Organic Small Fruit Disease Management Guidelines

Integrated Management of Grape Diseases

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Introduction

Disease management strategies are very similar for both organic and conventional small fruit production systems in the Midwest. In both systems it is important to develop and use an integrated disease management program that integrates as many disease control methods as possible, the more the better. Major components of the disease management program include: **use of specific cultural practices; developing knowledge of the pathogen and disease biology, use of disease resistant cultivars, and timely application of organically approved fungicides or biological control agents or products when needed.** These guidelines have been written for caneberries (raspberry and blackberry), strawberry, blueberry and grape. Specific information is provided for each crop in its respective chapter. Most disease control methods or strategies are identical for both conventional and organic production systems. Perhaps the greatest difference between organic and conventional production systems is that organic growers are not permitted to use synthetic "conventional" fungicides. If disease control materials are required in the organic system, growers are limited to the use of "inorganic" fungicides such as sulfur (elemental sulfur and lime-sulfur) or copper fungicides (Bordeaux mixture and fixed copper products). In addition, there are several new "alternative" disease control materials and biological control products that are currently available and are cleared for use in organic production.

There are several problems associated with the use of these inorganic fungicides and "alternative" products in small fruit disease control programs. Among the most important are 1) **Phytoxicity**, which is the potential to cause damage to foliage, fruit set and fruit finish (this is a concern primarily with copper and sulfur fungicides); and 2) **their limited spectrum of fungicide activity**, which means they may not be capable of providing simultaneous control of the wide range of fungal pathogens that can cause economic damage to the crop. For example, sulfur is highly effective for controlling powdery mildew on most fruit crops, but provides little or no control of most other diseases.

In a climate like the Midwest, environmental conditions during the growing season are generally very conducive (warm and wet) to the development of several important diseases, insect pests and weeds. Limitations in relation to which pesticides may or may not be used, present the organic grower with some unique and very demanding challenges. Whereas the use of various cultural practices and disease resistance will be the "back bone" of the organic disease management program, the limited use of organically approved pesticides or biocontrol agents will probably be required at times.

Integrated Management of Grape Diseases

Developing a disease management program that successfully controls all of the important grape diseases simultaneously presents a unique challenge. In order to accomplish this, all available control methods must be ***integrated*** into one overall disease management program. The disease management program should emphasize the integrated use of disease resistance, various cultural practices, a knowledge of disease biology, and the use of organically approved fungicides or biological control agents or products when necessary.

Identifying and Understanding the Major Grape Diseases

It is important for growers to be able to recognize the major grape diseases. Proper disease identification is critical to making the correct disease management decisions. In addition, growers should develop a basic understanding of pathogen biology and disease cycles for the major grape diseases. The more one knows about the disease, the better equipped they are to make sound and effective management decisions. The following publications contain color photographs of disease symptoms on grapes, as well as in-depth information on pathogen biology and disease development.

Compendium of Grape Diseases - Published by the American Phytopathological Society, 3340 Pilot Knob Rd., St. Paul, MN 55121. Phone: 612-454-7250 (1-800-328-7560). This is the most comprehensive book on grape diseases available. All commercial growers should have a copy.

Grapes: Production, Management and Marketing - Bulletin 815 from Ohio State University Extension can be obtained from: Ohio State University Extension Publications, 2120 Fyffe Rd., Columbus, OH 43210. Phone 614-292-1607.

The following information gives a description of symptoms and causal organisms for the most common grape diseases in the Midwest.

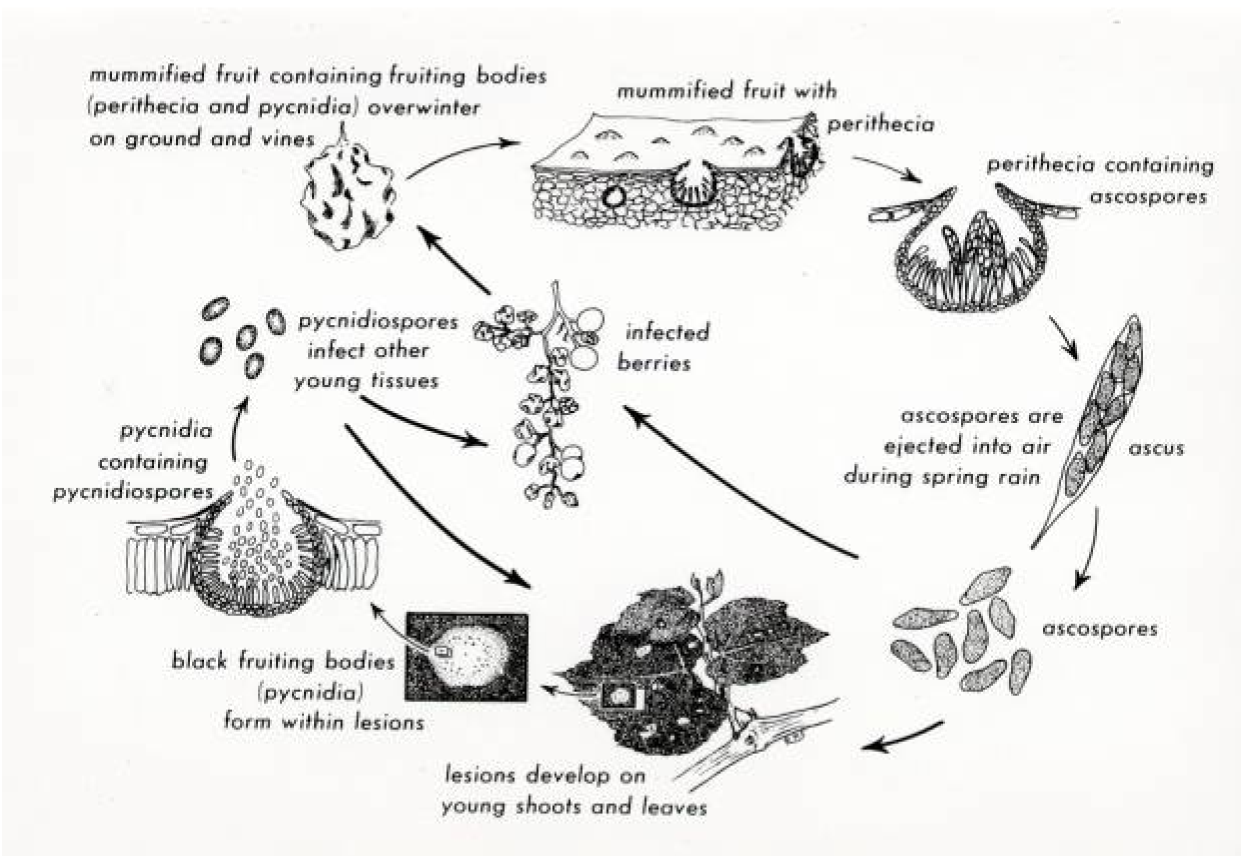
Identifying and Understanding the Major Grape Diseases

Black Rot

The causal fungus (*Guignardia bidwellii*) overwinters in mummified fruit on the vine or on the ground. Spring rains trigger the release of airborne ascospores and/or rain splashed conidia from the mummies. Primary infections occur on green tissues if temperatures and duration of leaf wetness are conducive (Table 5). Recent research indicates that the majority of ascospores from mummies on the ground are discharged within a time period from one inch shoot growth to 2 to 3 weeks after bloom. If mummies are allowed to hang on the vines, they can discharge ascospores and conidia throughout the growing season.

Black Rot Disease Cycle (Figure 58)

Figure 58: Black rot disease cycle. We wish to thank the New York State Agriculture Experiment Station for use of this figure. Figure taken from Grape IPM Disease Identification Sheet No. 4.



In conventional production systems, black rot is controlled primarily through the use of effective fungicides combined with various cultural practices. Black rot may be particularly important in organic production systems because the organically approved fungicides (copper and sulfur) are not very effective for black rot control. Therefore, growers should develop a thorough understanding of the black rot disease cycle and the cultural practices used to control it.

Lesions on canes from the previous season can also produce conidia for a period of at least one month starting at budbreak. Cane lesions are probably most important in mechanically pruned or hedged vineyards that have an abundance of canes in the canopy. All green tissues of the vine are susceptible to infection. Leaves are susceptible for about one week after they reach full size. Brown circular lesions develop on infected leaves about 9 to 11 days after infection (Figure 59). Within a few days, black spherical fruiting bodies (pycnidia) form within the lesions (Figure 60). Each one of these pycnidia can produce a second type of spore (conidia). These conidia are spread by rain splash and can cause secondary infections of leaves and fruit throughout the growing season. It is important to emphasize that a single ascospore can cause a primary infection (leaf lesion). Within each leaf lesion (primary infection), many pycnidia form. Each pycnidium can produce hundreds of thousands of conidia, each of which can cause another infection (secondary infection) later in the season. Therefore, it is extremely important to control the early season primary infections caused by ascospores. Remember, infection by one ascospore can result in the development of millions of secondary conidia in the vineyard.

Figure 59: Black rot lesions on grape leaf.

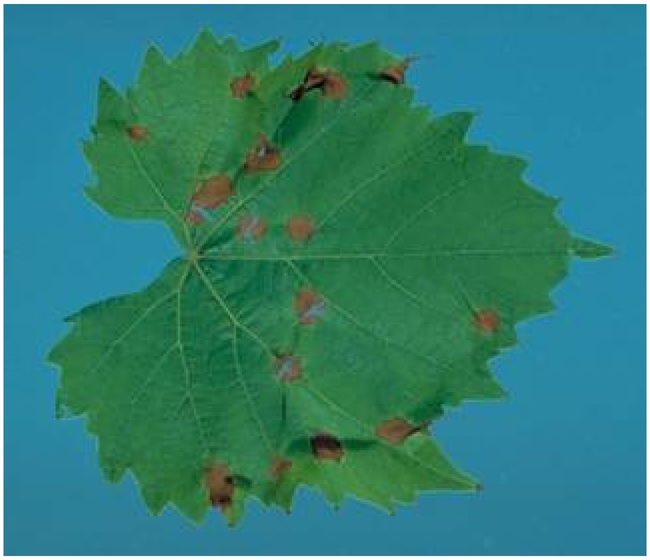


Figure 60: Close-up of black rot leaf lesion showing fungal fruit bodies (pycnidia).

Figure 61: Black rot on berries.

