 to 4 mm) in diameter. A spot may be surrounded by a circular brown halo up to 2/5 inch (1 cm) in diameter. The fungus overwinters in these spots. In the spring, they release airborne spores, which infect the new leaves.

Eutypa dieback

Eutypa lata

Eutypa dieback is a progressive disease of the woody tissues of the grapevine. It is mainly found in older vineyards. Symptoms may not show for several years after infection. Initial symptoms usually appear on one arm and are best observed in mid- to late spring when shoots are 10 to 12 inches (25 to 30 cm) long. Leaves are cupped, yellowish and smaller than normal. Shoots are variously stunted and have fewer and smaller fruit clusters, sometimes with large and small berries. Shoot and leaf symptoms result from a toxin produced by the fungus in infected wood.

Left, expanded leaves with chlorotic areas and tattered edges. Right, cupped leaves.

Eutypa – *continued*

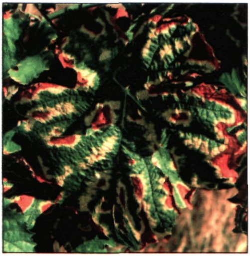
Severely infected arms or vines develop fewer shoots each year and eventually die. Below the bark, a canker can usually be found surrounding an old pruning wound on the affected arm.

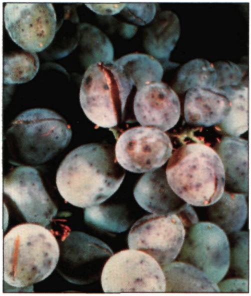
Wedge-shaped area of dead wood typical of Eutypa dieback. Below, a dying vine.

The fungus overwinters in infected wood and releases spores from the cankered area once the bark has weathered off. Most spores are released during late winter and early spring when temperatures above 32° F (0° C) and more than 1/25 inch (1 mm) rainfall or snowmelt occur. The fungus infects vines primarily through pruning wounds, which remain susceptible for a month or more.

Grapevine decline or Esca
Phaeomoniella chlamydospora, Phaeoacremonium spp., *Stereum hirsutum, Phellinus punctatus*

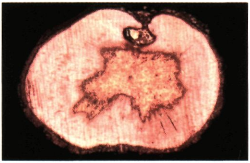
Grapevine decline affects both young and old vines. Young vines often show stunted growth, small trunk size and reduced foliage. On older vines, yellowish or reddish patches may appear between leaf veins in mid- to late season, eventually leading to marginal and interveinal "burning." Berries may show poor maturation and purplish gray flecks ("measles"). The entire vine or part of it may die suddenly, usually during hot periods. Sometimes shelflike mushrooms can be found on the trunk.





Above, leaf with marginal and interveinal "burning." Below, berries speckled with "measles."

Grapevine decline or Esca – *continued*



Causal fungi can infect vines through roots and pruning wounds and become systemic in the plant. Infected vines are often symptomless, so the disease can easily spread via planting material.

Cross-sections of the wood may show a white rot (left, above) or black spotting and dark, viscous sap oozing from the vascular bundles (left, below).

Armillaria root rot

Armillaria mellea

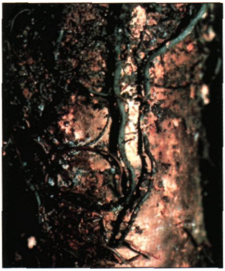
Armillaria root rot affects many woody plants, including grapes. Vineyards planted on old orchard sites or newly cleared forestland may be at risk. Aboveground symptoms are stunted shoots, yellow or red leaves, wilting and premature defoliation. Symptoms are most obvious in late summer, when vines may completely collapse and die. White, feltlike fungal mats occur below the bark near the soil line.

Infected vine with stunted shoots and chlorotic leaves.

Armillaria root rot – *continued*

Infected tissues have a distinct mushroomlike odor when moist. Black, shoestringlike strands (rhizomorphs) may be present on bark and in the soil. In the fall, clumps of golden-brown mushrooms may appear at the base of the vine.

