Crop Profile for Vinifera and French Hybrid Grapes in Pennsylvania

General Production Information

- **% U.S. Production:** 0.2%
- **Acres Planted:** 1200
- **Acres Harvested:** 1100
- **Cash Value:** $2,375,000
- **Yearly Production Costs:** $2,000,000
- **Commodity Destination:** 100% wine

Production Regions:
Vinifera and Hybrid production is concentrated in the southeast quadrant of the state below the Appalachian ridges and along the Piedmont Plain. Native American and Hybrid production is also located along the shore of Lake Erie. Smaller plantings exist in almost every county of the state.

Cultural Practices:
Cultivation of high quality wine grapes is a very labor and input intensive form of farming. Grapes are susceptible to a variety of disease and other pests and must be constantly protected during the growing season. Canopy management, harvest and other necessary practices involve large amounts of hand labor.

Wine grapes were first grown in Pennsylvania in the 1600s. The contemporary wine community began in 1968 with the passage of the Limited Winery Act and the establishment of wineries along the shore of Lake Erie. There are now over 60 wineries in Pennsylvania and almost 1200 acres of grapes devoted to wine grape production. The number of wineries and vineyards continues to expand rapidly, especially in the southeast counties of the state.

Pennsylvania viticultural industry is well situated both geographically and geologically. Being at the center of the Mid-Atlantic region, it is well situated to an enormous population base. This represents a tremendous market for wines. The Piedmont Plain is geologically diverse in many ways that are ideally suited for the production of high quality wine grapes. From its high calcium limestones, to grey schists and neutral shales, these well drained and moderately productive soils represent the ideal conditions for the classic European grapevines. The continental climate of Southeast Pennsylvania compares favorably with some of the great wine producing areas of France, Italy and Germany. But grapevines grow well in a wide range of conditions. Excellent wines are produced from the sandy soils of Erie County, where the lake effect helps to moderate the climate and protect delicate vinifera vines from harsh winter temperatures. Scattered around the state are vineyards and wineries that utilize modern viticulture technology to allow them to produce good wines under less than ideal growing conditions.

The summer climate presents a challenge to grape growers in Pennsylvania. Warm and humid conditions, significant rainfall, at times can ruin an entire crop. Disease, insect, and mite control are among the top priorities of any grower trying to produce high quality fruit. While the native varieties show considerable resistance to fungal infection, the hybrid and vinifera varieties must be constantly protected by a variety of fungicides. In addition to the use of pesticides, cultural practices such as canopy management are an essential supplement to every spray program. All of these practices are costly to growers. High quality wines exhibit a very low tolerance for unclean fruit. Just a small percentage of diseased grapes can alter the flavor of a wine. Wineries set strict standards on the amount of affected fruit that they will accept.

Fortunately for growers, there are new fungicides available to combat disease. The concern with many of these fungicides is resistance and growers must constantly monitor what class of chemical they are spraying and how often. Growers know that they must protect the effective chemicals in their arsenal. New computer modeling technology is being tested to allow growers to understand and utilize disease organism phenology to their advantage. Timing of sprays to coincide with infection periods can help to improve control and reduce total inputs. IPM is still an essential concept to responsible disease control. Many grape growers are interested in practicing sustainable, organic or even biodynamic viticulture as a way of protecting the environment and being good stewards of their land. These techniques have not yet been adequately refined to allow them to be use effectively in Pennsylvania's vineyards, but there are compelling environmental and marketing reasons to continue to pursue these forms of management.

Insect pests can be a significant problem in Pennsylvania's vineyards. Grape Berry Moth attacks berries just as they mature and create opportunities for secondary rot organisms to attack the berry. This can lead to a rapid decline in juice quality. Grape Root Borer may be a much more insidious problem. It is a known contributor to vine decline – a complex malady of older vineyards that cause vines to decline or die prematurely. Growers try to minimize the use of insecticides and will select the softer, user-friendlier materials as a first option. IPM techniques, such as scouting and monitoring, are important parts of any insect control program. As with fungicides, some new chemistry is helping growers, but resistance and diversity are a constant challenge. Education is the key to success. Growers must know what the threshold population levels for economic damage are for each insect pest in the vineyard.

Insect Pests

Angular Leaf Scorch

Type of Pest: Disease

Frequency of Occurrence: Angular leaf scorch is most likely to become a problem when high rainfall occurs during the period of early shoot growth.

Damage Caused: Disease symptoms occur mainly on the leaves and first appear as faint chlorotic spots. Lesions enlarge and change from yellow to reddish-brown, eventually killing the tissue. Lesions are confined by major veins and can have a yellow, red, or absent margin, depending on the cultivar. Infected leaves often fall prematurely.

% Acres Affected:35%

Pest Life Cycles: The fungus survives winter in infected leaves on the vineyard floor. Mature spores are ready for discharge in spring when grape buds begin to grow. During rainfall, spores are released into the air from fruiting structures and susceptible tissue is infected.

Timing of Control: Fungicides should be applied prior to rainfall, beginning at the 3-inch stage and continuing through fruit set. Angular leaf scorch is typically only a problem during years with extremely wet springs.

Yield Losses: Premature loss of leaves is detrimental to sugar accumulation in berries but is more detrimental to overall vine health in cold sensitive Vinifera varieties.

Regional Differences: There is higher potential for this disease in Southeastern Pennsylvania where it is routinely warm and wet.

Cultural Control Practices: Cultural practices that increase air circulation can reduce duration's of leaf wetness that favor disease development. Destruction of leaf litter by cultivation, before bud break, can also reduce disease incidence.

Biological Control Practices: None available at this time

Post-Harvest Control Practices: None

Other Issues: There is no currently labeled fungicide to control this disease. However, mancozeb utilized to control other diseases on grapes will control angular leaf scorch.

Black Rot

Type of Pest: Disease

Frequency of Occurrence: 3- to 5-inch shoot growth through approximately August 1

Damage Caused: Black rot is one of the most serious diseases of grapes in the eastern United States.

This disease can cause substantial crop loss under the appropriate environmental conditions. All green tissues of the vine are susceptible to infection.

% Acres Affected:75%

Pest Life Cycles: The black rot fungus overwinters primarily in mummified fruit on the vineyard floor or fruit retained within the vine. It can also overwinter within cane lesions. Spores within cane lesions are available for infection starting at bud break; however, the vast majority of spores (those within mummified fruit) first become available about 2-3 weeks after bud break, then reach peak levels from about 1-2 weeks before bloom until about 1-2 weeks after, depending on the year. Rain triggers the release of infective spores from mummies, and infection occurs if susceptible tissues remain wet for a sufficient length of time, which depends on temperature. Pycnidia develop within lesions caused by current season infections and release a new crop of spores during the summer. It is this secondary round of spore release and infection that is responsible for the majority of fruit rot damage. Thus, if very few current season infections are present, protective sprays can usually be stopped once most of the overwintering inoculum has been depleted (about the time berries become pea-sized). However, if more than a few current infections (and new spores) are present, protection must be maintained until fruit are no longer susceptible to infection.

Timing of Control: Disease severity the previous year and varietal susceptibility to black rot are the major factor in determining how early protection is required. Under heavy disease pressure protectant application could begin as early as 3-inch shoot growth on susceptible varieties.

Yield Losses: 100% in years of frequent early rainfall which favors development of primary infections.

Regional Differences: Differences in susceptibility among varieites and regional climatic differences are important to the development of the disease.

Cultural Control Practices: Removal of mummified clusters during pruning significantly reduces disease pressure for the coming season; spring cultivation to bury mummies also can contribute to a reduction of inoculum. Cultural practices that open the canopy are beneficial because they increase air circulation and improve spray coverage.

Biological Control Practices: None available at this time

Post-Harvest Control Practices: Removal of mummified berries during pruning

Other Issues: Many of the fungicides currently available for use in Pennsylvania vineyards provide control of more than one disease. Alternating different modes of action is recommended to delay resistance development. Fungicides are applied before infection as protectants.

Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates/ Acre	Timing	# of Appl.	PHI	REI
azoxystrobin (Abound) OUTSIDE ERIE COUNTY ONLY		foliar, ground	11-12 oz	3 to 5-inches of shoot growth (on highly susceptible varieties in years which frequent, early rainfall) to 3-4 weeks post bloom.	0-2	14	12
triadimefon (Bayleton)		foliar, ground	3-4 oz	10 to 12-inch shoot growth to 3-4 weeks post bloom	0-2	14	12
ferbam (Carbamate WDG)		foliar, ground	2 lbs/100 gallons	10 to 12-inch shoot growth to 3-4 weeks post bloom		7	24
Efficacy Issues:	Ziram is chemically related to ferbam and has the same general range of activity and effectiveness: good against black rot and Phomopsis, but only fair against downy mildew.						
mancozeb (Manzate, Dithane, Penncozeb)		foliar, ground	3-4 lb depending on formulation	3 to 5-inch shoot growth to 3-4 weeks post bloom	3-5	66	24
Efficacy Issues:	Mancozeb is chemically related to maneb + zinc salt and has the same general range of activity and effectiveness: good against black rot, downy mildew, and Phomopsis.						
maneb + zinc salt (Maneb Plus Zinc, Manex II)		foliar, ground	2.4-3.2 qt	3 to 5-inches of shoot growth to 3-4 weeks post bloom	3-5	66	24
Efficacy Issues:	Mancozeb is chemically related to maneb + zinc salt and has the same general range of activity and effectiveness: good against black rot, downy mildew, and Phomopsis.						
myclobutanil (Nova)		foliar, ground	4-5 oz	3 to 5-inches shoot growth to 3-4 weeks post bloom	0-2	14	24

Efficacy Issues:	Nova is used for both powdery mildew and black rot management. Reduced efficacy for powdery mildew has been observed in the field.						
ziram(Ziram)		foliar, ground	3-4 lb	6-inches shoot growth to 3-4 weeks after bloom.		21	48
Efficacy Issues:	Ziram is chemically related to ferbam and has the same general range of activity and effectiveness: good against black rot and Phomopsis, but only fair against downy mildew.						

Botrytis

Type of Pest: Disease

Frequency of Occurrence: Bloom through harvest

Damage Caused: Botrytis is a fungus that causes a bunch rot of clusters and may blight blossoms, leaves, and shoots. The bunch rot phase of the disease can cause severe economic losses, particularly on tight-clustered French hybrid and Vitis vinifera cultivars. Ripe berries are susceptible to direct attack and are particularly susceptible to infection through wounds caused by insects, hail, or cracking. Infections can spread rapidly throughout the cluster, causing withered and rotted berries. Gray masses of spores are frequently visible on infected plant parts.

% Acres Affected: 80%

Pest Life Cycles: The fungus overwinters in debris on the vineyard floor or on the vine. Spores are produced throughout the season, although their numbers appear to be much higher after veraison. Production of spores and subsequent infection are greatly favored by prolonged periods of wetness or very high humidity, particularly at moderate temperatures. The Botrytis fungus is most capable of attacking injured or senescing tissues; hence, infections usually occur as fruit are ripening or through wounds. Wounds caused by the grape berry moth are particularly common sites of infection. Under wet conditions, withering blossom parts can become infected between late bloom and bunch closing; such infections can lead to latent infections of the young berries, which then become active as the berries begin to ripen.

Timing of Control: A combination of the following timings: 50% bloom (in wet seasons), prior to bunch closure, 5° Brix and 14 days later. This depends on variety, disease history and weather conditions.

Yield Losses: Loss due to berry infection can be up to 100%

Regional Differences: Difference in susceptibility among varieties and regional differences are important considerations for the management of this disease.

Cultural Control Practices: Control of Botrytis is best accomplished through a combination of cultural and chemical procedures. Any practice that improves air circulation and thereby reduces humidity within the canopy is of significant benefit. These include site selection to avoid fog pockets and heavily wooded areas, and management of canopy densities through pruning, avoidance of excessive nitrogen, and selective leaf removal during the growing season.

Biological Control Practices: None available at this time

Post-Harvest Control Practices: None

Other Issues: Fungicides labeled for Botrytis have all been shown to be extremely prone to resistance development. The use of cultural practices and rotation of chemical controls is necessary to keep the tools we have available for the management of this disease working. Alternating different modes of action is recommended to delay resistance development. Fungicides are applied before infection as protectants.

Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates/ Acre	Timing	# of Appl.	PHI	REI
				Early-Maturing Varieties: Two applications, 1) when the disease is first observed or when the first berries reach 5° Brix, whichever comes first; and 2) 14 days after the first applications. Later-maturing varieties: The optimum timing for these varieties has not been researched			

iprodione *(Rovral)* *vanguard* *elevate*		foliar, ground	1.5-2 lb, 1.5-2 pt/ Acre depending on formulation 10 oz. 1 lb.	nearly as well. General observations indicate that the best strategy for such varieties is to make the first application at veraison (color change) , with the timing of subsequent sprays determined by label restrictions, weather, and the presence or absence of disease in the field. If only one application is planned (all varieties), wait until veraison or shortly thereafter, depending on weather and presence of disease.	0-2	7 7 0	12
Efficacy Issues:	The Botrytis fungus can develop resistance to both Rovral and Vangard after repeated exposure. Since these fungicides are prone to resistance, they should be rotated or tank-mixed during the growing season.						

Downy Mildew

Type of Pest: Disease

Frequency of Occurrence: 10-inch shoot growth to harvest

Damage Caused: Berries, leaves and young shoots can be infected. This can result in a loss of growth with early season shoot infection, premature defoliation with leaf infections and direct crop loss through berry infections.

% Acres Affected: 65%

Pest Life Cycles: The downy mildew fungus overwinters as dormant spores within infected leaves on the vineyard floor and first becomes active in the spring about 2-3 weeks before bloom (at approximately 10-inch shoot growth). Infective spores are then produced during rainy periods if temperatures are above 50 F, and are splashed onto susceptible tissues to cause the season's first (primary) infections. (Note that inoculum for such early-season infections comes from within the vineyard.) Epidemic disease development can then result from repeated cycles of secondary spread, which is caused by new spores produced within the white fungal growth on infected tissues. These spores are produced only at night when the relative humidity is extremely high (>95%). They can be blown relatively long distances and cause infection when they land on susceptible tissues that remain wet. (Note that later-season disease spread can be regional.) Thus, disease spread is most severe during periods when humid nights with moderate to warm temperatures (which allow the secondary spores to form) are followed the next day by rains or thundershowers (which allow them to germinate and cause new infection).

Timing of Control: 10-inch shoot growth through harvest, depending on frequency of early season rainfall, varietal susceptibility and overwintering inoculum.

Yield Losses: Can be 100% if early season infections to shoots, leaves and /or clusters are not controlled.

Regional Differences: Differences in susceptibility among varieites and regional differences are important to disease development.

Cultural Control Practices: Any practice that improves air circulation and speeds drying within vine canopies will help to control downy mildew. Spring cultivation to bury fallen, infected leaves from the previous year will also help to reduce early season disease pressure. However, properly timed fungicides are still necessary for reliable disease management.

Biological Control Practices: None available at this time

Post-Harvest Control Practices:

Other Issues: Many of the fungicides currently available for use in Pennsylvania vineyards provide control of more than one disease. Alternating different modes of action is recommended to delay resistance development. Fungicides are applied before infection as protectants.

Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates/ Acre	Timing	# of Appl.	PHI	REI
azoxystrobin (Abound) OUTSIDE ERIE COUNTY ONLY		foliar, ground	11-12 oz/Acre	Immediate prebloom, Immediate postbloom	0-2	14	12
Captan (Captan)		foliar, ground	2-4 lb depending on formulation	10 to 12-inch shoot growth through mid-summer	0-3	14	96
Copper (Copper)		foliar, ground	Varies by formulation	As needed	0-2	0	24-48
mancozeb (Manzate, Dithane, Penncozeb)		foliar, ground	varies by formulation	10 to 12-inch shoot growth to post bloom	0-3	66	24
maneb + zinc salt (Maneb + Zinc, Manex II)		foliar, ground	variable by formulation	10 to 12-inch shoot growth to post bloom	0-3	66	24
metalaxyl *(Ridomil Gold MZ, Ridomil/Copper/ Gold)*		foliar, ground	11-12 fl oz	Immediate prebloom to post bloom	0-2	66	48
Use in Resistance Management:	Resistance to Ridomil by the downy mildew fungus has been reported in several other countries. To reduce the risk of developing resistance, use no more than three total applications of Ridomil per season, and do not use to eradicate sporulating lesions on leaves or fruit.						

Eutypa Die Back

Type of Pest: Disease

Frequency of Occurrence: Spores are available during winter during rainfall or snow melt events.

Damage Caused: Eutypa dieback produces cankers in the cordons, or trunks, of a vine which slowly caused portions of the vine above the canker to die. The entire vine, or portions of the vine can be affected.

% Acres Affected: 20% -- Currently increasing. Expected to reach 40% in 10 years due to aging of vineyards.

Pest Life Cycles: In winter, during rainfall or snow melt, fungal spores are released from fruiting structures on dead infected wood. Spores are dispersed by the wind and infection occurs when they enter fresh pruning wounds. Cankers and foliage symptoms are not evident until two to four years after infection; then vine deterioration continues until the trunk or arm is finally killed. New shoots above cankers often appear stunted, with shortened internodes and small, cupped, greenish-yellow leaves in the spring. Healthy growth usually overgrows and obscures affected shoots by midsummer. Shoot and leaf symptoms become progressively worse each season until, eventually, no growth is produced.

Timing of Control: There is currently no chemical control with the loss of Benlate.

Yield Losses: Loss of vines due to infection can cause significant loss of crop if disease is not caught early and controlled.

Regional Differences:

Cultural Control Practices: Infected arms and trunks should be removed in late spring when foliar symptoms are noticeable and wounds are less susceptible to reinfection. Pruning should be far enough below the canker that healthy wood is evident. Any infected wood or stumps should be removed from the vineyard and burned.

Biological Control Practices: None available at this time

Post-Harvest Control Practices: None

<u>Phomopsis Cane and Leaf Spot and Fruit Rot</u>

Type of Pest: Disease

Frequency of Occurrence: Yearly, 1-inch shoot growth through immediate post bloom Shoot lesions can produce inoculum for a period of 5 to 7-years.

Damage Caused: All green tissues of the vine are susceptible to infection. Severely infected leaves are misshapen, yellow, and fall from the vine prematurely. Infected rachises are brittle so that portions of the cluster may fall off before harvest. Infected fruit are discolored and can drop to the ground before maturity.

% Acres Affected: 70%

Pest Life Cycles: Rainy weather during the early growing season favors disease development. Spores (pycnidiospores) are produced within the black fruiting bodies (pycnidia) and ooze out during wet weather. These spores are then splashed by the rain onto newly developing shoots. Shoot tips may become infected at any time during the year, but infection is more common between bud break and bloom. Shoot and leaf lesions typically appear 3 to 4 weeks after infection. Infection of the rachis can occur from the time clusters are first visible, when shoot growth measures 2- to 3-inches, through fruit set. Fruit becomes infected at or shortly after bloom, but the fungus remains latent until the fruits ripen. Symptoms of fruit rot and most rachis lesions begin to appear 1 to 3 weeks before harvest. Infected leaves may not develop symptoms until they become senescent. Some infections of the shoot may never develop symptoms but will produce pycnidia during the dormant season. The fungus overwinters on the vine in infected canes and rachises and may survive and sporulate in dead infected canes for more than one season. Spores from pycnidia are produced in the spring to renew the disease cycle.

Timing of Control: The critical period for development of the cane and leaf spot phase of the disease is during the first few weeks of growth (starting at 1-inch shoot growth). Rachises are susceptible from the time clusters first become visible until after pea-sized berries are formed. Fruit are most susceptible from bloom until after pea-sized berries are formed.

Yield Losses: When incidence of the disease is high, crop losses of 10 to 40 percent can occur.

Regional Differences: Varietal differences and differences in training systems are more apparent than regional differences.

Cultural Control Practices: None available

Biological Control Practices: None available at this time

Post-Harvest Control Practices: Removal of infected wood during dormant pruning. In cases of severe infection this method of control is not practical as the integrity of the training system would be compromised due to removal of canes used in the structure of the vine.

Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates/ Acre	Timing	# of Appl.	PHI	REI
azoxystrobin (Abound) OUTSIDE ERIE COUNTY ONLY		foliar, ground	11-12 oz/Acre	Immediate prebloom and/or immediate postbloom	0-2	14	12

captan (Captan, Captec)		foliar, ground	1.25-4 lb or 1.5-2 qt depending on formulation	1-inch shoot growth to 3-4 weeks post bloom	0-2	14	12
ferbam (Carbamate WDG)		foliar, ground	2 lbs/100 gallons	1-inch shoot growth to 3-4 weeks post bloom	0-2	7	24
mancozeb (Manzate, Dithane, Penncozeb)		foliar, ground	3-4 lb depending on formulation	1-inch shoot growth to 3-4 weeks post bloom	0-4	66	24
maneb + zinc salt (Maneb Plus Zinc, Manex II)		foliar, ground	2.4-3.2 qt	1-inches of shoot growth to 3-4 weeks post bloom	0-4	66	24

Powdery Mildew

Type of Pest: Disease

Frequency of Occurrence: 1-inch shoot growth through approximately August 1

Damage Caused: The powdery mildew fungus can infect all green tissues of the grapevine. It appears as a white or grayish-white powdery covering on the upper and lower surfaces of leaves and fruit. Expanding leaves that are infected become distorted and stunted. When green shoots are infected, the fungus appears dark brown to black and remains as brown patches on the surface of dormant canes. Cluster infection before or shortly after bloom may result in poor set and considerable crop loss. If berries are infected when they are pea-size or larger, the epidermis stops growing but the pulp continues to expand and the berry splits. When berries of purple or red cultivars are infected as they begin to ripen, they fail to color properly and have a blotchy appearance at harvest. Such fruit will produce wines with off flavors.

% Acres Affected: 100%

Pest Life Cycles: The powdery mildew fungus overwinters as cleistothecia on dead leaves and bark. Shortly after bud break, cleistothecia swell under moist conditions and break open, releasing the ascospores contained within. The ascospores may then cause infections on all green tissue. Lesions resulting from ascospore infections produce conidia, which spread the disease. Wind-borne spores (conidia) are produced abundantly on the infected tissue and spread the disease to neighboring vines. As adjacent leaves and flower clusters become infected, new conidia are produced on them and the disease can spread rapidly throughout the vineyard. In late summer the powdery mildew fungus produces black spherical bodies (cleistothecia) on the surface of the infected leaves, shoots, and berries.

Timing of Control: 1-inch shoot growth through late summer. One-inch spray is for highly susceptible varieties or problem areas if the weather forecasts call for rain and temperatures above 50°F. Sprays should not be delayed beyond the 3- to 5-inch stage for *V. vinifera* and other highly susceptible varieties.

Yield Losses: Severe, early season infections can result in 100% crop loss as the fruit becomes unmarketable for wine due to the off flavors the infected berries can transfer to the wine and there are no secondary markets for the infected crop.

Regional Differences: Varietal differences and regional differences are important.

Cultural Control Practices: Any practice that improves air circulation and thereby reduces humidity within the canopy is of significant benefit.

Biological Control Practices: None available at this time

Post-Harvest Control Practices: None available at this time

Other Issues: Many of the fungicides currently available for use in Pennsylvania vineyards provide control of more than one disease. Due to the risk of development of resistance to powdery mildew by the newer classes of fungicides, resistance management strategies have been developed which promote the integration of several fungicides with different modes of action to be used during each growing season. Alternating different modes of action is recommended to delay resistance development. Fungicides are applied before infection as protectants.

Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates/ Acre	Timing	# of Appl.	PHI	REI
azoxystrobin (Abound) OUTSIDE ERIE COUNTY ONLY		foliar, ground	11-12 oz	Immediate prebloom and/or immediate postbloom.	0-2	14	12
fenarimol (Rubigan)		foliar, ground	2-6 oz depending on time of year.	1-inch shoot growth to late summer.	0-4	30	12

paraffinic oil (JMS Stylet Oil)		foliar, ground	1-2% Conc.	1-inch shoot growth to late summer.	0-4	0	4
Use in Resistance Management:	JMS Stylet Oil can be used as a resistance management tool as it has a unique mode of action compared to the other pesticides used for powdery mildew.							
Efficacy Issues:	Thorough spray coverage is critical for the successful use of this product due to its mode of action. Some phytotoxicity has been seen with repeated applications in some varieties. Use of multiple applications of JMS Stylet Oil has been shown to reduce the rate of sugar accumulation which can be a detriment in seasons where sugar accumulation is slowed by weather conditions. JMS Stylet Oil is incompatible with many of the pesticides currently used in vineyard disease management in Pennsylvania. Care needs to be taken when using this product to limit use of other products prior to, during, and after the use of JMS Stylet Oil.							
triflumizole (Procure)		foliar, ground	4-6 oz/Acre	3 to 5-inches of shoot growth to 3-4 weeks post bloom	0-4	7	24
myclobutanil (Nova)		foliar, ground	4-5 oz/Acre	3 to 5-inches shoot growth to 3-4 weeks post bloom	0-4	14	24
Use in IPM Programs:	Nova can be used in powdery mildew management either on a protectant or post-infection basis. Using a post-infection program growers must be able to accurately monitor weather conditions as sprays are applied after an infection has occurred. Nova is effective against powdery mildew when applied within 72 hours after the start of an infection period. However, post-infection activity is strongly rate-dependent, thus high labeled rates must be used, particularly if extended kickback activity is required.							
Efficacy Issues:	Nova is used for both powdery mildew and black rot management. A slip in efficacy for powdery mildew has been observed in the field which may make this a less desirable choice of the sterol-inhibiting class of fungicides.							
fixed copper (COCS)		foliar, ground	2 lb + 4 lb of hydrated lime	Second post bloom through late summer.	0-2	0	24

Efficacy Issues:	Copper can be phytotoxic to some varieties. Berries of *V. vinifera* and certain hybrid varieties retain some susceptibility until veraison. Where powdery mildew management is needed, sprays must be applied even during extended dry periods when other diseases are not a threat. Fixed coppers will not control powdery mildew on highly susceptible varieties. Tank mixes of fixed copper and Nova should be sprayed out as soon as possible; periods of several hours or more in a solution with copper can reduce the effectiveness of Nova. Fixed copper plus lime should not be mixed with Bayleton, Carbamate, Guthion, Sevin, Imidan, or Thiodan.						
copper hydroxide (Champ 4.6F)		foliar, ground	1.33 pt + 3 lb of hydrated lime	Second post bloom through late summer.	0-2	0	48
Efficacy Issues:	Copper can be phytotoxic to some varieties. Berries of *V. vinifera* and certain hybrid varieties retain some susceptibility until veraison. Where powdery mildew management is needed, sprays must be applied even during extended dry periods when other diseases are not a threat. Copper hydroxide will not control powdery mildew on highly susceptible varieties. Tank mixes of Champ and Nova should be sprayed out as soon as possible; periods of several hours or more in a solution with copper can reduce the effectiveness of Nova. Champ should not be mixed with Bayleton, Carbamate, Guthion, Sevin, Imidan, or Thiodan.						
sulfur (Wettable sulfur, COCS, Super Six Liquid Sulfur)		foliar, ground	varies due to formulation	1-inch shoot growth through late summer.	0-6	0	24
Efficacy Issues:	Sulfur can be phytotoxic to some varieties. Sulfur will provide no more than 7-10 days protection following each spray. Sulfur is much less active at temperatures below 65°F, and may therefore provide mediocre control under heavy disease pressure. Many wine makers discourage the use of sulfur late in the season due to it’s effect on the wine making process and finished product.						

<u>Banded Grape Bug</u>

Type of Pest: Insect

Frequency of Occurrence: Sporadic pest of grapes. When present damage occurs between mid-May and early June

Damage Caused: Feeding injury results in floret drop, reduced berry set, and reduced cluster number

% Acres Affected: 5%

Pest Life Cycles: Nymphs of this insect emerge in the spring and feed, using their sucking and piercing mouth parts, on flowers and young berries. Injury by small nymphs, occurring between 3- to 5-inch shoot growth (around May 15) and early June, results in floret drop, reduced berry set, and reduced cluster number. Subsequent feeding by larger nymphs and adults does not affect cluster development. This injury only occurs in the early prebloom stages (between 5- and 10-inch shoot growth). Subsequent feeding by nymphs does not reduce berry set. Adults appear to be predaceous and do not cause injury to berries. This pest is sporadic and does not require treatment in most years.

Timing of Control: 3- to 10-inch shoot growth

Yield Losses: Up to 100% reduction in area infested by this pest through loss of florets. Reduction of crop size of 40% or more typical in heavy infestations.

Regional Differences: This pest appears to be more widespread in the Lake Erie region as opposed to southeastern Pennsylvania.

Cultural Control Practices: None available

Biological Control Practices: None available

Post-Harvest Control Practices: Not applicable

Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates/Acre	Timing	# of Appl.	PHI	REI
Carbaryl (Sevin)		Foliar, Ground	0.75 - 4 lb depending on formulation	3- to 5-inch shoot growth and 10- to 12-inches of shoot growth	1	7	12
Use in IPM Programs:	Used in conjunction with scouting protocol of examining clusters and shoot tips for presence of nymphs. Research has shown that due to the destructive nature of this pest ,an economic threshold of 1 nymph per 10 shoots is required to prevent crop loss.						

Climbing Cutworm

Type of Pest: Insect

Frequency of Occurrence: Sporadic pest of grapes. Cool springs which delay buds moving from bud swell to shoot growth favor injury by this pest.

Damage Caused: Feeding results in the loss of primary and in some instances loss of secondary and tertiary buds. Grapevines do compensate, at least to some extent, for primary bud loss through production of secondary buds. However, shoots from such buds are less fruitful than those from primary buds. When both primary and secondary buds are damaged the tertiary buds produce only a shoot but no fruit.

% Acres Affected: 1%

Pest Life Cycles: Larvae feed on the buds from full bud swell through bud break and until shoots are 10 to 15 cm long. Larvae hide during the day under the bark and in the soil litter beneath a vine and come out at night to feed.

Timing of Control: Bud swell

Yield Losses: In areas with high levels of feeding activity 30% crop reduction can occur. This pest can severely impact newly planted vineyards by destroying buds and delaying, or eliminating, shoot development needed to produce the necessary training systems.

Regional Differences: This pest is more prolific in the Lake Erie Region due to its preference of sandy, light textured soils.

Cultural Control Practices: Maintaining a vegetation-free band under the row can reduce habitat needed by the climbing cutworm to hide during the day.

Biological Control Practices: No alternatives have been shown to be viable at this time.

Post-Harvest Control Practices: Not applicable

Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates/Acre	Timing	# of Appl.	PHI	REI

Carbaryl (Sevin)	10	foliar, ground	2.5-4 lb, 2 qt depending on formulation	Bud swell	1	7	12
Use in IPM Programs:	Scouting for damaged buds is used prior to application of insecticide for this pest.						

European Red Mite

Type of Pest: Arachnid

Frequency of Occurrence: Sporadic to yearly pest of grapes depending on location.