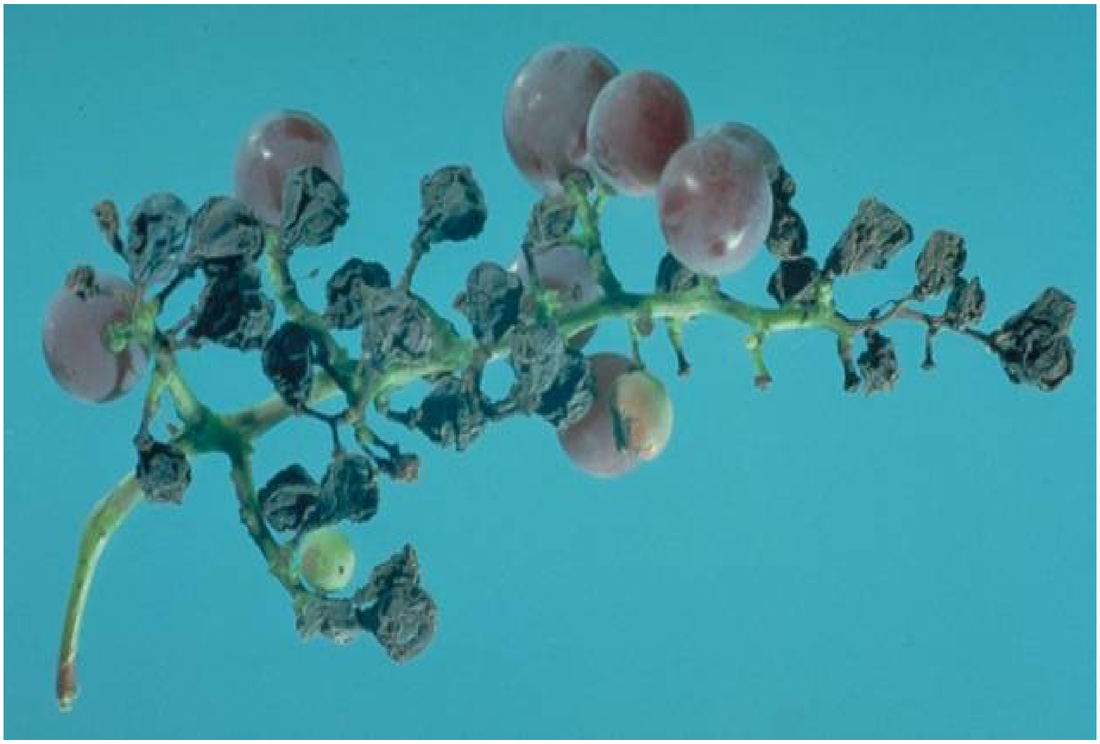
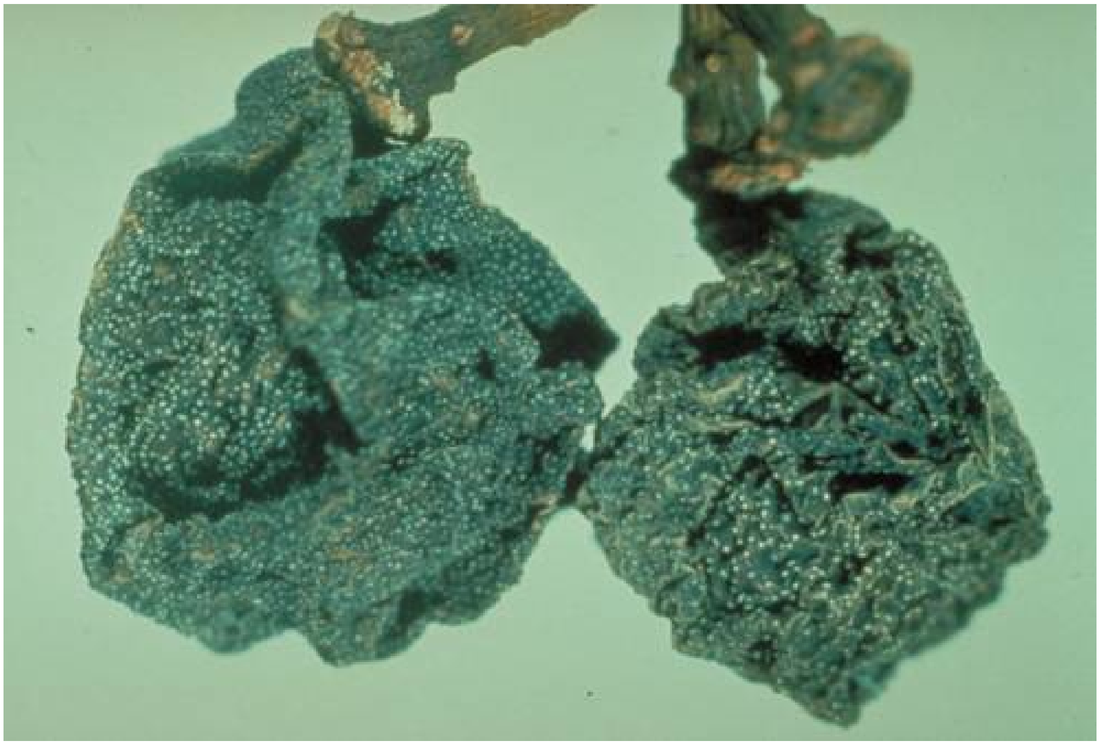


Figure 62: Close-up of black rot mummy.



The fruit infection phase of the disease can result in serious economic loss. Berries are susceptible to the infection from bloom until shortly after bloom. Older literature reports that berries become resistant when they reach 5 to 8 percent sugar. Recent research in New York indicates that berries become resistant to black rot much earlier (2 to 3 weeks after bloom). Therefore, the most critical time to control black rot fruit infections with fungicide is from immediately prior to bloom through 2 to 4 weeks after bloom. An infected berry first appears light brown in color. Soon the entire berry turns dark brown, and then black pycnidia develop on its surface. Infected berries eventually turn into shriveled, hard, black mummies (Figure 61, 62). These mummies also serve as a source of secondary inoculum later in the growing season and are the primary means by which the fungus overwinters.

Table 5. Grape Black Rot. Leaf wetness duration-temperature combinations necessary for grape foliar infection by black rot.

Temperature °F and minimum leaf wetness duration (hr) for light infection	
Temperature	Leaf wetness duration
50	24
55	12
60	9
65	8
70	7
75	7
80	6
85	9
90	12

*Data represent a compilation from several experiments with the cultivars Concord, Catawba, Aurora and Baco noir.

The bottom line for black rot control

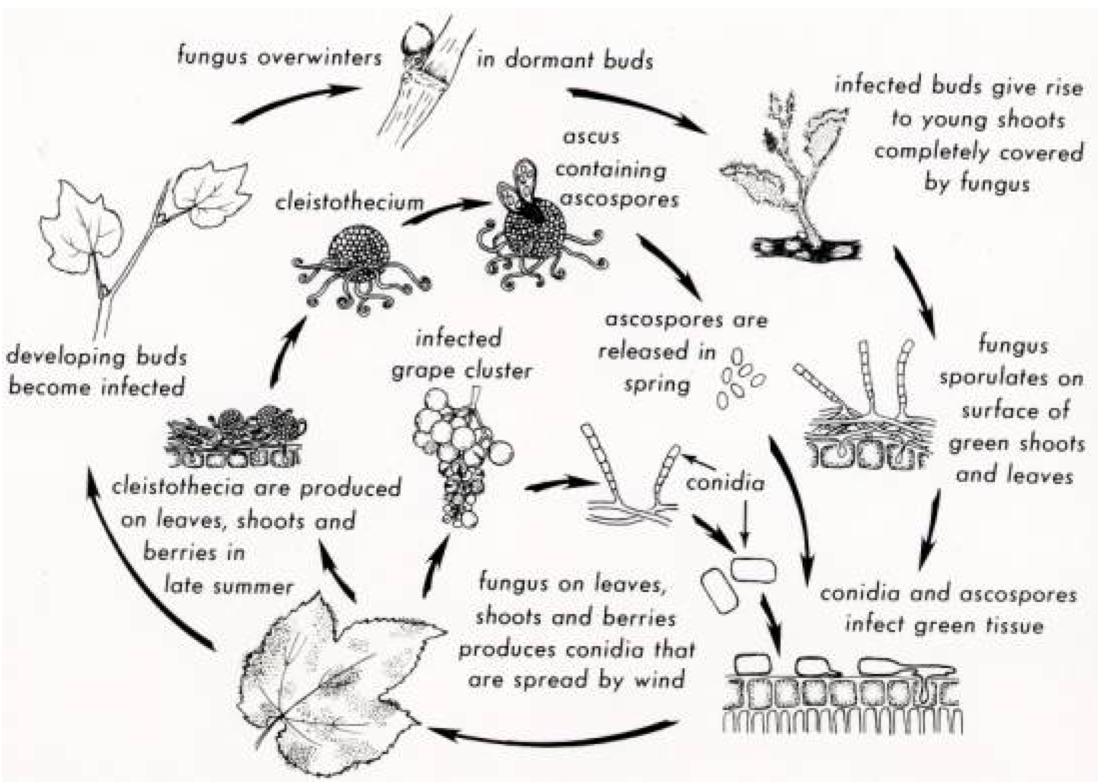
Sanitation is critical to successful black rot control. Mummies are the most important overwintering source of the black rot fungus. If all mummies and infected canes are removed from the vineyard, there is no source of primary inoculum in the spring and, thus, the disease is controlled. Any practice that removes mummies and other infected material from the vineyard will be beneficial to the disease management program. If all mummies cannot be removed from the vineyard, it is extremely important that they are not left hanging in the trellis. As mentioned previously, mummies on the ground appear to discharge their ascospores early in the season, while those hanging in the trellis may discharge ascospores and conidia throughout the growing season. Sulfur is not effective for black rot control. Copper fungicides are not highly effective, but will provide some level of control. The most critical period to control black rot with fungicide is from immediate prebloom through 2 to 4 weeks after bloom.

Powdery Mildew

Powdery mildew is an important fungal disease of grapes. If not controlled on susceptible cultivars, the disease can reduce vine growth, yield, quality, and winter hardiness. Cultivars of Vitis vinifera and its hybrids (French hybrids) are generally much more susceptible to powdery mildew than are native American varieties such as "Concord"(Table 6). On susceptible cultivars, the use of fungicides (primarily sulfur) to control powdery mildew is an important part of the disease management program. Failure to provide adequate control of powdery mildew early in the growing season can result in increased levels of other fruit rots such as Botrytis bunch rot and sour rot.

Powdery Mildew Disease Cycle (Figure 63)

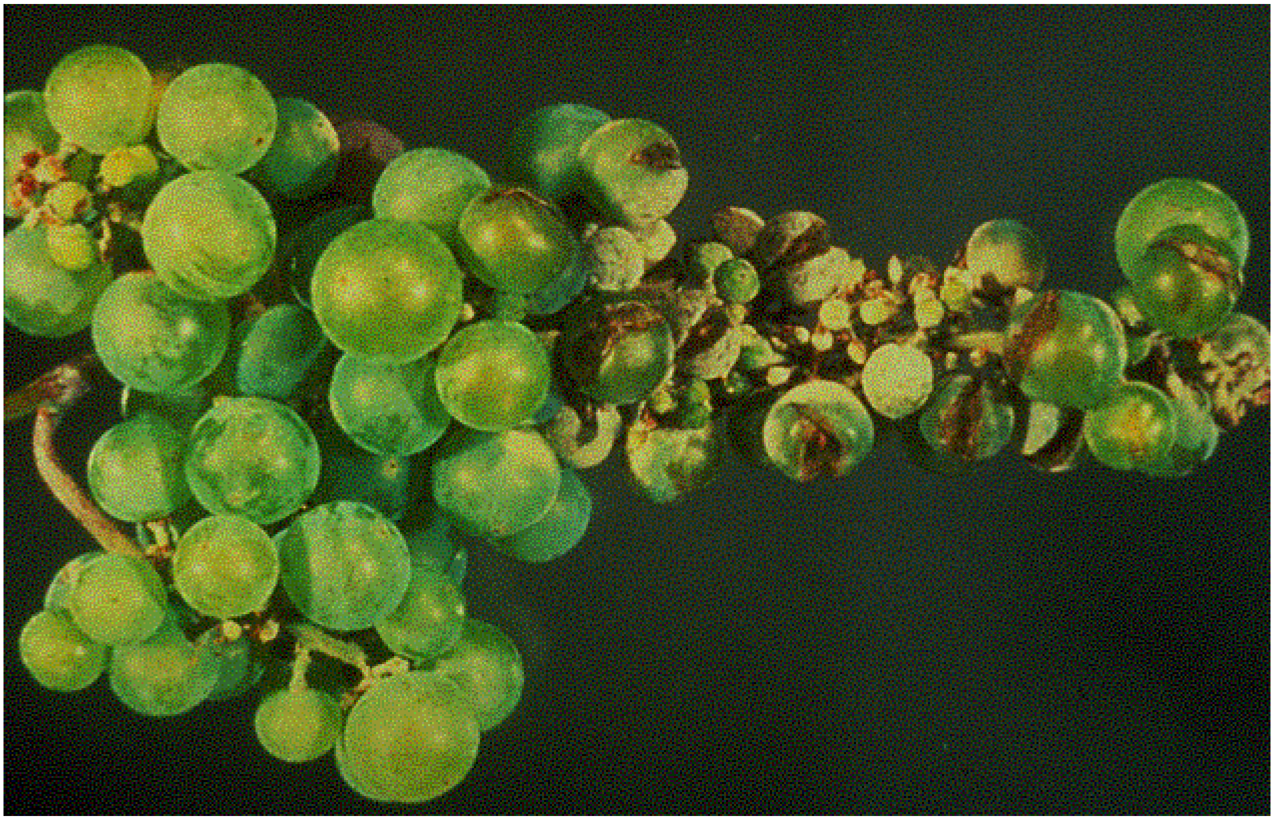
Figure 63: Powdery mildew disease cycle. We wish to thank the New York State Agriculture Experiment Station for use of this figure. Figure taken from Grape IPM Diseases Identification Sheet No.2