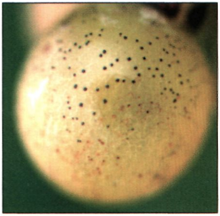
The fungus spreads to neighboring vines via root contact and rhizomorphs, resulting in distinctive clusters of dead vines within the vineyard. Armillaria can survive for years on dead roots and old tree and vine stumps in the soil.



Above, black rhizomorphs. Left, white fungal mat beneath bark at base of trunk.

Flyspeck

Schizothyrium sp.



Flyspeck is characterized by small, black specks on the berries. The specks are caused by a fungus, which grows superficially on the fruit surface. The fungus also infects many cultivated and wild hosts, which serve as a reservoir of inoculum. High relative humidity is conducive to development of this disease.

Crown gall

Agrobacterium vitis

This bacterial disease is particularly damaging to vinifera grapes and interspecific hybrids. The major symptom is fleshy galls on the lower trunk near the soil. Galls may also form up to 3 feet high on trunks and canes and on below-ground plant parts.

Crown gall – *continued*

Initially, galls are cream-colored and fleshy, but later they turn brown and woody. Affected vines appear weak and portions of the vines above the galls may die. They may also be more prone to freeze injury. Young vines may be girdled by galls in one season. The crown gall bacterium lives in the soil and enters the plants through wounds caused by freeze injury, mechanical damage, grafting or insect damage. Crown gall may be confused with natural callus growth at graft unions.

Above left, early crown gall growth on wood. Above right, old galls look woody and fissured.

Pierce's disease

Xylella fastidiosa

Leaves have dropped off, leaving the petiole.

This disease occurs primarily in the southeastern United States and California. It has not yet been found in the Great Lakes region. Initially, only a few shoots start to show symptoms in mid- to late summer. Leaves show scorching from the margin inwards and drop off, leaving the petiole attached to the shoot. Flower clusters may set berries, but these tend to dry up.

Left, early leaf symptoms.

Right, late leaf symptoms.

Pierce's disease – *continued*

In fall, infected shoots mature in a patchy manner, leaving "islands" of green tissue surrounded by dark brown mature wood. In spring, bud break on infected vines may be delayed as much as two weeks, and new shoots are stunted. An infected vine may die the first year after infection or may live for five or more years, depending on the cultivar, the vine's age and climatic conditions. Pierce's disease is caused by a bacterium that lives in the xylem and is vectored by sharpshooter leafhoppers and spittlebugs. The bacterium is present in native plants such as grasses, sedges, bushes and trees. The range of the competent insect vectors determines the range of the disease.

Dead and dying vines because of Pierce's disease.

Tomato/Tobacco ringspot virus decline

Tomato ringspot virus, tobacco ringspot virus

These viruses occur sporadically in vinifera grapes and interspecific hybrids. Labrusca grapes are resistant. In the first year of infection, a few leaves may show mottling. The second year, new growth is generally sparse because infected buds are prone to winterkill. Infected vines show shortened internodes with small, distorted leaves and sparse fruit clusters with uneven ripening. The third year, growth is very stunted and limited to basal suckers, and the vine eventually dies. Dead and dying vines are usually present in a roughly circular pattern in the vineyard. The viruses are

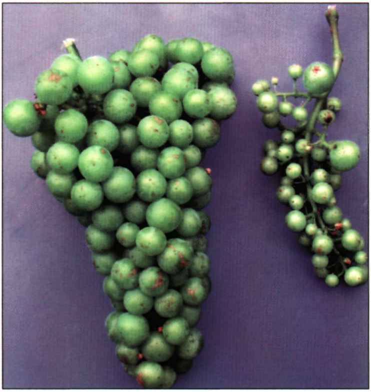
Left, stunted shoots on infected vine. Above, symptoms on a Riesling leaf.

Tomato/tobacco ringspot virus – *continued*

introduced into vineyards with infected planting stock or by dispersal of seed from infected weeds. The virus is then spread by dagger nematodes feeding on roots of infected plants. The nematodes can retain the virus for long periods.