Damage Caused: Given a head start, the vine can tolerate a fair amount of feeding damage on lower leaves. If mites get out on the shoot tips early in the season, however, they can stunt shoot development. Heavy mite infestations (20 to 30 mites per leaf) early in the season can cause stunted, chlorotic shoots with small leaves and pinpoint necrotic areas on leaves. Later in the season, as shoot growth rate declines and the vine allocates more resources to fruit, mites may also have an increased capacity to cause damage.

% Acres Affected: 15-25%

Pest Life Cycles: Mites overwinter as eggs on the bud scales. Nymphs appear very early in the growing season and pierce the leaf cells to extract plant juices. Both nymphs and adults feed on grape leaves. European red mite can have four to nine generations per year depending on weather conditions.

Timing of Control: Particular attention should be paid to the 1- to 4-inch shoot growth stage and immediate to 20 days postbloom. Vines should be monitored for the presence of this pest and acaricides applied if populations are over the economic threshold for that scouting period.

Yield Losses:

Regional Differences: Problems with spider mites in the Lake Erie region are uncommon. There is potential for serious infestations in wine varieties outside the Lake Erie region.

Cultural Control Practices:

Biological Control Practices: Predatory mites, when present in the vineyard at sufficient densities, can provide excellent biological control of spider mites. Recent research indicates that frequent use of mancozeb fungicides (a common fungicide in vineyard disease management programs) reduce predatory mite populations.

Post-Harvest Control Practices: Not applicable

Other Issues:

Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates/ Acre	Timing	# of Appl.	PHI	REI
Osdicofol (Kelthane)		foliar, ground	1.5-3.5 lb depending on formulation	When scouting indicates mite populations are above threshold	1-2	7	12
Use in IPM Programs:	Scouting for European red mite can be accomplished at any time after bud break. Particular attention should be paid to the 1- to 4-inch stage and immediate to 20 days postbloom period.						
hexakis fenbutatin-oxide (Vendex)		foliar, ground	1.25-2.5 lb	When scouting indicates mite populations are above threshold	1-2	28	48
Use in IPM Programs:	Scouting for European red mite can be accomplished at any time after bud break. Particular attention should be paid to the 1- to 4-inch stage and immediate to 20 days postbloom period.						

Grape Berry Moth

Type of Pest: Insect

Frequency of Occurrence: There are three to five generations of this pest every year. Grape Berry Moth is one of the most serious insect pests affecting grapes in Pennsylvania.

Damage Caused: Direct feeding on clusters by larvae during the bloom period. After berries have developed, larvae enter berries and feed within. Late season feeding results in damage to multiple berries per clusters as berry enlargement causes berries to touch each other facilitating movement of a single larvae from berry to berry within a cluster.

% Acres Affected: 90%

Pest Life Cycles: Overwintered pupae emerge as adult moths in late May and lay eggs among the grape clusters. The larvae are small (up to 0.38 inch long) and feed internally in grape berries. The larvae cut flaps in grape leaves and pupate inside, emerging as adult moths (wingspan is 0.5 inch). Three to five generations of this pest can occur each season depending on length, and heat accumulation, of growing season.

Timing of Control: Timing of sprays is correctly determined using the Grape Berry Moth Risk Assessment protocol and scouting. Timings could include: 10 days post bloom, first week in August and first week in September. Applications are made using the Grape Berry Moth Risk Assessment Protocol developed by Hoffman and Dennehy. The Risk Assessment Protocol is detailed in Bulletin No. 138. Risk Assessment for Grape Berry Moth and Guidelines for Management of the Eastern Grape Leafhopper. This bulletin can be found on line at: http://www.nysaes.cornell.edu/ipmnet/ny/fruits/grapes/grmanfs/risk.pdf

Yield Losses: Percent crop loss has not been determined but research has shown 50-80% cluster infestation at harvest is not uncommon and complete crop loss can occur. Secondary fungal infection can seriously affect wine quality.

Regional Differences: No regional differences are apparent. Vineyards located next to wooded areas, those having prolonged snow cover, and or vineyards in areas where winter temperatures are mild (i.e. lake plains) are more susceptible to infestation by grape berry moth. High risk vineyard sites are found across Pennsylvania.

Cultural Control Practices: No feasible cultural control practices are available

Biological Control Practices: While research is being conducted on biological alternatives for grape berry moth no economically feasible alternatives are currently available.

Post-Harvest Control Practices: Not applicable

Other Issues:

Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates/ Acre	Timing	# of Appl.	PHI	REI

Carbaryl (Sevin)		foliar, ground	2.5-4 lb, 2.5 qt depending on formulation	Timing is determined by used the Grape Berry Moth Risk Assessment protocol.	0-3	7	12
Use in IPM Programs:	Prior to use of insecticide, vineyards are rated using the grape berry moth risk assessment protocol to determine timing of scouting and the need for insecticide applications.						
azinphosmethyl (Guthion)		foliar, ground	1.5 lb	Timing is determined by used the Grape Berry Moth Risk Assessment protocol.	0-3	0-10	48
Use in IPM Programs:	Prior to use of insecticide, vineyards are rated using the grape berry moth risk assessment protocol to determine timing of scouting and the need for insecticide applications.						
phosmet (Imidan)		foliar, ground		Timing is determined by used the Grape Berry Moth Risk Assessment protocol.	0-3	14	24
Use in IPM Programs:	Prior to use of insecticide, vineyards are rated using the grape berry moth risk assessment protocol to determine timing of scouting and the need for insecticide applications.						
bacillus thuringiensis (Dipel 2X)	<1	foliar, ground	0.5-1 lb	Timing is determined by used the Grape Berry Moth Risk Assessment protocol.	0-6	0	4
Use in IPM Programs:	Prior to use of insecticide, vineyards are rated using the grape berry moth risk assessment protocol to determine timing of scouting and the need for insecticide applications.						

Efficacy Issues:	Research has shown that to be effective in the management of grape berry moth two applications of Dipel 2X are required as a replacement for each conventional insecticide application. Applications are timed just prior to the conventional timing and one week later. The double application of this material makes it difficult to justify economically.							
bacillus thuringiensis (Biobit)	<1	foliar, ground	1.5-3 pints	Timing is determined by used the Grape Berry Moth Risk Assessment protocol.	0-6	0	4
Use in IPM Programs:	Prior to use of insecticide, vineyards are rated using the grape berry moth risk assessment protocol to determine timing of scouting and the need for insecticide applications.							
Efficacy Issues:	Research has shown that to be effective in the management of grape berry moth two applications of Dipel 2X are required as a replacement for each conventional insecticide application. Applications are timed just prior to the conventional timing and one week later. The double application of this material makes it difficult to justify economically.							
methomyl (Lannate)		foliar, ground	0.5-1 lb	Timing is determined by used the Grape Berry Moth Risk Assessment protocol.	0-3	14	168
Use in IPM Programs:	Prior to use of insecticide, vineyards are rated using the grape berry moth risk assessment protocol to determine timing of scouting and the need for insecticide applications.							
fenpropathrin (Danitol)		foliar, ground	10.66 oz	Timing is determined by used the Grape Berry Moth Risk Assessment protocol.	0-3	2	24hr
Use in IPM Programs:	Prior to use of insecticide, vineyards are rated using the grape berry moth risk assessment protocol to determine timing of scouting and the need for insecticide applications.							