The fungus can infect all green tissues of the grapevine. Disease loses due to fruit infection can be severe (Figure 64). It was previously thought that the fungus overwintered inside dormant buds of the grapevine. Research in New York has shown that almost all overwintering inoculum comes from cleistothecia, which are fungal fruiting bodies that overwinter primarily in bark crevices on the grapevine. In the spring, airborne spores (ascospores) released from the cleistothecia are the primary inoculum for

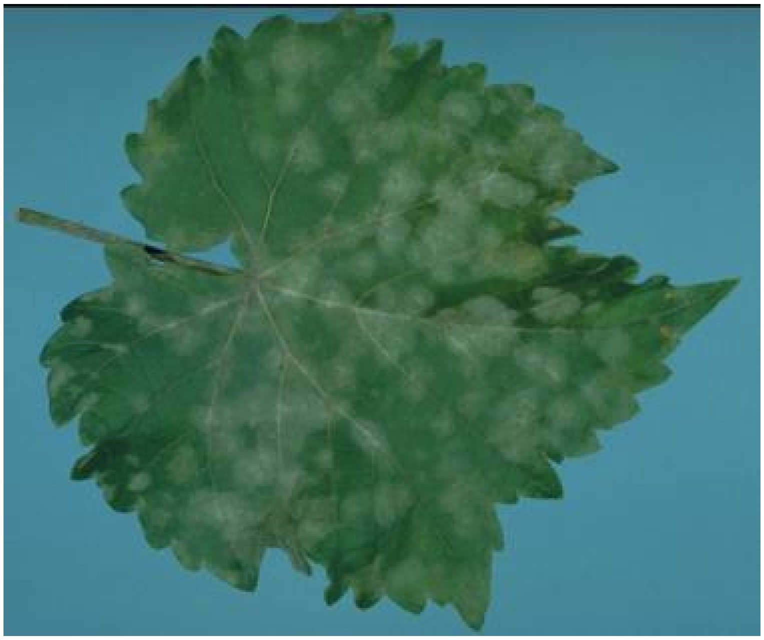
powdery mildew infections.
NOTE: Ascospore discharge from cleistothecia is initiated if 0.10 inch of rain occurs at an average temperature of 50 ° F. Most mature ascospores are discharged within 4 to 8 hours. It is important to remember that these conditions can occur very early in the growing season. Thus, on highly susceptible cultivars, control needs to be initiated early in the growing season.

Figure 64: Powdery mildew on grape berries.



Ascospores are carried by wind. They germinate on any green surface on the developing vine, and enter the plant resulting in primary infections (Figure 63). The fungus grows and another type of spore (conidia) is formed over the infected area after 6 to 8 days. The conidia and fungal mycelia give a powdery or dusty appearance to infected plant parts (Figure 65 and 66). The conidia serve as "Secondary inoculum" for new infections throughout the remainder of the growing season. It is important to note that a primary infection caused by one ascospore will result in the production of hundreds of thousands of conidia, each of which is capable of causing secondary infections. Therefore, early season control of primary infections caused by ascospores is necessary. If primary infections are controlled until all the ascospores have been discharged, the amount of inoculum available for causing late season (secondary) infections is greatly reduced.

Figure 65: Powdery mildew primary infections on grape leaf.



(Figure 66) Powdery mildew covering grape leaf surface.

Most economic losses from powdery mildew result from fruit infection. Research in New York has shown that berries are susceptible to infection from bloom through a few weeks after bloom. Berries of Concord grapes are quite resistant within 2 to 3 weeks after bloom. Therefore, the most critical time to control fruit infection with fungicide is from immediately prior to bloom through 2 to 4 weeks after bloom. Even though the berries become resistant with age, cluster stems (rachis) and leaves remain susceptible throughout the season. Therefore, a full season fungicide program is generally required for powdery mildew control on susceptible varieties.

Conditions that favor disease development

Although infection can occur at temperatures from 59° to 90°F, temperatures of 68° to 77°F are optimal for infection and disease development. Temperatures above 95°F inhibit germination of conidia and above 104°F they are killed. High relative humidity is conducive to production of conidia. Atmospheric moisture in the 40 to 100% relative humidity range is sufficient for germination of conidia and infection. Free moisture, especially rainfall, is detrimental to the survival of conidia. This is in contrast to most other grape pathogens, such as black rot and downy mildew, that require free water on the plant surface before the spores can germinate and infect. Low, diffuse light seems to favor powdery mildew development. Under optimal conditions, the time from infection to production of conidia is only about 7 days.

It is important to remember that powdery mildew can be a serious problem during growing seasons when it is too dry for most other diseases, such as black rot or downy mildew, to develop. Thick canopies that retain high levels of relative humidity are highly conducive to infections in the center of the row canopy.

Cleistothecia are formed on the surface of infected plant parts in late fall. Many of them are washed into bark crevices on the vine trunk where they overwinter to initiate primary infections during the next growing season.

Phomopsis Cane and Leaf Spot

For many years, the Eastern grape industry recognized a disease called "Dead-arm" which was thought to be caused by the fungus *Phomopsis viticola*. In 1976, researchers demonstrated that the dead-arm disease was actually two different diseases that often occur simultaneously. Phomopsis cane and leaf spot (caused by the fungus Phomopsis viticola) is the new name for the cane and leaf-spotting phase of what was once known as "Dead-arm" Eutypa dieback (caused by the fungus Eutypa lata) is the new name for the canker-and shoot-dieback phase of what was also once known as "Dead-arm" The name "Dead-arm" has been dropped. Growers should remember that Phomopsis cane and leaf spot and Eutypa dieback are distinctly different diseases and their control recommendations vary greatly.

Disease incidence of Phomopsis cane and leaf spot appears to be increasing in many vineyards throughout the Midwest. Crop losses up to 30% have been reported in some Ohio vineyards in growing seasons with weather conducive to disease development. The most commonly observed symptoms are on shoots where infections give rise to black elliptical lesions that are most numerous on the first 3-4 basal internodes. Although this phase of the disease can appear quite severe, crop loss due to shoot infections has not been demonstrated. Heavily infected shoots are more prone to wind damage.

Although shoot infections may not result in direct crop loss, it is important to remember that lesions on shoots serve as an extremely important source of inoculum for cluster stem (rachis) and fruit infections in the spring. Rachis and fruit infection is the phase of the disease that causes most crop loss.

Phomopsis Cane and Leaf Spot Disease Cycle (Figure 67)

The fungus overwinters in lesions or spots on 1- to 3- year-old wood infected during previous seasons. It requires cool weather and rainfall for spore (conidia) release and infection. Conidia are released from pycnidia (fungal fruiting bodies) in early spring and are spread by rain to developing shoots and leaves. Shoot and leaf infection (Figure 68 and 69) is most likely during the period from bud break until shoots are 6 to 8 inches in length. Lesions appear 3 to 4 weeks after infection. The critical period for fruit and rachis infection (Figure 70) is also early in the season. The rachis and young fruits are susceptible to infection throughout the growing season; however, most infections appear to occur early in the growing season. The fungus does not appear to be active during warm summer months, and most or all of its primary inoculum is probably released and expended early in the growing season. Thus, the critical period to provide fungicide protection for fruit infection is probably from when the clusters are first exposed until 2 to 3 weeks after bloom.

Figure 67: Phomopsi cane and leaf spot disease cycyle. We wish to thank the New York State Agricultural Experiment Station for use of this figure. Figure taken from Grape IPM Disease Identification Sheet No. 6.

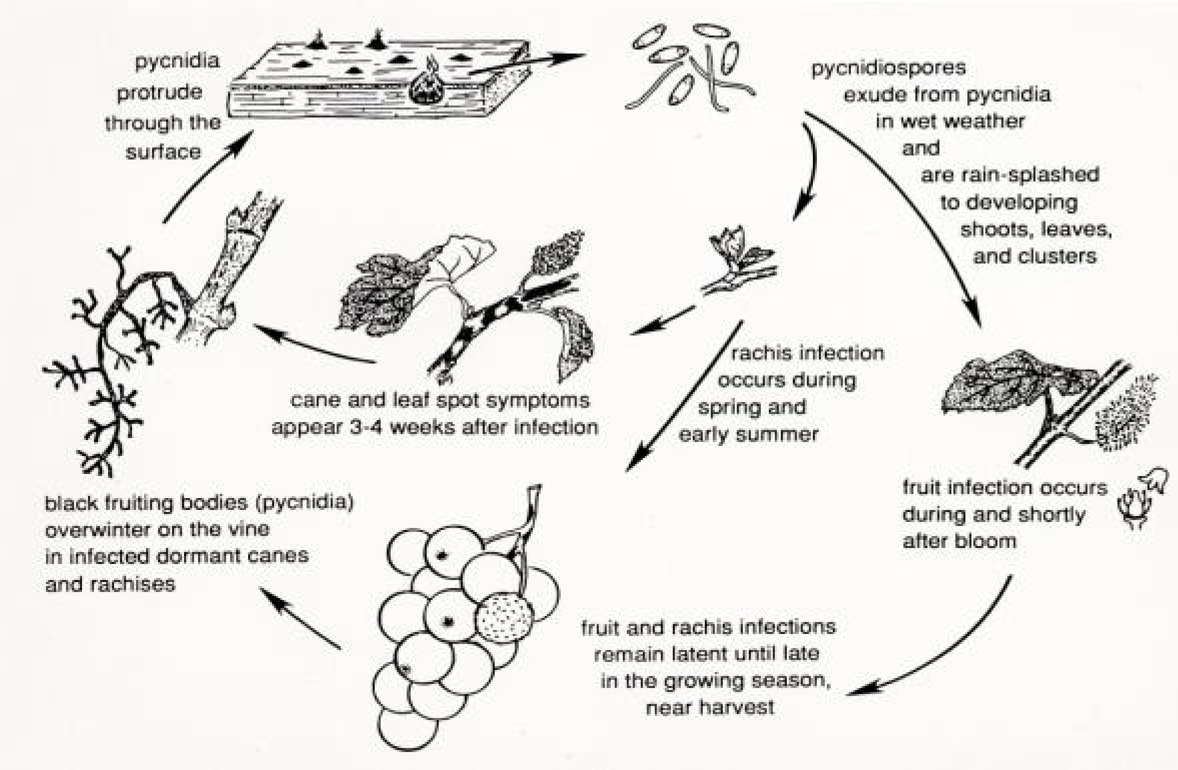


Figure 68: Phomopsis cane and leaf spot on internodes and rachis.

Figure 69: Phomopsis symptoms on grape leaf.

Figure 70: Phomopsis fruit rot on grape.