Ringlike lesion on leaf

Both viruses infect common weeds such as dandelion, sheep sorrel, common chickweed and red clover. Tomato ringspot virus also infects many fruit crops. These viruses may already be present in land used to establish new vineyards.



Clusters from healthy (left) and declining (right) Chardonnay.

Peach rosette mosaic virus decline

Peach rosette mosaic virus

This virus occurs only in Concord and Catawba grapes in Michigan. Symptoms appear three to four years after infection. The growth pattern is umbrellalike with shortened and crooked internodes. Leaves are misshapen with a flattened base. Clusters are scraggly and may shell berries. Infected vines lack vigor, are prone to winter injury and may die after several years. The virus is spread by nematodes, infected planting stock and in grape pomace. The virus also infects peaches and perennial weeds such as dandelion, Carolina horse nettle and curly dock. Boron deficiency and fanleaf degeneration may mimic this disease.

Dead and dying vines in a slowly spreading, circular pattern, and an infected shoot (left), compared with a healthy shoot (right).

Fanleaf degeneration

Grapevine fanleaf virus

Fanleaf degeneration affects vinifera cultivars. It is characterized by fan-shaped leaves with toothed margins, proliferation of shoots, short internodes and zigzag growth. Foliar symptoms appear early in spring and persist throughout the growing season. Sometimes leaves show a bright yellow mosaic or yellow vein banding with little or no malformation. Fruit clusters are small with poor fruit set, irregular ripening and shot berries. The causal virus is spread by dagger nematodes and planting material. The virus is not transmitted through seeds and has no natural weed hosts. Roots from infected vines can be a source of infection even after the mother plant has been removed.

Leaf with fanleaf symptoms (left) compared with a healthy leaf (right).

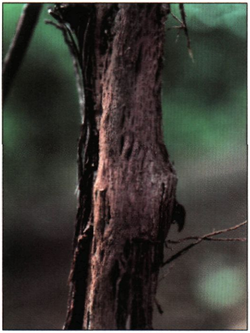
Leafroll
Leafroll virus

Left, infected Chardonnay leaf. Right, healthy leaf.

Leafroll virus is found in most grape-growing areas. Symptoms are most obvious in fall. Infected vines are slightly smaller than healthy vines. Leaves become yellow or reddish purple as the season progresses; the main veins remain green. By late summer, the leaves start rolling downward, beginning at the base of the shoot. At harvest, fruit clusters are small, poorly colored and low in sugar. The disease does not kill the vine but will remain chronic. Not all infected vines show symptoms. The leafroll virus spreads primarily via infected nursery stock and the grape mealybug. Within-field spread by mealybug is very slow.

Rupestris stem pitting
Rupestris stem pitting virus

Rupestris stem pitting virus causes a slow decline of vinifera cultivars and interspecific hybrids. Tests have shown that the disease is widespread in French-American hybrids in commercial vineyards in the northeastern United States and Canada. The main symptoms are delayed bud break, poor spring growth, stunting of infected plants and a decline in yield. No leaf discoloration is observed. When the bark is peeled off the trunk, the wood may reveal the presence of small pits. This virus mainly spreads via planting material.



Flavescence dorée

Grapevine flavescence dorée phytoplasma

Black pustules in rows

Flavescence dorée infects only vinifera grapes and interspecific hybrids. Labrusca cultivars are resistant. Symptoms usually appear the year after infection and either get progressively worse until the vine dies or disappear in an apparent recovery. Symptoms include delayed or no bud break and progressively shortened internodes. In summer, vines take on a weeping posture and shoots become rubbery and fail to lignify. Characteristic black pustules may be seen in longitudinal rows near the bases of shoots. The leaves have golden yellow or reddish patches and curl downward. Growing points become necrotic, and flowers and fruit clusters shrivel up and fall. The pathogen overwinters in infected canes and is spread by a leafhopper. Symptoms may resemble those of certain virus diseases or potato leafhopper damage.

Nematodes

Root knot, dagger and lesion nematodes

Left, roots with black discoloration caused by dagger nematode. Right, healthy roots.