Grape Cane Gallmakers

Type of Pest: Insect
Frequency of Occurrence: Early spring
Damage Caused: Gall-like swellings on canes are caused by the oviposition injury. Galls are usually twice as thick as the cane and 2.5 to 4 cm long. In newly planted vineyards gallmaker can destroy canes necessary for developing a training system, resulting in an extra year being necessary before a crop can be harvested from the vine. Galls usually have little effect on vigor and growth of mature vines but they can weaken the mechanical strength of the cane and cause breakage. In cases of severe infestations, shoot length can be severely stunted resulting in the loss of the crop on infested canes and the loss of the shoot for canopy management for next year.
% Acres Affected: 10%
Pest Life Cycles: The grape cane gallmakers has only one generation per year.
Timing of Control: 4 to 6-inches of shoot growth
Yield Losses: In newly planted vineyards gallmaker can destroy canes necessary for developing a training system, resulting in an extra year being necessary before a crop can be harvested from the vine. Galls usually have little effect on vigor and growth of mature vines but they can weaken the mechanical strength of the cane and cause breakage. In cases of severe infestations, shoot length can be severely stunted resulting in the loss of the crop on infested canes and the loss of the shoot for canopy management for next year.
Regional Differences: Appears to be most common along Lake Erie.
Cultural Control Practices: Removal of infected canes below the galls during dormant pruning. This is not always feasible if infestation was severe or if canes are needed to maintain training system.
Biological Control Practices: None available
Post-Harvest Control Practices: None available

Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates	Timing	# of Appl.	PHI	REI
phosmet *(Imidan)*	5	Foliar, ground	2-3 lb per acre	3 to 5 inch shoot growth	0-1	14	24

Grape Cane Girdlers

Type of Pest: Insect
Frequency of Occurrence: 10 to 12-inch shoot growth.
Damage Caused: The girdling by the female causes the terminal growth of the new shoots to bend over above the upper girdle and drop to the ground. Later the whole infested shoot dies back to the lower

girdle and falls from the vine. Vines 'pruned' by the grape cane girdler have a ragged appearance suggesting serious injury to the plant. However, the actual damage is usually minor. Girdling of the terminal growth has little or no effect on the crop unless fruit-producing nodes are close to attacked shoot tips.
% Acres Affected: 10%
Pest Life Cycles: Adult beetles emerge from infested canes during August and subsequently overwinter in trash on the ground. In May of the following year the adults leave their overwintering sites. When grape shoots are 30 to 50 cm long, usually in late May, the female begins to lay her eggs and girdle new canes. Egg-laying continues for about one month.
Timing of Control: 10 to 12-inches of shoot growth
Yield Losses: Girdles are generally beyond the last grape cluster, so there is usually no loss of fruit, except in years of heavy infestation.
Regional Differences: Appears to be most common outside Lake Erie region.
Cultural Control Practices: Removal and burning of infested canes below the girdle prior to the emergence of adults in late summer.
Biological Control Practices: None available
Post-Harvest Control Practices: None available
Other Issues:
Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates/ Acre	Timing	# of Appl.	PHI	REI
azinphosmethyl (Guthion)	5	Foliar, ground	0.5 lb per acre	10 to 12-inches of shoot growth	0-1	0-10	48
phosmet (Imidan)	5	Foliar, ground	2-3 lb per acre	3 to 5 inch shoot growth	0-1	14	24

Grape Flea Beetles

Type of Pest: Insect
Frequency of Occurrence: A sporadic pest which does it damage at bud swell to 3-inches of shoot growth. This pest is most damaging in years with cool springs which prolong the time which buds remain in the bud swell to 3-inch shoot growth stage.
Damage Caused: Overwintering adults attack the swelling buds by boring into them and hollowing out the inside. In contrast, the larvae and summer adults feed on the tender leaf tissues but avoid the leaf veins. Feeding on the primary buds is by far the more serious damage by this insect, causing yield loss and stunted growth from secondary or tertiary
% Acres Affected: 5%

Pest Life Cycles: The grape flea beetle is one of the first insect pests to appear in vineyards in the spring. There is only one generation per year. Overwintering adults become active and migrate to the grapevines at about the time grape buds begin to swell. Overwintering adults attack the swelling buds by boring into them and hollowing out the inside. Eggs are placed on the hardened scales surrounding the buds, but most are laid under the loose bark of the canes and near the buds. As foliage develops some eggs are laid on the upper side of the leaves but none are deposited on the underside. The larvae and summer adults feed on the tender leaf tissues but avoid the leaf veins.
Timing of Control: Bud swell
Yield Losses: The amount of yield loss varies from year to year. It is more serious in years when bud development is prolonged by unfavorable climatic conditions. Feeding on the primary buds is by far the more serious damage by this insect, causing yield loss and stunted growth by the secondary and tertiary buds. No fruit develops on canes where the primary and secondary buds were destroyed.
Regional Differences: No regional differences are evident.
Cultural Control Practices: Cleaning up wasteland and woodland areas located near cultivated vineyards eliminates or reduces hibernating sites. Frequent disking to control weeds between grape rows can also break the pupal cells in the soil. However, the practice of disking has been reduced in recent years due to concerns over erosion, poor economics as a weed management method and the need for a firm vineyard floor for various vineyard operations occurring throughout the summer (especially after heavy rainfalls)
Biological Control Practices: None available
Post-Harvest Control Practices: None available
Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates/Acre	Timing	# of Appl.	PHI	REI
carbaryl (Sevin)		Foliar, ground	1.25-4 lb depending on formulation	Bud swell	0-1	7	12

Grape Leafhoppers:

Type of Pest: Insect
Frequency of Occurrence: One to two generations per year depending on growing degree day accumulations. Leafhoppers are present every year at varying levels.
Damage Caused: Both the adults and nymphs feed on the underside of grape leaves by piercing the tissue and sucking out the plant juices. Damaged leaves become mottled with yellow dots. Excessive feeding can result in necrosis of large areas of leaf surface. A moderate infestation of grape leafhopper does not affect yield and quality significantly.
% Acres Affected: 50%
Pest Life Cycles: Adults overwinter in leaves and litter and enter vineyards in the spring and feed on sucker leaves. These overwintered adults generally do not cause serious damage. Depending on growing degree day (heat units) accumulations, one to two generations occur. Rapid population increases are

most likely in hot, dry years.
Timing of Control: Timing of control measures is determined using the leafhopper scouting protocol. Control measures are typically timed in conjunction with grape berry moth scouting with insecticide applications specifically for leafhoppers necessary only if an insecticide for grape berry moth is not required.
Yield Losses: Research has shown that the only time significant yield losses occur are during seasons which are hot (which drives increases in leafhopper populations) and dry enough to put vines under water stress. Moderate to heavy feeding by leafhoppers in a "normal" year can produce a slight decrease in sugar accumulation causing grapes to be harvested later in the season and reducing the time period vines have to recover prior to the first frost.
Regional Differences: Regional differences are not as critical as differences between varieties. Different species of leafhopper are found on Vinifera and Hybrid grapes than on Labrusca-type cultivars. Labrusca-type grapes (i.e. Concord, Niagara, Catawba, Delaware) have Erythroneura comes, also known as Eastern grape leafhopper. Hybrids and Vinifera grapes are infested by other Erythroneura leafhopper species, principally Erythroneura bistrata. The species of leafhoppers found on hybrid and vinifera grapes are not affected by resistance at this time.
Cultural Control Practices: None available
Biological Control Practices: Research has been conducted using Anagros epos, a wasp which parasitizes leafhopper eggs. This wasp is found in the wild but has not been shown to be effective in keeping leafhopper population below economic levels during years of high infestations.
Post-Harvest Control Practices: None available
Chemical Controls:

Pesticide	**% Trt.**	**Type of Appl.**	**Typical Rates/ Acre**	**Timing**	**# of Appl.**	**PHI**	**REI**
Carbaryl *(Sevin)*		foliar, ground	.75 lb - 2 lb or 0.5-1 qt depending on formulation	Immediate prebloom or end of July. Timing of control measures is linked to grape berry moth risk assessment protocol scouting. Treatment for leafhopper is only necessary if leafhopper populations exceed threshold and no insecticide is required for grape berry moth.	0-1	7	12