The tiny green fruits that are infected during this critical period may appear to be normal. The fungus remains inactive in these fruits as a "Latent" infection. Not until the fruit starts to ripen near harvest does the fungus become active and cause the fruit to rot. Therefore, fruit rot that appears at harvest is probably due to infections that occurred during or shortly after bloom.

Berry infections first appear close to harvest as a light-brown color. Black, spore-producing structures of the fungus (pycnidia) then break through the berry skin and the berry soon shrivels.

At this advanced stage, Phomopsis fruit rot can be easily mistaken for black rot. Growers should remember that the black rot fungus does not infect berries late in the growing season. Berries become resistant to black rot infection by 3 to 4 weeks after bloom. Fruit infection by Phomopsis generally does not appear until this time. Although the fungus does not appear to be active during the warm summer months, it can become active during cool, wet weather later in the growing season.

Organic fungicides (sulfur and copper) applied during the growing season are not highly effective for control. A dormant application of liquid lime sulfur may be beneficial in control.

Eutypa Dieback

Eutypa dieback, caused by the fungus *Eutypa lata*, is the new name for the canker- and shoot- dieback phase of what was once known as dead-arm. The name "Dead-arm" should be dropped.

Symptoms

The earliest symptom to develop is a canker that generally forms around pruning wounds in older wood of the main trunk (Figure 71). These cankers usually are difficult to see because they are covered with bark. One indication of a canker is a flattened area on the trunk. Removal of bark over the canker reveals a sharply defined region of darkened or discolored wood bordered by white, healthy wood. Cankers may be up to 3 feet long and may extend below the soil line. When the trunk is cut in cross-section, the canker appears as darkened or discolored wood extending in a wedge shape to the center of the trunk.

Figure 71: Eutypa canker on grape trunk.

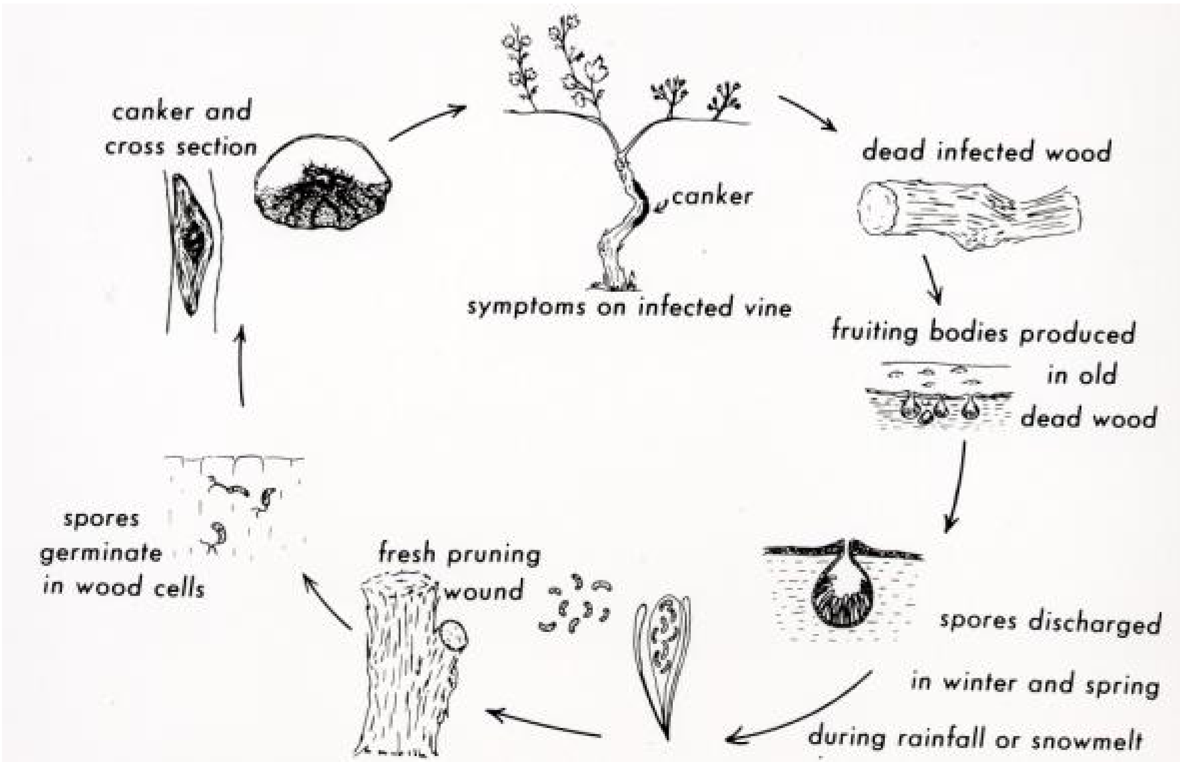
The most striking and obvious symptoms of Eutypa dieback are the leaf and shoot symptoms (Figure 72), which may not develop for 2 to 4 years after the vine was first infected. These symptoms are most obvious in spring, when healthy shoots are 12 to 24 inches long. Spring shoot growth on diseased canes is weak and stunted above the cankered area. Leaves are at first smaller than normal, cupped, distorted, and yellow. These leaf and shoot symptoms may not be as obvious later in the season (mid-July). Leaf and shoot symptoms are more pronounced each year until the affected portion of the vine finally dies.

Figure 72: Eutypa symptoms on grape leaves.

Eutypa Dieback Disease Cycle (Figure 73)

The fungus survives in infected trunks for long periods, whether as part of the in-place vine or as old, dead grape wood in the vineyard. The fungus is generally present in older wood, such as vine trunks, but generally not in younger wood, such as 1- or 2-year-old prunings. The fungus eventually produces reproductive structures (perithecia) on the surface of infected wood. Spores (ascospores) are produced in these structures and discharged into the air. Ascospore discharge is initiated by the presence of free water (rainfall or snow melt). Most spores appear to be released during winter or early spring; few are released during the summer. Unfortunately, most spores are released at about the same time pruning is being conducted. Air currents can carry the ascospores long distances to fresh wounds on the trunk. Pruning wounds are by far the most important points of infection. The ascospores germinate when they contact the newly cut wood, and a new infection is initiated. Stunted shoots and small, cupped leaves appear 2 to 4 years after infection. After approximately 5 years, the fungus produces perithecia and ascospores in the dead wood on cankers.

Figure 73: Eutypa dieback disease cycle. We wish to thank the New York State Agriculture Experiment Station for the use of this figure. Figure taken from Grape IPM Disease Identification Sheet No. 1.



Control of Eutypa Dieback

The primary control method is removal of infected trunks from the vineyard. The vine must be cut off below the cankered or discolored wood. If the canker extends below the soil line, the entire vine must be removed. If the canker does not go below the soil line, the stump can be left and a new trunk formed. The best time to identify and remove infected vines is in early spring (May and June) when leaf and shoot symptoms are most obvious. In addition, large wounds are less susceptible to infection at this time of year, and fewer ascospores are present to cause reinfection. If trunks cannot be removed in the spring, they should be marked for easy identification and removal later in the growing season.

Sanitation is critical. All wood (especially trunks and stumps) from infected plants must be removed from the vineyard and destroyed (either buried or burned) as soon as possible. An old infected stump or trunk lying on the ground may continue to produce spores for several years.

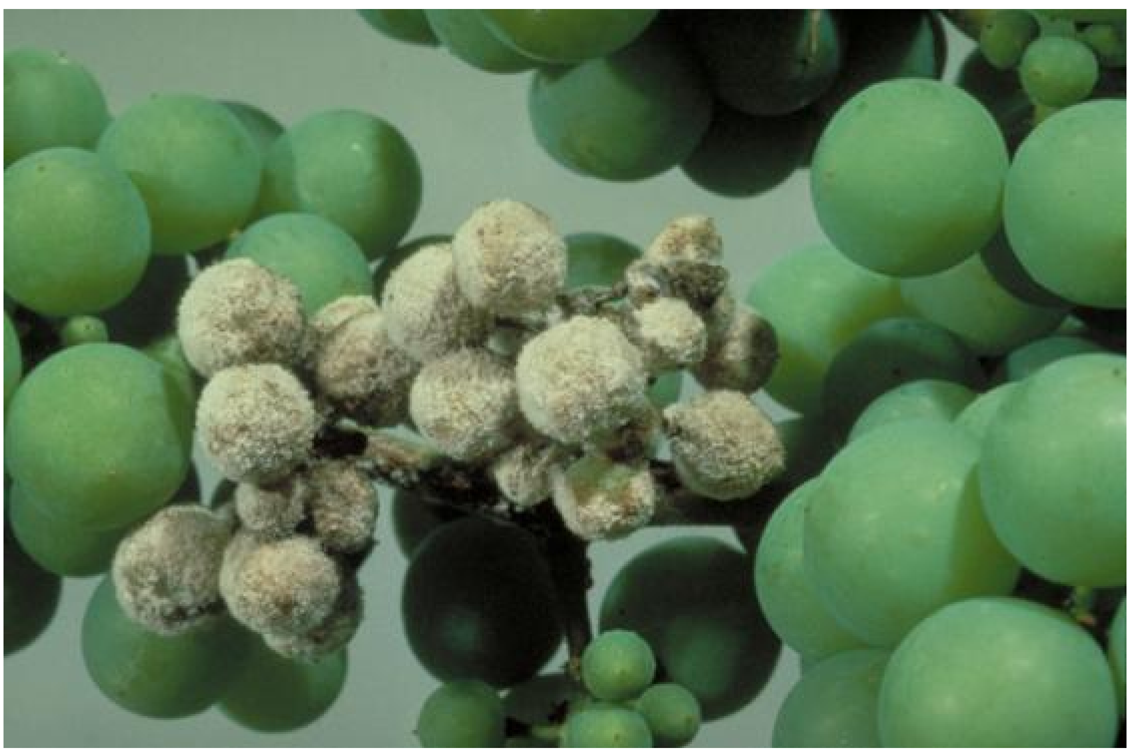
The double trunk system of training, where each trunk is pruned to carry half the number of buds, may help reduce crop loss caused by Eutypa dieback. If a diseased trunk must be removed, the remaining trunk can be pruned to leave the full number of buds until a new second trunk can be established.

Fungicide recommendations currently are not available for control of this disease.

Downy Mildew

Downy mildew is a major disease of grapes throughout the eastern United States. The fungus (*Plasmopara viticola)* causes direct yield losses by rotting inflorescences, clusters (Figure 74) and shoots. Indirect losses can result from premature defoliation. Premature defoliation is a serious problem because it predisposes the vine to winter injury. It may take a vineyard several years to fully recover after severe winter injury. In general, vinifera (*Vitis vinifera*) varieties are much more susceptible than American types and the French hybrids are somewhat intermediate in susceptibility (Table 6).