Plant-parasitic nematodes are microscopic roundworms that live in soil and feed on plant roots. Aboveground symptoms are poor growth, low yields and an "off" color. The symptoms may resemble those of nutrient deficiencies or virus diseases. Belowground symptoms include poor root development, root browning, root swelling and stunting or death of feeder roots. In new vineyards, nematodes may cause poor establishment and weak growth of young vines. Nematodes seldom kill vines but contribute to a steady decline in vigor. Some nematodes are also vectors of viruses. Nematodes spread with soil and plant roots. Once established in a vineyard, nematode infestations tend to be permanent.

Diuron injury

Diuron herbicide injury causes leaf veins to appear yellow to cream-colored. Severe cases can cause stunting of vines. This injury is often associated with light soils or areas where soil has eroded so that the vine roots are near the soil surface. Vines may need more than one year to outgrow this injury.

Leaves showing the typical yellow veinal pattern of diuron herbicide injury.

Chemical injury

Simazine injury

Injury from this herbicide appears as yellowing in the leaves between veins that remain green. In more advanced stages, portions or the entire leaf becomes brown. As with diuron, simazine injury tends to occur on light soils and sites where erosion has exposed roots near the soil surface.

Simazine herbicide injury showing the characteristic yellowing between green veins. As the injury becomes more severe, leaves become lighter, eventually becoming brown and falling from the vine.

Chemical injury

Glyphosate injury

Glyphosate (Roundup®) injury to grapevines has several characteristics. Young shoots injured early in the growing season will produce misshapen, stunted leaves from the point where the herbicide contacted the leaf to the end of the shoot. Leaves are roughly triangular and crinkled with cuplike depressions.

A single node of a grape shoot injured by glyphosate showing a primary leaf and two lateral shoots that undergo branching to produce an array of stunted, crinkled, somewhat triangular leaves.

Glyphosate injury – *continued*

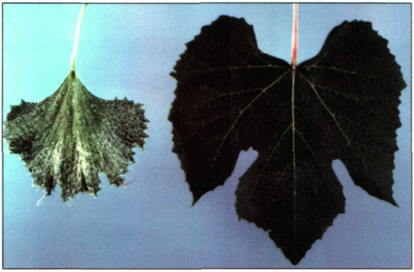
Injury late in the growing season may stop shoot growth and result in off-green leaves. Late-season injury will be carried over to the next year. Multiple severely stunted shoots will emerge from nodes. This stunted growth will continue throughout the growing season or until the vine dies, presumably from lack of functional leaf area.

Glyphosate-injured grapevines a year after application. Multiple stunted shoots may arise from each node with highly crinkled, somewhat triangular leaves.

Chemical injury

Phenoxy herbicide injury

Grapevines are injured by 2,4-D and related phenoxy compounds at concentrations in parts per billion. Herbicide applications that drift from field crops such as corn and wheat are the most common sources. Aerial applications to field crops have injured grapevines several miles from the point of application. More often, ground application in an adjacent field or the use of so-called "weed and feed" products for lawn care adjacent to a vineyard are the sources of injury. Young leaves at the tips of shoots become smaller than usual. They are irregularly shaped, often fan-shaped, and crystalline in texture.



A normal leaf (right) and a 2,4-D-injured Concord grape leaf (left) showing the difference in size and the fanlike shape that occurs with this injury.

Chemical injury

Paraquat injury

Injury from the contact herbicide paraquat (Gramoxone Extra®) typically appears as rusty-orange spots or irregular-shaped blotches on leaves (see photo). At times this injury may look similar to black rot infections on leaves, but paraquat injury lacks the dark pycnidia (fruiting bodies) and the cream-colored center that occurs with black rot. This injury typically results from spray drift, so the damage is most severe on leaves near the ground.