				In most vineyards, which are classified as being at high or intermediate risk for grape berry moth damage, insecticide applications for grape berry moth also control leafhopper populations.			
Use in IPM Programs:	Leafhopper is typically only a problem in vineyards which are classified as being at low risk for grape berry moth and where scouting does not indicate a need for control of berry moth. Scouting protocols have been established and are used by growers in determining the need for insecticide applications for leafhoppers.						
Insecticidal Soap (M-Pede)		?	?	?	?	?	?
imidcloprid (Provado)		foliar, ground	0.75 - 1 oz	Immediate prebloom or end of July. Timing of control measures is linked to grape berry moth risk assessment protocol scouting. Treatment for leafhopper is only necessary if leafhopper populations exceed threshold and no insecticide is required for grape berry moth. In most vineyards, which are classified as being at high or intermediate risk	0-1	0	12

				for grape berry moth damage, insecticide applications for grape berry moth also control leafhopper populations.			
Use in IPM Programs:	Provado is a selective insecticide which works effectively against leafhopper without harming beneficial mite predators. In situations where only leafhopper management is necessary (grape berry moth is under threshold), Provado is a good alternative to the broad spectrum insecticides such as Sevin, Penncap, or Guthion which have been shown to decrease the predatory mite populations in some vineyards resulting in damaging populations of European red mite.						
Use in Resistance Management:	Provado has been shown to be effective in controlling leafhopper populations where resistance to Carbaryl or methyl parathion has developed.						
methomyl *(Lannate)*		foliar, ground	0.5 - 1 lb	Immediate prebloom or end of July. Timing of control measures is linked to grape berry moth risk assessment protocol scouting. Treatment for leafhopper is only necessary if leafhopper populations exceed threshold and no insecticide is required for grape berry moth. In most vineyards, which are classified as being at high or intermediate risk for grape berry moth damage, insecticide applications for	0-1	14	168

				grape berry moth also control leafhopper populations.			

Grape Phylloxera:

Type of Pest: Insect
Frequency of Occurrence: Yearly, from 5-inches of shoot growth to harvest
Damage Caused: Heavily infested leaves may fall prematurely, retarded shoot growth, and decreased vine vigor or vine death if roots are heavily infested.
% Acres Affected: 90%
Pest Life Cycles: This small aphid-like insect has a complex life cycle that involves survival on the roots throughout the year, and on the leaves during the growing season. The sequence of events in the life cycle is different for the foliar and root forms of this insect. The foliar form survives the winter as an egg under the bark of the grapevine. Asexual, wingless forms hatch in the spring and crawl onto the new leaves, where they develop galls. Young crawlers settle on the upper surface of immature leaves, causing galls to form on the under surface of the leaves. The only opening in a gall is to the upper leaf surface. Once mature, the female begins to lay eggs within a gall. Nymphs hatching from these eggs crawl to new leaves at shoot tips, settle on the leaves, and form new galls. In the case of the root form of grape phylloxera, the insects overwinter as immature forms on the roots. These forms mature in the spring and produce eggs that hatch into nymphs. The nymphs then start new galls on the roots. Winged forms develop in the spring, summer or fall and emerge from the soil to lay eggs on stems. These eggs hatch and produce the true sexual forms that produce the overwintering eggs laid under the bark. Several generations of each form of phylloxera may occur each season. Although the two forms behave differently, both belong to the same species of phylloxera that occurs on the leaves and roots of grapes. (Information from Bulletin 861, Midwest Small Fruit Pest Management Handbook, Ohio State University, 1997.)
Timing of Control: Foliage should be examined on a weekly basis before and after bloom. Apply spray when first galls are detected; spray again 10 to 12 days later if new growth becomes infested.
Yield Losses: Serious losses can occur in own rooted susceptible varieties.
Regional Differences: Regional differences are not as apparent as differences in susceptibility between varieties
Cultural Control Practices: Loss by the root feeding form can be substantially reduced by grafting to a phylloxera-resistant rootstock. This grafting will not affect injury caused by the leaf gall form of the phylloxera
Biological Control Practices: There are some natural predators which feed upon the foliar form of grape phylloxera, but none of these provide adequate control of the pest and none are available commercially.
Post-Harvest Control Practices: Not applicable

Other Issues: There is no registered compound for control of room form phyloxera. This is a serious concern.
Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates/ Acre	Timing	# of Appl.	PHI	REI
endosulfan (Thiodan)		Foliar, ground	2 lb	Apply when galls are first detected; spray again 10-12 days later if new growth is infested.	0-2	7	24

Grape Rootworm:

Type of Pest: Insect
Frequency of Occurrence: Mid- to late May through July
Damage Caused: Grape rootworm is a beetle that feeds on grape foliage as an adult, producing chain-like feeding patterns on the leaves. Immature stages, however, feed on grape roots, and can cause serious damage and vineyard decline over a period of years if left untreated.
% Acres Affected: 5%
Pest Life Cycles: The grape rootworm produces only one generation per year. During its lifetime, a rootworm will begin as an eggs which is deposited under the bark of grape vines by an adult female. It will spend the following 9 to 10 months of its life in the immature grub stage in the soil feeding on roots, and will spend the ultimate month or so of its life as an adult feeding on grape foliage and laying eggs. The grape rootworm requires at least one year to complete its life cycle.
Timing of Control: An insecticide is applied when the chain-like feeding of the adult is first seen in the vineyard.
Yield Losses: If uncontrolled, root feeding by the immature stage of rootworm can lead to vineyard decline and total crop loss.
Regional Differences: Grape rootworm has historically been of a concern more in the Lake Erie Region than other areas.
Cultural Control Practices: None available
Biological Control Practices: None available
Post-Harvest Control Practices: Not applicable
Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates/ Acre	Timing	# of Appl.	PHI	REI

carbaryl (Sevin)	10	Foliar, ground	1.25-2 lb depending on formulation	10 to 12 inches of shoot growth or when adult feeding is first seen on leaves (feeding is typically seen on leaves of suckers first)	1	7	12
Use in IPM Programs:	Scouting for leaf feeding by adults is the trigger for an insecticide application.						

Japanese Beetles:

Type of Pest: Insect
Frequency of Occurrence: Mid-summer
Damage Caused: Damage is caused by direct feeding on the leaves
% Acres Affected: 50%
Pest Life Cycles: This pest overwinters as a larva below the soil surface. During late spring, larvae move closer to the soil surface and complete their development, with the larvae feeding principally on roots. Adults emerge in late-June or early-July and begin feeding on foliage. Mating occurs at this time and eggs are laid in the thatch layer of soil and take approximately 10 days to hatch. Young grubs begin feeding on plant roots and continue to feed until cold weather, at which time they tunnel 3 to 12 inches down into the soil where they construct overwintering cells. There is one generation per year.
Timing of Control: After beetles appear in early to mid-July
Yield Losses: Damage is mostly cosmetic in vigorously growing vines. Excessive foliar feeding in newly planted vineyards can result in delayed root and canopy development resulting in a delay of one year or more in terms of full crop production.
Regional Differences: No regional differences are apparent.
Cultural Control Practices: None available
Biological Control Practices: No economically effective biological control is available for grapes at this time.
Post-Harvest Control Practices: Not applicable
Other Issues:
Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates/ Acre	Timing	# of Appl.	PHI	REI

Carbaryl(Sevin)	10	Foliar, ground	2.5 - 4 lb or 2 qt per acre depending on formulation	Early to mid-July when damage from feeding is considered to be detrimental.	0-1	7	12
Azinphosmethyl (Guthion)	1	Foliar, ground	1.5 lb per acre	Early to mid-July when damage from feeding is considered to be detrimental.	0-1	0-10	48
Phosmet(Imidan)	2	Foliar, ground	3 lb	Early to mid-July when damage from feeding is considered to be detrimental.	0-1	14	24

Grape Root Borer:

Type of Pest: Insect
Frequency of Occurrence: Annually, will feed on grape roots for a two year period.
Damage Caused: Can cause total vineyard loss if left uncontrolled.
% Acres Affected: 70%
Pest Life Cycles: Mature larvae burrow to just below the soil surface, spin a dirty brown silk cocoon,, and pupate. Adults emerge in mid- to late summer, mate and lay eggs beneath the vines. The eggs hatch and re-enter the root system.
Timing of Control: Preventative control only. Soil barrier of chlorpyrifos must be in place when adult root borers are flying (first week in July).
Yield Losses: Complete vineyard loss if left uncontrolled.
Regional Differences: Does not appear in Lake Erie production.
Cultural Control Practices: None available
Biological Control Practices: None available
Post-Harvest Control Practices: Not applicable
Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates/Acre	Timing	# of Appl.	PHI	REI
Carbaryl (Sevin)	70	5 foot band	4.5 pints per 100 Gal. 2 quarts of mixture per vine	Late July	1	35	5 days