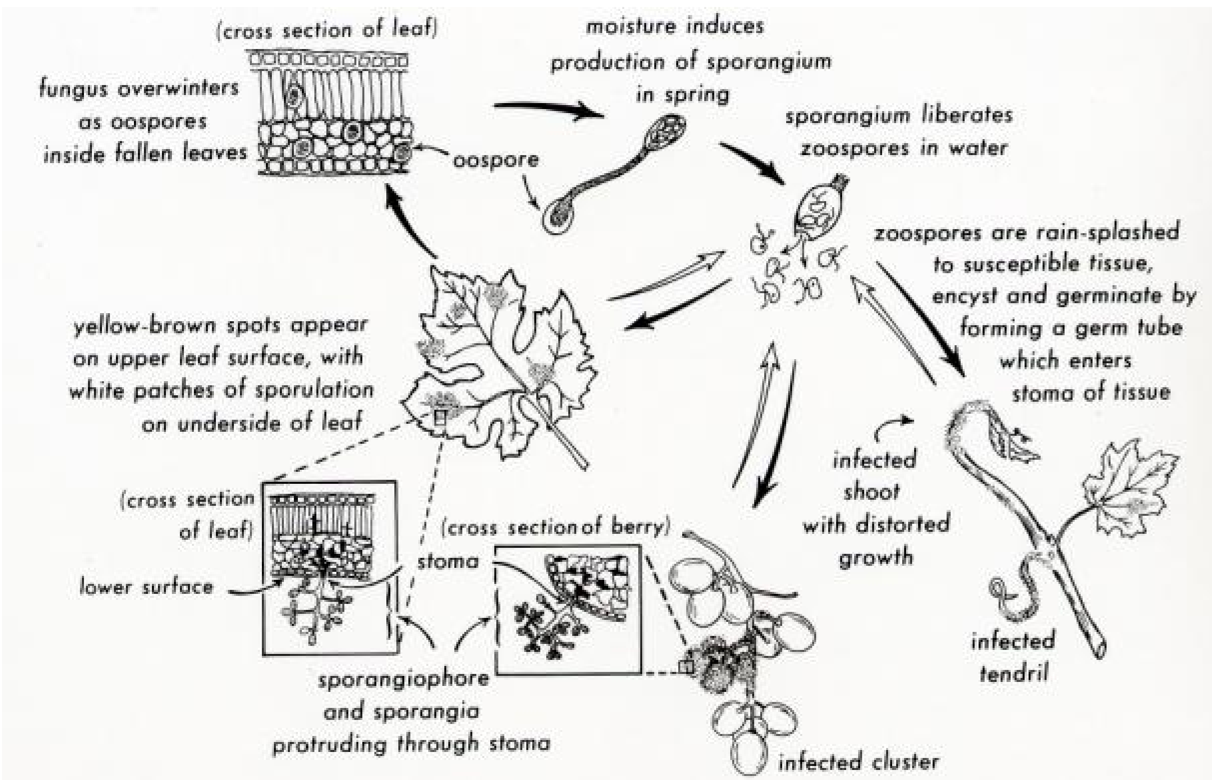
Figure 74: Downy mildew fruit infection.



Downy Mildew Disease Cycle (Figure 75)

The causal fungus overwinters as tiny oospores in leaf debris on the vineyard floor. In the spring, the oospores serve as primary inoculum and germinate in water to form sporangia. The sporangia liberate small swimming spores, called zoospores, when free water is present. The zoospores are disseminated by rain splash to grape tissues where they swim to the vicinity of stomata and encyst. Stomata are tiny pores through which the plants exchange air and transpiration occurs. Stomata are concentrated on the underside of the leaves. Encysted zoospores infect grape tissues by forming germ tubes that enter stomata and from there invade inner tissues of the plant. The fungus can infect all green, actively growing parts of the vine that have mature, functional stomata.

Figure 75: Downy mildew disease cycle. We wish to thank the New York State Agriculture Experiment Station for use of this figure. Figure taken from Grape IPM Disease Identification Sheet No. 1.



Infected leaves develop yellowish-green lesions on their upper surfaces (Figure 76) 7 to 12 days after infection. As lesions expand, the affected areas turn brown, necrotic or mottled. At night, during periods of high humidity and temperatures above 55°F, the fungus sporulates by forming sporangia on numerous branched structures, called sporangiophores, that protrude out through stomata on the undersides of the leaf. Sporulation only occurs on plant surfaces that contain stomata, such as the underside of leaves, and it gives the surface of the lesion its white, downy appearance, which is characteristic of the disease (Figure 77). Sporangia are disseminated by wind or rain splash. On susceptible tissue they liberate zoospores into water films formed by rain or dew. These zoospores initiate secondary infections which can occur in as little as two hours of wetting at 77°F or up to 9 hours at 43°F. Infections are usually visible as lesions in about 7 to 12 days, depending on temperature and humidity. The number of secondary infection cycles depends on the frequency of suitable wetting periods that occur during the growing season and the presence of susceptible grape tissue. In general, Catawba, Chancellor, Chardonnay, Delaware, Fredonia, Ives, Niagara, White Riesling, and Rougeon are highly susceptible cultivars (Table 6).

Figure 76: Downy mildew on upper leaf surface.

Figure 77: Downy mildew on lower leaf surface.

Severely infected leaves may curl and drop from the vine. The disease attacks older leaves in late summer and autumn, producing a mosaic of small, angular, yellow to red-brown spots on the upper leaf surface. Lesions commonly form along leaf veins, and the fungus sporulates in these areas on the lower leaf surface. When young shoots, petioles, tendrils, or cluster stems are infected, they frequently become distorted, thickened, or curled. White, downy sporulation can be abundant on the surface of infected areas. Eventually, severely infected portions of the vine wither and die. Infected green fruit turn light brown to purple, shrivel, and detach easily. White, cottony sporulation is abundant on these berries during humid weather. The fruits remain susceptible as long as stomata on their surfaces are functional. After that, new infections and sporulation do not develop, but the fungus continues to grow into healthy berry tissue from previously infected areas. Later in the season, infected berries turn dull green to reddish purple, remain firm, and are easily distinguished from non-infected ripening berries in a cluster. Infected berries are easily detached from their pedicels leaving a dry stem scar.

Throughout most of the Midwest, downy mildew symptoms often do not appear until after bloom. This is why we often refer to it as a "Late season" disease. The role of oospores in causing early season primary infections is not clearly defined. Although we emphasize the use of fungicides for downy mildew control after bloom, early season fungicide applications can be very important. Especially on highly susceptible cultivars, the early season fungicide program should contain a fungicide that has efficacy against downy mildew. Copper fungicides are highly effective for controlling downy mildew; however, repeated applications of copper can result in some vine damage. Sulfur is not effective. The selection on use of less susceptible varieties is very important in organic production (Table 6).

Botrytis Bunch Rot

Botrytis bunch rot (gray mold) and blight of leaves, shoots, and blossom clusters occurs throughout the viticultural world. The fungus causing the disease grows and reproduces on senescent or dead plant tissue. Botrytis bunch rot is especially severe in grape cultivars with tight, closely packed clusters of fruit. Botrytis is also responsible for storage losses of grapes picked for fresh market.

Symptoms

Botrytis infection of leaves begins as a dull, green spot, commonly surrounding a vein, which rapidly becomes a brown necrotic lesion. The fungus may also cause a blossom blight or a shoot blight, which can result in significant crop losses. Debris, i.e. dead blossom parts, in the cluster may be colonized by the fungus which can then move from berry to berry within the bunch prior to the beginning of ripening, and initiate development of an early season sour rot. However, the most common phase of this disease is the infection and rot of ripening berries (Figure 78). This will spread rapidly throughout the cluster. The berries of white cultivars become brown and shriveled and those of purple cultivars develop a reddish color. Under proper weather conditions, the fungus produces a fluffy, gray-brown growth containing spores (Figure 79).

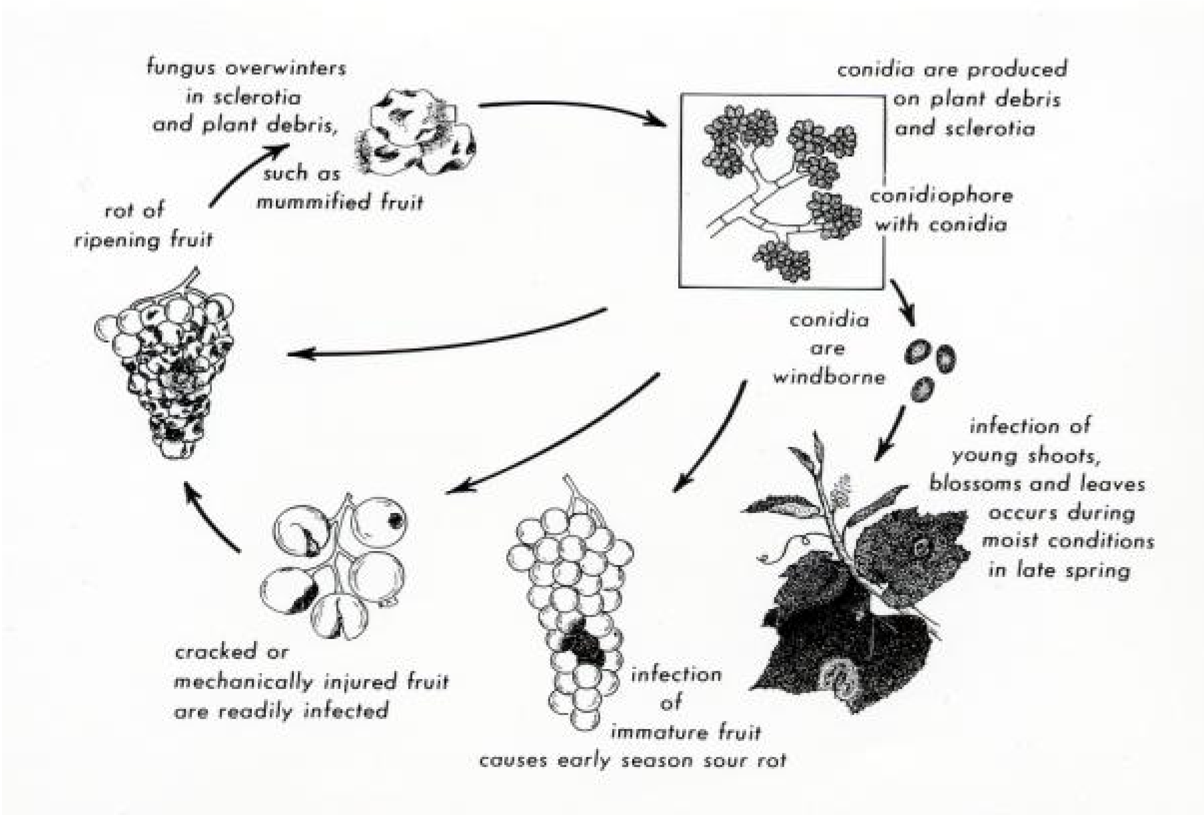
Figure 78: Botrytis bunch rot of grape.

Figure 79: Close-up showing Botrytis sporulating on infected berries.

Botrytis Bunch Rot Disease Cycle (Figure 80)

Botrytis overwinters on debris in the vineyard floor and on the vine. The fungus produces small, dark, hard, resting structures called sclerotia. Sclerotia are resistant to adverse weather conditions and usually germinate in spring. The fungus then produces conidia, which spread the disease. Sporulation may occur on debris left on the vine during the previous growing season, such as cluster stems remaining after mechanical harvest or mummified fruit, or it may occur on sclerotia on canes. The fungus usually gains a foothold by colonizing dead tissue prior to infection of healthy tissue. Tissue injured by hail, wind, birds, or insects is readily colonized by Botrytis. Ripe berries that split because of internal pressure or because of early season infection by powdery mildew, are especially susceptible to infection by Botrytis. Botrytis conidia are usually present in the vineyard throughout the growing season. Moisture in the form of fog or dew and temperatures of 59 to 77°F are ideal for conidia production and infection. Rainfall is not required for disease development, although periods of rainfall are highly conducive to disease development.

Figure 80: Botrytis bunch rot disease cycle. We wish to thank the New York state Agriculture Experiment Station for the use of this figure. Figure taken from Grape IPM Disease Indentification Sheet No. 5.



Control of Botrytis bunch rot

Organic fungicides (copper and sulfur) are not effective for control of Botrytis. There are several biological control agents or products that are registered for control of Botrytis on grapes (Table 1). The efficacy of these products under moderate service disease pressure needs to be determined. Cultural practices that open the canopy such as leaf removal are very important for disease control. Cultivar selection is also very important. Cultivars with tight clusters that are highly susceptible to Botrytis bunch rot should be avoided in organic production in the Midwest.