Chemical injury

Pesticide spray injury

Pesticide sprays can cause brown spots on leaf tissues and fruit (see also Copper Injury). Injury may be caused by a known incompatibility between a specific variety and a particular pesticide (e.g., sulfur injury on several grape varieties). An unknown incompatibility may result from the variety being sprayed, the specific mix of pesticides, the equipment being used or the weather conditions during spraying. This injury typically occurs on the youngest leaves at the end of shoots and often

Pesticide spray injury on a young, emerging leaf at the end of a shoot. The injured leaf will continue to develop at an uneven rate, becoming crinkled and misshapen.

Pesticide spray injury – *continued*

goes undetected until several days after the application. By that time, several new leaves may have emerged at the shoot tips so that the injury has a pattern of healthy leaves at the shoot tip with injured leaves farther back on the shoot.

Some sprays such as sulfur (injury shown above) may cause extensive browning of mature leaves.

Chemical injury

Copper injury

Copper-based fungicides may cause a slight russeting (browning) to severe foliage burn. The greatest risk of injury is from copper sulfate, especially when used during cool, damp weather. Reduce the risk of copper injury by making applications only to copper-tolerant varieties, using fixed copper compounds, adding spray lime as a safening agent, avoiding use with

Copper injury – *continued*

spray oils and making applications during dry weather.

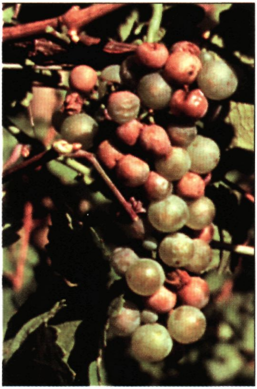
Using copper compounds for disease control is a very old practice. The positive attributes of copper as a fungicide include: (a) it is at least slightly effective for all of the major grape diseases and moderately to highly effective for controlling downy mildew, (b) it is acceptable for organic production, and (c) there is no restriction on days-to-harvest use.

Negative attributes of copper fungicides include: (a) difficulty in using products when combined with spray lime as a safening agent, (b) the risk of severe phytotoxicity under certain conditions and (c) less effectiveness than many other products for controlling most diseases. Grape varieties reported to be especially sensitive to copper phytotoxicity include Aurore, Chancellor, Merlot and Rougeon.

Abiotic vine condition

Sun scald

Sun scald causes grape berry surfaces to become brown and possibly shriveled. These symptoms appear on the portions of the cluster exposed to direct sunlight. This injury often occurs when fruit that has developed in shade is exposed to direct sunlight, such as when leaf removal, summer pruning, shoot positioning or other canopy management practices occur in mid-to late season. Fruit exposed to sunlight for the entire growing season may also develop sun scald when drought conditions develop. Fruit damaged by sun scald may develop various fruit rots and deteriorate further.

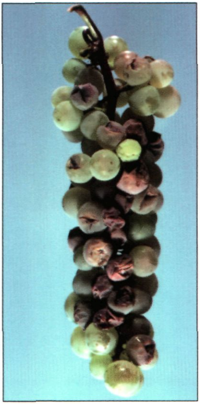


White Riesling grapes near harvest injured by sun scald and subsequently infected with fruit rot.

Abiotic vine condition

Bird damage

Birds damage grapes either by totally removing berries or by pecking the berry surface. The resulting angular punctures often develop into depressions in the berry surface. Look for a pattern of injury on visible clusters, especially next to structures where birds may perch.

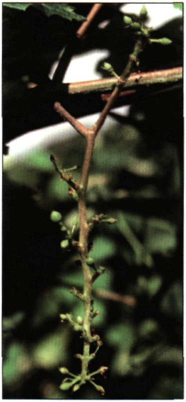


At left, bird damage at harvest on the Leon Millot variety with berries completely missing from some pedicels. At right, the variety Aurore shows bird-pecked areas deteriorating with fruit rot.

Abiotic vine condition

Lack of fruitset

Several factors can cause a lack of fruitset: nutritional deficiencies (see boron, page 103), lack of node fruitfulness caused by weather and vine management in the previous growing season, extremely hot or cool weather during bloom, or winter or spring freeze injury (see pages 91-92). In addition, herbicide injury, nutritional imbalances (see bunch stem necrosis) and diseases, especially botrytis and downy mildew, may have an effect.

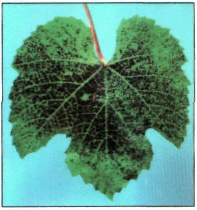


At right, high temperatures during bloom greatly reduced fruitset on this cluster.

Below, a bud cross-section shows the dead primary bud in the middle and live secondary and tertiary buds on the sides. Cross-sections of nodes that have been warmed for at least 48 hours can be used to determine how severely to prune vines in response to winter injury.

Abiotic vine condition

Ozone injury (oxidant stipple)



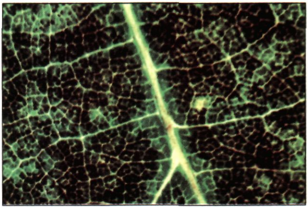
Mild injury on a Catawba grape leaf. The veins of the leaves remain light-colored.

Some grape varieties, including Concord and Chambourcin, are highly susceptible to injury from ozone, which originates from lightning storms or industrial pollution. This injury becomes more severe with increased exposure to ozone. Therefore, the injury is most severe on older, basal leaves and less severe or non-existent on the very youngest leaves (photo above). Injury is concentrated on leaves on the canopy's exposed exterior.

An injured Concord grapevine. Exposed and older leaves are most affected.

Ozone injury – *continued*

Close examination of darkened leaf areas will reveal that the small veins remain light-colored or green.



Abiotic vine condition

Hail damage

Hail damage to grapevines can range from occasional tears in leaf blades to defoliation. Shoots and petioles become scarred. Petioles may remain attached to shoots while leaf blades are shredded from the vine. Damage to berries

Severe early-season hail damage on the Catawba variety showing scarring on the shoots and petioles as well as an emerging lateral shoot, which will be the source of new leaves for the vine.

Hail damage – *continued*

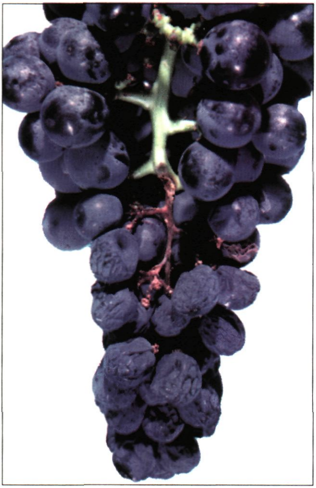
on exposed clusters during light to moderate hail will be associated with torn leaf blades. Severe defoliation from hail during early to midseason will typically cause a new canopy to develop from lateral shoots. Fruit maturity will be greatly retarded after severe defoliation. During early stages of berry development, berries will be scarred or will die without onset of fruit rot. Hail during or after veraison will promote fruit rot.

Hail damage showing tears in leaves and scarring of shoots as well as damaged berries. This late-season injury resulted in deterioration of damaged berries by fruit rot.

Abiotic vine condition

Bunch stem necrosis

Bunch stem necrosis can occur around bloom (when it is called early bunch stem necrosis) or at veraison or later. No pathogens are believed to cause this condition. Instead, certain weather conditions and vine nutrition seem to be associated with its occurrence. Low temperatures and high humidity around bloom or excessive rainfall after veraison may be related to its development. Imbalances between calcium and potassium as well as low levels of nitrogen in vines are other possible causes. Unaffected portions of clusters develop normal fruit quality.

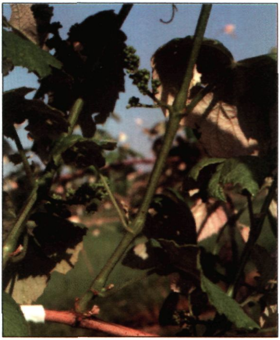


Abiotic vine condition

Spring freeze injury

A spring freeze causes grapevine leaves and shoots to shrivel and turn brown (Right, similar damage from fall frost). Symptoms appear within a few hours of the episode. Typically shoots will emerge from secondary and tertiary buds over the next three weeks.