Crown Gall

Crown gall is a bacterial disease caused by *Agrobacterium tumefaciens* that infects more than 2,000 species of plants. Crown gall of grape is a major problem in cold climate regions. Wounds are necessary for infection to occur. Observations suggest that freeze injury wounds are highly conducive to infection. The disease is particularly severe following winters that result in freeze injury on cold-sensitive cultivars, such as those of Vitis vinifera. Crown gall is characterized by galls or overgrowths that usually form at the base of the trunk. Galls form as high as 3 feet or more up the trunk (aerial galls). Galls generally do not form on roots. The disease affects all grape cultivars. Vines with galls at their crowns or on their major roots grow poorly and have reduced yields. Severe economic losses result in vineyards where a high percentage of vines become galled within a few years of planting.

Symptoms

The disease first appears as small overgrowth or galls on the trunk, particularly near the soil line. Early in their development, the galls are more or less spherical, white or flesh-colored, and soft. Because they originate in a wound, the galls at first cannot be distinguished from callus. However, they usually develop more rapidly than callus tissue. As galls age, they become dark brown, knotty, and rough (Figure 81).

Figure 81: Crown gall symptoms on grape trunk.

When galls are numerous on the lower trunks or major roots, they disrupt the translocation of water and nutrients, which leads to poor growth, gradual dieback, and sometimes death of the vine. In some cases, infected vines appear stunted and as if they are suffering from nutrient deficiency.

Life Cycle

The causal organism, a bacterium, is soilborne and persists for long periods in plant debris in the soil. Fresh wounds are required to infect and initiate gall formation. Wounds that commonly serve as infection sites are those made during pruning, machinery operations, freezing injury, or any other practice that injures the vine. In addition to the primary galls, secondary galls may also form around other wounds and on other portions of the plant, even in the absence of the bacterium. Crown gall bacteria also survive systemically within grapevines and probably are most commonly introduced into the vineyard on or in planting material.

Control of Crown Gall

Examine new plants before planting, and discard any that have galls. Wounding by freeze injury appears to be important in the development of crown gall. If winter injury is controlled, crown gall may not be an important problem. Prevent winter injury to vines. Practices, such as hilling or burying vines of cold-sensitive cultivars is beneficial. Proper pruning practices and proper crop loads for maximum vine vigor will result in stronger plants that are less susceptible to winter injury. Controlling other diseases, such as downy and powdery mildew, is also important in preventing winter injury and crown gall.

The double-trunk system of training, in which each trunk is pruned to carry half the number of buds, may help reduce crop loss caused by crown gall. If a diseased trunk must be removed, the remaining trunk can be pruned, leaving the full number of buds until a second trunk is established. Galls on arms or the upper parts of the trunk can be removed by pruning.

There are no current chemical or biological control recommendations for crown gall on grapes.

Use of Resistant Cultivars for Grape Disease Management

In an integrated disease management program where emphasis is placed on reducing overall fungicide use, it is essential that any available disease resistance be identified and used. If resistance is not available, we should at least identify and avoid those cultivars that are highly susceptible to important diseases. There are a few grape varieties with high levels of resistance to most diseases. Norton (Cynthiana) is a variety that has great potential for organic production in the southern portion of the Midwest. It has good resistance to most diseases and in several commercial plantings, growers rarely apply fungicides. Hopefully, new varieties with improved levels of disease resistance will be introduced in the near future. Unfortunately, resistance to most of the major diseases is not available in most commercially grown grape cultivars in the Midwest. Thus, the disease management program must rely heavily on the use of cultural practices and efficient use of organically approved fungicides or biocontrol agents or products. Whereas resistance is generally not available for most diseases, some grape cultivars are known to be much more susceptible to certain diseases than others (Table 2). For example, the cultivar Chancellor is highly susceptible to downy mildew, whereas downy mildew is seldom a serious problem on Concord and several other cultivars. Growers should consider disease susceptibility before establishing the vineyard. Segregating highly-susceptible cultivars into blocks that can be easily treated separately allows growers to apply more fungicide or other control agents when needed to highly susceptible cultivars while reducing their use on less susceptible cultivars. In addition, varieties differ greatly in their sensitivity to copper and sulfur fungicides. When planting the vineyard, it is important to isolate blocks of sensitive varieties from those that will be sprayed with these materials.

In many situations, growers do not have the flexibility of avoiding highly susceptible cultivars. The demand for a specific wine, juice grape, or table grape cultivar generally dictates which cultivars are planted. Whereas this situation usually cannot be avoided, growers need to recognize that when highly- susceptible cultivars are planted, their disease management options are greatly restricted.

Table 2. Relative disease susceptibility and Sulfur, and Copper sensitivity among grape cultivars.

The relative ratings in this chart apply to an average growing season under conditions usually favorable

for disease development. Any given cultivar may be more severely affected.

									Susceptible or sensitive to	
Cultivar	**BR**	**DM**	**PM**	**Bot**	**Phom**	**Eu**	**CG**	**Als**	**S[1]**	**C[2]**
Aurore	+++	++	++	+++	+	+++	++	+++	No	++
Baco Noir	+++	+	++	++	+	++	+++	++	No	?
Cabernet Franc	+++	+++	+++	+	?	?	+++	?	No	?
Cabernet Sauvignon	+++	+++	+++	+	+++	+++	+++	?	No	+
Canadice	+++	++	+	++	?	?	++	++	?	?
Cascade	+	+	++	+	++	++	+	?	No	?
Catawba	+++	+++	++	+	+++	+	+	+	No	++
Cayuga White	+	++	+	+	+	+	++	++	No	+
Chambourcin	+++	++	+	++	?	?	++	?	Yes	?
Chancellor	+	+++	+++	+	+++	+	+++	+++	Yes	+++
Chardonel	++	++	++	++	?	?	++	++	No	?
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	?
Gewürztraminer	+++	+++	+++	+++	?	?	+++	+	No	+
Himrod	++	+	++	+	?	?	?	+	No	?
Ives	+	+++	+	+	?	++	+	+	Yes	?
Jupiter	++	+	+++	+	+	?	?	?	?	?
LaCrosse	+++	++	++	+++	++	?	?	?	?	?
Leon Millot	+	++	+++	+	+	+	?	?	Yes	?
Limberger	+++	+++	+++	+	?	+++	+++	?	No	?
Maréchal Foch	++	+	++	+	?	+++	?	+	Yes	?
Marquis	+	+++	+	+	+++	?	?	?	?	?
Mars	+	+	+	+	+	?	+	?	?	?
Melody	+++	++	+	+	?	?	?	?	No	?
Merlot	++	+++	+++	++	+	+++	+++	?	No	++
Moore's Diamond	+++	+	+++	++	?	++	?	?	No	?
Muscat Ottonel	+++	+++	+++	++	?	+++	+++	?	No	?
Niagra	+++	+++	++	+	+++	+	++	+	No	+
Pinot gris	+++	+++	+++	++	?	+++	+++	?	No	?

Pinot Meunier	+++	+++	+++	+++	?	+++	+++	?	No	?
Pinot blanc	+++	+++	+++	++	?	?	+++	?	No	+
Pinot noir	+++	+++	+++	+++	?	?	+++	+	No	+
Reliance	+++	+++	++	+	++	?	?	?	No	+
Riesling	+++	+++	+++	+++	++	++	+++	+	No	+
Rosette	++	++	+++	+	++	++	++	++	No	+++
Rougeon	++	+++	+++	++	+++	+	++	+++	Yes	+++
Saint Croix	?	++	++	++	?	?	?	?	?	?
Sauvignon blanc	+++	+++	+++	+++	?	?	+++	?	No	+
Seyval	++	++	+++	+++	++	+	++	++	No	+
Steuben	++	+	+	+	?	?	+	++	No	?
Traminette	+	++	+	+	?	?	++	?	?	?
Vanessa	+++	++	++	+	+	?	+	?	?	?
Ventura	++	++	++	+	+	?	+	+++	No	?
Vidal blanc	+	++	+++	+	+	+	++	+	No	?
Vignoles	+	++	+++	+++	++	++	++	++	No	?
Villard noir	?	+	+++	+	?	?	?	?	?	?

» Key to susceptibility or sensitivity: **BR**=black rot; **DM**=downy mildew; **PM**=powdery mildew; **Bot**=Botrytis; **Phom**=Phomopsis; **Eu**=Eutypa; **CG**=crown gall; **ALS**=angular leaf scorch; **S**=sulfur; **C**=copper.

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

[1] Slight to moderate sulfur injury may occur even on tolerant cultivars when temperatures are 85 degrees. For higher during or immediately following the application.
[2] Copper applied under cool, slow-drying conditions is likely to cause injury.
[3] Berries not susceptible.

Cultural Practices For Disease Control in Grapes

The use of any practice that reduces or eliminates pathogen populations or creates an environment within the planting that is less conducive to disease development should be used. It is important to remember that certain diseases, such as viruses, Eutypa dieback, and crown gall, cannot be directly controlled with pesticides at the present time. Therefore, cultural practices are the major means for their control. When fungicides or other control agents are required, any practice that opens the plant canopy, such as shoot thinning, leaf removal, berry and cluster thinning, and pruning and shoot positioning, can greatly increase the efficacy of the fungicide program by allowing better spray penetration and coverage. These practices also have a direct effect on vine microclimate.

Vine Microclimate

Vine microclimate refers to the climate within the leaf canopy of the vineyard. In relation to disease management, the most important elements of the vine microclimate are relative humidity, ventilation, the temperature of the air and of vine tissues, and the intensity and quality of light. In general, factors that increase relative humidity also increase fungal diseases. Factors that increase ventilation (air movement) of the vine canopy generally reduce disease incidence and severity by lowering the humidity, shortening periods of leaf and fruit wetness, and aiding spray penetration and coverage. The following cultural practices should be carefully considered and implemented whenever possible into the organic disease management program.

Use Virus-Indexed Planting Stock

Always start the planting with "Healthy" virus-indexed nursery stock from a reputable nursery. The importance of establishing plantings with virus-indexed nursery stock cannot be overemphasized, since the selection of planting stock and planting site are the only actions a grower can take to prevent or delay the introduction of most virus diseases. Plants obtained from an unknown source or neighbor may be contaminated with a number of major diseases that reputable nurseries work hard to avoid.

Site Selection

Site selection can have a direct effect on vine microclimate. A site that provides for maximum air drainage which promotes faster drying of foliage can substantially reduce the risk of black rot and downy mildew. In the northern hemisphere, north-facing slopes receive less light than south-facing slopes. Therefore, vineyards on north-facing slopes may dry more slowly and be at a higher risk for disease development. Avoid planting the vineyard adjacent to woods that will prevent sunlight from reaching the vines during any part of the day. Woods act as a windbreak that may be beneficial in preventing shoot breakage in high winds, but may also reduce air movement (ventilation) in the vineyard which results in prolonged wetting periods. Close proximity to woods can also increase the risk of introducing certain diseases and insect pests into the vineyard.

Planting rows in a north/south row orientation should be the grower's first choice for maximum light penetration. However, rows planted in the direction of prevailing winds will promote better air movement, which results in faster drying of foliage and fruit. Rows should never be planted parallel to a steep slope where erosion could be more of a problem than pests.

Good soil drainage is also very important. Avoid sites that are consistently wet during the growing season. These soils may have an impervious subsoil or other drainage problems. Such sites will usually result in unsatisfactory vine growth and yields, in addition to providing a humid microclimate that is conducive to disease development. In some situations poor drainage can be corrected by tiling prior to planting.

If nematodes have been a problem in previous crops or nematodes are suspected to be a problem on the site, a soil analysis to determine the presence of harmful nematodes should be conducted. Nematodes are most likely to be a problem on lighter (sandy) soils. Nematode sampling kits and instructions for taking samples can be obtained through your county Extension office.