Above, leaf damaged by fall frost. Below, a dead, shriveled primary shoot beside an emerging secondary shoot.



At left, a fruitful secondary shoot.

The long-term vine health is rarely jeopardized. Severe injury reduces yield. Shoots from secondary buds may produce significant crop.

Abiotic vine condition

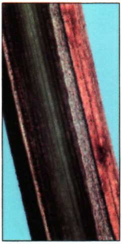
Winter injury

To assess the kill of dormant fruiting buds from low winter temperatures, gather 10 canes of the same quality that would be retained during pruning. Store them at room temperature for a minimum of 48 hours, then make cross-sections of fruiting nodes. Systematically evaluate damage to buds and alter pruning practices accordingly. Healthy cambium tissues are green; injured cambium tissues immediately below the bark or older wood become brownish. Even when these tissues appear completely dark brown, they may be viable and worth saving to maintain balanced growth.

A cross-section with dead primary bud in the middle and live secondary and tertiary buds on the sides.

Healthy tissue

Injured tissue



Winter injury – *continued*

Portions of severely winter-injured vines may begin to grow and then collapse around the time of bloom or shortly thereafter.

Winter injury as it appeared in early July on the Baco Noir variety. Shoot growth may begin on injured vines because of the mechanical uptake of water and nutrients. Shoots then collapse early in their development because woody portions of the vine lack live cambium tissue.

Abiotic vine condition

Chimera

A chimera is a portion of a plant that has undergone genetic alteration so that it appears different from the rest of the plant. One type of chimera is a change in the color of leaf tissue.

Abiotic vine condition

Guttation

This physiological vine condition may occur on spring mornings when grapevine shoots are young. If vineyard soils are saturated with water and high humidity and calm weather minimize evaporation from leaf surfaces, a positive pressure of sap in vines can cause water droplets to form on the tips of serrations on the edge of the leaf. When that water evaporates, it may leave salt deposits on the leaf margins. Guttation is not harmful to the vine.

Salt accumulation from guttation on the margin of a DeChaunac grape leaf in early June.

Abiotic vine condition

Pearl bodies

Pearl bodies are enlarged cells on the surface layer of grapevine cells. They are often mistaken for the insect eggs and cause no harm to the vine.

Abiotic vine condition

Lightning

Lightning can cause sudden browning and death to portions of vines, portions of rows or entire rows of grapevines. Watch for several affected vines within a particular row, possibly in conjunction with severely damaged trellis posts.

Abiotic vine condition

Sour soil (Säureschäden)

When varieties of *Vitis vinifera* L. are grown on highly acidic soils (pH of 4.5 or less), the margins of basal leaves may become yellow and then speckled with brown areas. The low soil pH level associated with these symptoms results in low levels of calcium, magnesium and phosphorus in vines and high levels of potassium, aluminum and manganese. This condition may cause poor fruit and shoot maturity.

Säureschäden on the basal leaves of White Riesling vines.

Nutrient deficiency

Manganese deficiency

Manganese deficiency occurs frequently in grapevines but seldom causes economic harm. Symptoms occur on basal, often shaded leaves. The yellowing pattern between the veins occurs as “islands” of yellow areas rather than a continuous discoloration of the leaf. The leaves maintain a normal size and shape.

Manganese deficiency showing the characteristic “islanding” pattern. This symptom often occurs on basal shaded leaves.

Nitrogen deficiency

A deficiency of nitrogen is associated with low vine vigor. Symptoms of low levels in vines include light green (chlorotic) leaves and reduced shoot growth.

At left, a light-colored, nitrogen-deficient leaf among normal leaves. Above, Niagara vines managed with nitrogen and, at left, without nitrogen fertilization. These vines were at the start of their second growing season.

Nitrogen deficiency – *continued*

Petiole analysis, based on either total nitrogen or nitrate nitrogen, can be used to confirm either very high or very low nitrogen levels in grapevines.

Niagara vines with (above) and without (below) nitrogen fertilization. Nitrogen-deficient vines are smaller and have shorter shoots and smaller, light green leaves. These vines were in their fourth growing season.

Potassium deficiency

Potassium is important for grapevines to function and is one of the most frequent nutritional deficiencies of vines. A grapevine with inadequate potassium produces poor, unevenly ripened fruit and reduced yields. Severe deficiency results in defoliation. Leaves in the mid- to basal portions of shoots are affected. Clusters of deficient vines tend to be small with a few unevenly ripened berries. Shatter of berries occurs in extreme cases. The relationship between another reported symptom, "black leaf," and potassium deficiency is in doubt. Leaf petiole testing can reliably confirm potassium deficiency.

Leaf symptoms may begin in mid-June. Leaf margins turn yellow (above) and progress so that leaf margins become brown (below) and the tissue around the veins blackens.

Nutrient deficiency

Magnesium deficiency

Early symptoms: green leaf margins with yellow between the veins.

A deficiency of magnesium appears first on the basal leaves of shoots as a yellowing between the veins. Some of the affected leaves will maintain a halo of green on their margins, which confirms this nutritional deficiency. Symptoms progress to dead blotches on the leaves, which may be a rusty-red. These symptoms are often associated with high levels of potassium (possibly from fertilization) in acid soils. Applying dolomitic lime and/or magnesium foliar sprays may be a remedy. Leaf petiole analysis can confirm this deficiency.

Advanced stage: yellow between the veins interspersed with brown or often rust-colored areas.

Nutrient deficiency

Boron deficiency

A yellowing, cupped leaf.

Boron deficiency dramatically influences yield. Leaves toward the end of the shoot show a spotty yellowing. Affected leaves tend to be undersized and cupped. Affected clusters may totally abort or develop a few small berries, often with many small, green "shot" berries. This condition results because ovules on affected flowers are poorly fertilized.

Petiole tests can confirm this deficiency. Soil or foliar boron applications may correct the deficiency. Excess boron fertilization may result in toxicity to vines.

An affected cluster with lack of fruit-set and green shot berries.

Nutrient deficiency

Iron deficiency

Iron deficiency occurs occasionally on grapevines but seldom has economic impact. Affected vines have young, very light yellow leaves near shoot tips that may appear almost white (see photos). Extremely fast-growing shoots may exhibit this symptom. Some varieties are especially vulnerable to this deficiency when grown on highly alkaline soil.

Pocket guide index

Insect and mite pests

Natural enemies

Diseases

Physiological/chemical disorders

Vineyard Scouting Calendar (continues on next page)

Vine growth stage	Bud swell	1-5" shoot	8-12" shoot	Pre-bloom	Bloom	Pea-sized
Insects						
Cutworm	+	+				
Rose chafer				+	+	+
Grp berry moth				+	+	+
Grape leafhppr				+	+	
Potato leafhppr			+	+	+	
Japanese btl						
Diseases						
Phomopsis		+	+	+	+	+
Black rot		+	+	+	+	+
Downy mldw			+	+	+	+
Powdry mldw		+	+	+	+	+
Botrytis bnch rot					+	

Usual time for monitoring and control.
Lesser risk, but monitoring and control may still be required.

+ Potential period of insect activity or disease infection risk

Vineyard Scouting Calendar (continued from previous page)

Vine growth stage	Berry touch	Bunch closing	Veraison	Pre-harvest	Harvest	Post-harvest
Insects						
Cutworm						
Rose chafer						
Grp berry moth	+	+	+	+	+	+
Grape leafhppr	+	+	+	+	+	
Potato leafhppr	+	+	+			
Japanese btl		+	+	+		
Diseases						
Phomopsis	+	+	+	+	+	
Black rot	+	+	+			
Downy mldw	+	+	+	+	+	+
Powdry mldw	+	+	+	+	+	+
Botrytis bnch rot		+	+	+	+	

Usual time for monitoring and control.

Lesser risk, but monitoring and control may still be required.

+ Potential period of insect activity or disease infection risk

4

3

2

1

0 inches

0 mm 10 20 30 40 50 60 70

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