Avoid Excessive Fertilization

Fertility should be based on soil and foliar analysis. The use of excessive fertilizer, especially nitrogen, should be avoided. Sufficient fertility is essential to produce a crop, but excessive nitrogen can result in dense foliage that increases drying time in the plant canopy.

Control Weeds in and Around the Planting

Good weed control within and between the rows is essential. From a disease control standpoint, weeds in the planting prevent air circulation and result in the fruit and foliage staying wet for longer periods. For this reason, most diseases caused by fungi are generally more serious in plantings with poor weed control than in those with good weed control.

Canopy Management

Any cultural practice that alters vegetative growth and canopy density has an effect on vine microclimate. Most cultural practices are chosen primarily to enhance yield or fruit quality rather than to influence the microclimate. However, practices, such as shoot thinning, pruning, and positioning, have a direct impact on vine microclimate. Increasing cluster thinning and decreasing pruning stimulates vegetative growth and hence reduces light exposure and ventilation within the canopy. Shoot thinning, leaf removal, and summer pruning are frequently done specifically to reduce canopy density, so as to increase fruit exposure to light, improve ventilation, and aid spray coverage. Leaf removal in the fruiting zone of the canopy is important for optimal control of Botrytis bunch rot. This is becoming a common practice in California vineyards and has been shown to be effective in Midwest vineyards as well. Shoot positioning is usually done to ensure canopy separation of divided canopies or to enhance light exposure of the renewal zone of the vine; it also decreases vegetative growth and canopy density and increases light exposure of fruit.

Avoid Winter Injury

Wounding by freeze injury is important in the development of crown gall. If winter injury is reduced, crown gall may not become an important problem. Practices such a hilling or burying vines of cold-sensitive cultivars are beneficial. Proper pruning practices and proper crop loads for maximum vine vigor will result in stronger plants that are less susceptible to winter injury. Controlling other diseases, such as downy and powdery mildew, is also important in preventing winter injury and crown gall.

Sanitation

(Removal of Overwintering Inoculum)

Vineyard sanitation is an extremely important part of the disease management program. Most pathogens overwinter (survive from one season to the next) in old diseased plant material, such as mummified fruit, leaves and infected canes or trunks, within the vineyard. Removal of old, infected wood, tendrils, and clusters with mummified berries from the vines and wires greatly reduces overwintering inoculum of several diseases. Wild grapes in nearby woods and fence rows also are sources of disease inoculum and insects. Removal of these wild hosts is beneficial to the disease management program. This especially applies to abandoned vineyards adjacent to managed sites with respect to contamination from powdery and downy mildews.

5A) Fungicides for Use in Organic Production Systems

The following is a brief description of some disease control materials that are commonly or traditionally used in organic production systems. Copper fungicides, elemental sulfur and liquid lime sulfur are the old "standard" fungicides, and have been used for many years in organic production systems.

Note: Prior to using any material in the organic system, it is important that the grower consult his/her organic certification agency or program to be positive that use of the material is permitted.

Copper Fungicides

When different formulations of copper are dissolved in water, copper ions are released into solution. These copper ions are toxic to fungi and bacteria because of their ability to destroy proteins in plant tissues. However, because copper can kill all types of plant tissues, the use of copper fungicides carries the risk of injuring foliage and fruit of most crops. Factors promoting this injury include: 1) the amount of actual copper applied, and 2) cold, wet weather (slow drying conditions) that apparently increases the availability of copper ions and, thus, increases the risk of plant injury. Because of the potential to injure plants and to accumulate in soil, the use of copper fungicides in conventional production systems has largely been replaced with conventional fungicides that are generally safer to plant tissues and often more effective.

Several terms are used when discussing copper as a fungicide. The original material used was copper sulfate (also known as blue vitriol or bluestone). When this material was combined with lime in the French vineyards, the combination became known as Bordeaux mixture.

Bordeaux Mixture

Bordeaux mixture is a mixture of copper sulfate and hydrated lime in water. It has long residual action and has been used for years to control many diseases, including downy mildew and powdery mildew of grape. It can be made (mixed) on site by combining copper sulfate with spray grade lime. It is also commercially available as a dry wettable powder.

Fixed Copper Fungicides

Following the discovery and use of Bordeaux mixture, several relatively insoluble copper compounds or fixed coppers were developed. Fixed copper formulations release less copper ions and are generally less injurious to plant tissues (safer to use) than Bordeaux mixture, but their use is still limited because of their potential to injure plants and lack of compatibility with other pesticides. Some of the more common commercial formulations of fixed copper include C-O-C-S, Kocide 101, Tribasic Copper sulfate, Champ, and

Tenn-Copp 5E. There are several fixed copper fungicides registered for use on small fruit.

Sulfur Fungicides

Sulfur is available as liquid lime sulfur and as dry wettable powders or liquid (flowable) formulations of elemental sulfur.

Liquid Lime Sulfur

Liquid lime sulfur can be used at high concentrations as a dormant spray on raspberries and blackberries for control of cane blight, spur blight and anthracnose and on grapes for control of anthracnose. At high concentrations, it should be used only when plants are dormant. It can cause severe damage if applied after green foliage appears. Lime sulfur has a foul odor that many people dislike. It is also registered for use on grapes and caneberries as a more dilute concentration for use during the growing season.

Dry Wettable Sulfurs or Flowable Sulfurs

Sulfur for use as a fungicide is available under many trade names. The microfine wettable sulfurs or flowable sulfurs are usually much less injurious to foliage and fruit than liquid lime sulfur, but their use during hot weather (above 85F) may result in some leaf burning and fruit damage. Sulfur fungicides are very effective for control of powdery mildew on most fruit crops, but are not highly effective for control of most other fruit crop diseases. Sulfur is very toxic to foliage of certain grape varieties (mainly American grapes) including Concord, Chancellor, DeChaunac and Foch. Sulfur is relatively safe on most other varieties see Table 6, page 68. Applications after the fruit begins to ripen may pose problems during fermentation if the grapes are intended for wine making.

Growers should note that sulfur is lethal to some beneficial insects, spiders and mites. These beneficial insects are natural predators of harmful insects and mites that affect fruit crops. Killing these beneficial insects may increase certain pest problems, especially mites.

Specific comments on fungicide use will be made in the text for each crop where applicable.

5B) "New Alternative" Disease Control Materials for Small Fruit

Many products are currently available or currently being introduced as "biological control agents" or "biopesticides". These include living microorganisms, "natural chemicals" such as plant extracts, and "plant activators" that induce resistance in plants to disease. For most of these products, independent evaluations are currently being conducted; however, their effectiveness under moderate to high disease pressure is uncertain.

Although many of these new products have great potential for use within organic production systems, their effectiveness needs to be determined in field tests. It is important to remember that registration of these materials for control of a specific disease on a crop is no guarantee that they will provide effective control

under moderate to heavy disease pressure. In addition, many products may be effective for only one or a few diseases and most have very limited residual activity (they have to be applied often). It is also important to remember that these are registered pesticides and growers need to be certain that their use is permitted within their organic certification program.

The biological control committee of the American Phytopathological Society has developed a web page for **"Commercial Biocontrol Products Available for Use Against Plant Diseases".** The web page address is: [www.oardc.ohio-state.edu/apsbcc/productlist.htm.](www.oardc.ohio-state.edu/apsbcc/productlist.htm) This web page lists all the products currently available along with information such as registered crops and diseases controlled. It also lists the name of the company that manufacturers or distributes the product along with phone numbers and web site addresses. This site is updated regularly and is a valuable resource for growers interested in these products.

The following are a few of the most common "alternative" disease control products currently registered for use on small fruit.

- -**AC10** (*Ampelomyces quisqualis*) is a biofungicide registered for control of powdery mildew in grapes, strawberries, blueberries, raspberries, currants, and gooseberries. *A. quisqualis* is a fungus, that parasitizes powdery mildew fungi. Preliminary results in grapes in Michigan show moderate disease control. Adding an adjuvant such as Nufilm (0.02% v/v) enhances its efficacy. Application should start as soon as susceptible tissue becomes available and continue on a 7 to 14 day schedule. A minimum of 2 sequential applications if needed to maintain the population of *A. quisqualis*. The following chemicals cannot be tank-mixed with AQ10: sulfur and potassium salts of fatty acids.
- -**Armicarb 100** (potassium bicarbonate) is a reduced-risk, protectant (contact) fungicide. Armicarb 100 is registered for control of powdery mildew and other diseases in grapes, blueberries, strawberries, and brambles. Preliminary results in grapes in Michigan indicate moderate control of powdery mildew. It provides little or no control of the other grape diseases. Start applications at the first sign of disease and continue on a 7-14 day schedule. The preharvest interval (PHI) on all crops is 0 days.
- -**Kaligreen** (potassium bicarbonate) is a reduced-risk protectant (contact) fungicide. Kaligreen is registered for control of powdery mildew on grapes, strawberry, brambles (raspberry and blackberry) and blueberry. It provides good control of powdery mildew when applied on a frequent-protectant program of 7 to 10-day intervals. It has little or no efficacy against most other fungal diseases on small fruit. It is formulated as a micro-encapsulated powder that is mixed in water

and sprayed directly on the crop. Kaligreen has a preharvest interval (PHI) of 1 day on all small fruit crops.

- -**Messenger** (harpin) is a reduced risk product registered for use on grapes, blueberries, cranberries, strawberries, brambles, and currants. The active ingredient is derived from a protein produced by certain bacteria. This protein stimulates natural plant defenses. Messenger has no direct effect on pathogens. The efficacy of this material for disease control or suppression has not been sufficiently confirmed. Messenger has a 0 day PHI.
- -**Mycostop** (Streptomyces griseoviridis strain K61) is a biocontrol product registered for use on all fruit crops for control of several important pathogenic fungi that cause seed, root, and stem rot and wilt diseases. The active ingredient is the bacterium, Streptomyces griseoviridis strain K61. It is sold as a powder formulation that is mixed with water and applied as a spray or a drench. It's efficacy for control of grape diseases has not been demonstrated.
- -**Oxidate** (hydrogen dioxide) is a broad-spectrum bactericide/fungicide registered for use in grapes, blueberries, cranberries, strawberries, and brambles. It is a rather corrosive material and works by oxidizing fungal and bacterial cells. The efficacy of the material for disease control has not been sufficiently confirmed on several diseases. In one Ohio fungicide evaluation, it provided no control of grape black rot.
- -**Serenade** (*Bacillus subtilis*) is a biocontrol product registered for control of powdery mildew, Botrytis bunch rot and sour rot in grapes. Serenade is also reported to provide some suppression of downy mildew. This product needs further evaluation, but preliminary results show a moderate level of control of Botrytis bunch rot and powdery mildew. Serenade did not control grape black rot in Ohio. Good coverage is important for control. Applications are recommended on a 7-10 day schedule. Serenade has no maximum seasonal application rate and has a 0 day PHI.
- -**Trichodex** (Trichoderma harzianum) is a biofungicide registered for use on all small fruit crops for control of a wide range of diseases, but primarily for control of Botrytis fruit rot. It is sold as a wettable powder formulation that is mixed with water and sprayed directly onto the plants.
- -**Trilogy** (Clarified Hydrophobic Extract of Neem Oil). The label states that Trilogy is a broad spectrum fungicide of certain diseases and controls mites in citrus, deciduous fruits and nuts, vegetable crop, cereal grains and other miscellaneous crops. The label does not state what diseases are controlled on specific crops. Trilogy is registered for use on grapes, strawberry, brambles (raspberry and blackberry), and blueberry. Trilogy is a liquid that is applied for diseases as a 1% solution in sufficient water to achieve complete coverage of the foliage.

As the efficacy of these new materials is tested and validated, they will be included in these guidelines where appropriate.

5C) Fungicide Use Strategies for Organic Production

Unfortunately, there are not many options to choose from when one considers current fungicide use strategies. The current options are:

1. **Do Not Use Fungicides**

This is always an option, but may not be a wise decision for commercial grape plantings in the Midwest. This option should not be confused with "organic" production. Grape growers in "organic" production systems will most probably use Sulfur or Copper to some extent for disease control. Sulfur and Copper are fungicides. Growers that choose not to use fungicides must rely completely on cultural practices, disease resistance, or biological control agents or products for disease control.

2. **Protectant Fungicide Program**

In a protectant program, fungicides are used as a protective barrier on the plant surface. This chemical barrier prevents the fungus from entering the plant. It works much like paint on a piece of wood to keep out water. Protectant fungicides (such as sulfur and copper) are not systemic and cannot move into plant tissues. Once the fungus penetrates into the plant, protectant fungicides will not control it. As the protective barrier breaks down or new foliage is produced, additional applications are required to maintain the protective barrier.

Protectant fungicide programs have been, and still are very effective; however, they generally result in a fairly intensive use of fungicide. On grapes, protectant fungicides are usually applied on a 7-10 day schedule early in the growing season and on a 10-14 day schedule later in the season. Obviously, maintaining a protective barrier on the plant surface throughout the growing season requires several applications. It is important to note that the most critical period for disease control on grapes with fungicides is from immediate prebloom through 3 to 4 weeks after bloom. It is during this period when protection of fruit is most critical. Cover sprays later in the season may also be required to protect foliage and cluster stems (rachis) from infection by powdery and downy mildew.

5D) Fungicides for Organic Grape Disease Control

Due to the complex of grape diseases in the Midwest (black rot, powdery mildew, downy mildew, Phomopsis cane and leaf spot, Botrytis bunch rot) some use of fungicide within the organic production system will probably be required. The use of sulfur and copper fungicides on grapes has a long history, and these fungicides are commonly used in conventional grape production systems today. The challenge for the organic producer is to develop a program using only these fungicides that will provide simultaneous control of the entire disease complex. Especially in wet growing seasons, all of the above mentioned diseases can develop within the vineyard simultaneously. The exclusive use of sulfur and copper, even in combination, may not provide acceptable disease control of all the diseases under moderate to heavy disease pressure.

Liquid Lime Sulfur

Lime sulfur is recommended for control of anthracnose as a dormant application in the spring. It is recommended at the rate of 10 gallons per acre. The dormant application is generally not recommended unless anthracnose is a problem. Some growers routinely make a dormant application of lime sulfur or copper, and feel they are getting some benefits for control of other diseases as well. University research indicates that a dormant application alone will not provide season long control of any grape disease; thus, foliar applications through the growing season will probably be required.

Sulfur is highly effective against powdery mildew if used in a protectant program with a minimum of 7 to 10 days between applications. Sulfur provides very good control of powdery mildew, but has little or no effect on all the other grape diseases. Under moderate to heavy powdery mildew disease pressure, a minimum of 7 to 10 days between spray intervals will probably be required.

There are many formulations of sulfur (wettable powders, dusts, dry flowables and flowables). The flowable formulations appear to most effective and result in much less applicator exposure when preparing sprays.

Note: On sulfur tolerant varieties that are susceptible to PM (Table 2), Sulfur will be a major component of the fungicide program. On highly susceptible varieties, spray intervals shorter than 14 days (7-10 days) will probably be required.

Although Sulfur is highly effective for PM control, it has little or no effect on the other grape diseases. It is important to remember that Sulfur can cause severe injury on some varieties. Sulfur should only be used varieties known to be sulfur tolerant (Table 2).

Note: Concord grapes are extremely sensitive to Sulfur. Sulfur injury may occur even on sulfur-tolerant varieties when temperatures of 80 to 85F or higher are experienced during or immediately after application.

Copper fungicides are highly effective against downy mildew and are moderately effective against powdery mildew. Copper fungicides are weak for controlling black rot, Botrytis Bunch, and Phomopsis Cane and Leaf Spot. A concern with the use of copper fungicides is the potential they have for phytotoxicity or "vine damage".

The following summary of recommendations are intended to reduce the danger of phytotoxicity when using copper:

1. Do not make a complete season-long spray program with any copper fungicides.

2. Use fungicides other than copper whenever possible.

3. When using copper fungicides, delay their use as late in the growing season as possible.

4. When using copper fungicides, avoid the use of copper sulfate. Always us a "fixed" copper formulation.

5. Use the full recommended rate of lime. ***Never*** eliminate the use of lime completely, unless the pesticide label indicates that lime should not be used.

6. Remember that cool, wet weather enhances the risk of copper injury. Be especially certain to use adequate lime levels during such periods or switch to other fungicides.

7. Make sure that any material you tank mix with copper is ***compatible.*** Many materials are incompatible (cannot be tank-mixed) with copper.

8. Avoid copper and lime sprays on fruit destined for fresh market.

Other Disease Control Materials for Powdery Mildew

Powdery mildew is different from most other grape diseases, because the fungus that causes it lives almost entirely on the surface of infected plant parts. The fungus may penetrate only one cell layer deep into the plant. Thus, it is exposed to eradication following topical treatment with a range of products that do not affect other diseases that colonize deeper into infected plant tissues, such as black rot. Research in New York and other locations has demonstrated that many new and "alternative" materials can provide effective control of powdery mildew if applied often enough (7 day schedule) through the growing season. These materials burn out the fungus growing on the surface, but do not provide protection against new infections; thus, repeated applications are important. These materials include: Nutrol (manopotassium

phosphate); Kaligreen and Armicarb (potassium bicarbonate-baking soda); oils such as Stylet Oil and Trilogy; and dilute solutions of hydrogen peroxide (Oxidate). In Australia, dilutions of milk and whey (the dairy by-product) have been effective for controlling powdery mildew.

Unfortunately, these materials have very little or no effect on the other grape diseases. In addition, organic growers need to consult with their certification agency or program to be sure that any material they use is "certified" or acceptable as organic.

Table 3 in section 5E shows the relative effectiveness of organically approved fungicides for control of the major grape diseases. It should be noted that none of the materials or highly effective against black rot, phomopsis cane and leaf spot, and Botrytis bunch rot.

These diseases will be a major concern on susceptible varieties in organic production systems. Whereas, most varieties do not have complete resistance to these diseases, varieties differ greatly in their level of susceptibility. Organic growers should at least AVOID varieties that are highly susceptible to these diseases (Table 2). In addition, the use of cultural practices mentioned in these guidelines must be strongly emphasized.

There are many biocontrol materials and other products such as oils and salts currently registered for use on grapes. Most of these are registered for control of powdery mildew and Botrytis bunch rot, and their effectiveness under moderate to severe disease pressure needs to be determined. As information on these materials becomes available, they will be included in these guidelines.

5E) Table 3: Relative effectiveness of organically approved fungicides for controlling grape diseases.

		Disease				
Material	**Anthracnose**	**Black rot**	**Powdery mildew**	**Downy mildew**	**Phomopsis cane and leaf spot**	**Botrytis bunch rot**
Lime sulfur	H	W	H	W	M	W
Sulfur	W	W	H	W	W	W
Copper fungicide	M	M	H	H	W	W
Horticulture grade spray oils	W	W	H	W	W	W
Salts: **Monopotassium** **Phosphate** **Potassium bicarbonate** **(Kaligreen, Armicarb)**	W	W	H	W	W	W
Hydrogen peroxide (oxidate)	W	W	M	W	W	W

H= highly effective

M= moderately effective

W= weak or not effective

5F) Suggested Guidelines for Developing A Fungicide Spray Program for Organic Wine Grapes in Ohio

Remember that these are only "Suggested Guidelines". The program you develop will be based largely upon the diseases you have in the vineyard and disease pressure, which is largely dependent upon weather. In dry production areas, powdery mildew may be the only disease that needs to be controlled. In Ohio, (midwest and northeast U.S.), all of the diseases mentioned in these guidelines need to be considered. The materials mentioned are "suggestions". They can be replaced by any material that will provide effective control. The timing or scheduling of applications throughout the growing season is very important. The timing and comments in these "suggested guidelines" should be considered regardless of the material used.

Application Timing	**Material and Rate**
Dormant immediately prior to bud swell	Lime sulfur 10 gallons/A
1-3 inch shoot	Lime sulfur 2 qt/100 gal
Comments: Primarily for control of Phomopsis and powdery mildew.	
5-6 inch shoot or 7-10 days after last spray	Lime sulfur 2 qt/100 gal
Comments: Primarily for control of Phomopsis and powdery mildew.	
10-12 inch shoot or 7-10 days after last spray	Flowable sulfur 6F (4 qt/A) or Wettable sulfur (8-10 lb/A) or Potassium Bicarbonate (2-5 lb/A) or JMS Stylet Oil (1%)
Comments: For control of powdery mildew	
Immediate prebloom	Bordeaux mixture or Fixed Copper fungicide
NOTE: This is the CRITICAL period to control fruit infection by black rot, powdery mildew, and downy mildew.	
Comments: The period from **immediate prebloom through 3 to 4 weeks after bloom** is the most critical for protecting the fruit from infection by Phomopsis, black rot, powdery mildew and downy mildew. Although not highly effective against black rot, copper fungicides appear to be the most effective organic materials for black rot and are highly effective for control of powdery and downy mildew. For this reason, a copper fungicide should be applied during this period if conditions are wet and conducive to	

black rot and downy mildew infection (Table 1). Black rot and downy mildew require free water on the plant surface in order to infect. Powdery mildew does not require free water, only high relative humidity. Therefore, when it is very dry, sulfur, potassium bicarbonate, or JMS Stylet Oil can be used in place of copper for powdery mildew control only.

In tests in New York and Ohio, three applications of a conventional fungicide such as Myclobutonil (Nova) on a 10 to 14 day schedule during this critical period (**immediate prebloom through 3-4 weeks after bloom**), provided excellent control of black rot without any additional applications. By 3 to 4 weeks after bloom, the fruit of most varieties become resistant to infection by black rot, powdery mildew and downy mildew. Although fruit become resistant, cluster stems (rachis) and leaves remain susceptible to powdery and downy mildew infection throughout the growing season. Under the proper environmental conditions, additional applications later in the growing season may be required.

Application Timing	**Material and Rate**
First post bloom spray 10-14 days after last spray **NOTE:** Critical period application.	Bordeaux mixture or Fixed Copper fungicide
Second post bloom spray **NOTE:** Critical period application.	Bordeaux mixture or Fixed Copper fungicide

Summer Sprays - throughout summer until harvest.

Remaining sprays should be determined by weather. At this point, the threat of black rot infection should be over. If it is dry and powdery mildew is a concern or problem in vineyard, sulfur would be the material of choice. Potassium bicarbonate or JMS Stylet Oil could also be used. If powdery is a problem, sprays should not exceed 10 to 14 days. If weather is wet, foliar infection by downy mildew may need to be controlled. A copper fungicide is most effective against downy mildew

Summer Spray Materials

Disease Controlled	**Material and Rate**
Powdery mildew	Flowable sulfur 6F (4 qt/A) or Wettable sulfur (8-10 lb/A) or Potassium bicarbonate (Kaligreen) (2.5-5 lb/A) or JMS Stylet Oil (1%)

Downy mildew and Powdery mildew	Bordeaux mixture or Fixed Copper fungicide
NOTE: Black rot should not be a problem during this period.	
Comments: Do not apply copper or sulfur within 30 days of harvest or fermentation may be affected.	
Post harvest	
Depending upon varieties, there may be considerable time between harvest and the first killing frost. Especially in wet years, post harvest applications of copper may be required to control downy mildew. If downy mildew develops to sufficient levels, it can result in premature defoliation. Premature defoliation prevents vines from hardening off properly and they are much more susceptible to winter injury.	