<u>Potato Leafhopper</u>:

Type of Pest: Insect
Frequency of Occurrence: Sporadic pest of grapes. When present damage occurs between mid-May and early June
Damage Caused: Feeding injury results in floret drop, reduced berry set, and reduced cluster number
% Acres Affected: 10%
Pest Life Cycles: Over-inters in south and migrates annually.
Timing of Control: July-August
Yield Losses: Weakens plant by sucking sap from the plant's vascular system and injection of a salivary toxin that produces characteristic symptoms including leaves with yellow margins that are cupped downward and dark and light green coloration.
Regional Differences: None
Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates/ Acre	Timing	# of Appl.	PHI	REI
Carbaryl *(Sevin)*		foliar, ground	.75 lb - 2 lb or 0.5-1 qt depending on formulation	Immediate prebloom or end of July. Timing of control measures is linked to grape berry moth risk assessment protocol scouting. Treatment for leafhopper is only necessary if leafhopper populations exceed threshold and no insecticide is required for grape berry moth. In most vineyards, which are classified as being at high or	0-1	7	12

				intermediate risk for grape berry moth damage, insecticide applications for grape berry moth also control leafhopper populations.			
Use in IPM Programs:	Leafhopper is typically only a problem in vineyards which are classified as being at low risk for grape berry moth and where scouting does not indicate a need for control of berry moth. Scouting protocols have been established and are used by growers in determining the need for insecticide applications for leafhoppers.						
Insecticidal Soap (M-Pede)		?	?	?	?	?	?
imidcloprid (Provado)		foliar, ground	0.75 - 1 oz	Immediate prebloom or end of July. Timing of control measures is linked to grape berry moth risk assessment protocol scouting. Treatment for leafhopper is only necessary if leafhopper populations exceed threshold and no insecticide is required for grape berry moth. In most vineyards, which are classified as being at high or intermediate risk for grape berry moth damage, insecticide	0-1	0	12

				applications for grape berry moth also control leafhopper populations.			
Use in IPM Programs:	Provado is a selective insecticide which works effectively against leafhopper without harming beneficial mite predators. In situations where only leafhopper management is necessary (grape berry moth is under threshold), Provado is a good alternative to the broad spectrum insecticides such as Sevin, Penncap, or Guthion which have been shown to decrease the predatory mite populations in some vineyards resulting in damaging populations of European red mite.						
Use in Resistance Management:	Provado has been shown to be effective in controlling leafhopper populations where resistance to Carbaryl or methyl parathion has developed.						
methomyl *(Lannate)*		foliar, ground	0.5 - 1 lb	Immediate prebloom or end of July. Timing of control measures is linked to grape berry moth risk assessment protocol scouting. Treatment for leafhopper is only necessary if leafhopper populations exceed threshold and no insecticide is required for grape berry moth. In most vineyards, which are classified as being at high or intermediate risk for grape berry moth damage, insecticide applications for grape berry moth also control	0-1	14	168

				leafhopper populations.			
Pesticide	**% Trt.**	**Type of Appl.**	**Typical Rates/ Acre**	**Timing**	**# of Appl.**	**PHI**	**REI**
Carbaryl *(Sevin)*		Foliar, Ground	0.75 - 4 lb depending on formulation	3- to 5-inch shoot growth and 10- to 12-inches of shoot growth	1	7	12
Use in IPM Programs:	Used in conjunction with scouting protocol of examining clusters and shoot tips for presence of nymphs. Research has shown that due to the destructive nature of this pest ,an economic threshold of 1 nymph per 10 shoots is required to prevent crop loss.						

Grape Tumid Gallmaker:

Type of Pest: Insect
Damage Caused: Feeding injury results in floret drop, reduced berry set, and reduced cluster number
% Acres Affected: 1%
Pest Life Cycles: It lays its eggs in masses between developing tissues at the bud or shoot tips from early May to mid-September. It is the larvae of this species that causes injury to grape plants. After hatching, the larvae bore into vine tissue and cause a round, reddish gall to form. These galls can develop on leaf tissue or petioles, where they probably do little actual damage to the vine, or the grape clusters, where there is more concern about economic injury. Hence, the greatest concern for this pest is in the early part of the season.
Timing of Control: 3- to 10-inch shoot growth
Yield Losses: Causes <10% yield loss to infected plants.
Regional Differences: None
Cultural Control Practices: None available
Biological Control Practices: None available
Post-Harvest Control Practices: Not applicable
Other Issues: No registered treatment is currently recommended in Pennsylvania.

Broadleaf weeds:

Type of Pest: Weed
Frequency of Occurrence: Yearly, throughout the season

Damage Caused: Weeds compete directly with the vine for water and nutrients. Weed growth under the row in vineyards has been shown to be responsible for stunted vine size and crop reduction.
% Acres Affected: 100%
Pest Life Cycles: Variable due to species of broadleaf weed
Timing of Control: Prior to emergence, prebloom
Yield Losses: Up to 30% dependent on species of weeds present and degree of ground surface covered. Reduction in vine size due to competition of weeds for water and nutrients can result in decreased yield capacity over the next several growing seasons.
Regional Differences: None
Cultural Control Practices: The practice of "hilling up" or pushing a berm of soil against the vine and "pulling away", or the removal of the berm, can reduce weed populations under the row. However, these practices are labor intensive and less cost efficient than traditional pesticide based practices.
Biological Control Practices: None available
Post-Harvest Control Practices: Not applicable
Other Issues:
Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates	Timing	# of Appl.	PHI	REI
oxyflourfen (Goal 2X)		Soil applied, ground	5-8 pt per acre surface sprayed	Prior to bud swell. Application must be made prior to the emergence of weeds to be controlled.	0-1	N/A	24
paraquat (Gramoxone Extra)		Weed foliage, ground	2-3 pt per acre surface sprayed	Gramoxone should be applied to emerged weeds when they are small. Weeds 1 to 6-inches tall are easiest to control	0-2	0	48

Use in IPM Programs:	Gramoxone has been successfully used in a post emergence weed management program which uses no preemergence herbicides. Weeds are allowed to grow to an average height of 6-inches prior to the first application of Gramoxone. A second application (and possibly a third), if necessary, is applied when regrowth of weeds reaches 6-inches in height. This program has been shown to provide weed management comparable to that of a conventional weed management program that uses both pre- and postemergence herbicides.						
Efficacy Issues:	The use of post emergence herbicides is limited in Vinifera and French Hybrid vineyards where sucker growth is required for training system maintenance.						
diuron (Karmex DF)		Soil applied, ground	2-6 lb per acre surface sprayed	Apply in the spring just prior to the germination and growth of annual weeds.	0-1	0	12
Efficacy Issues:	The label urges caution for use on soils low in clay or organic matter (1-2%) and limits the rate to 2-3 lb/A under those conditions. Tank mix with Solicam or Surflan for improved annual grass control. Use only in vineyards established for at least 3 years.						
simazine (Princep Caliber 90, Princep 4L)		soil applied, ground	2.2-5.3 lb or 2.0-4.8 qt per acre surface sprayed depending on formulation	Apply between harvest and early spring.	0-1	0	12
glufosinate (Rely)		Weed foliage, ground	3-6 qt per acre surface sprayed. Rate is based on height and species of weeds present.	Best results are obtained when applications are made to actively growing weeds. Repeat applications may be necessary.	0-2	14	12
Use in IPM Programs:	Rely has been successfully used in a post emergence weed management program which uses no preemergence herbicides. Weeds are allowed to grow to an average height of 6-inches prior to the first application of Rely. A second application of Rely is applied when regrowth of weeds reaches 6-inches in height. This program has been shown to provide weed management comparable to that of a conventional weed management program that uses both pre-and post emergence herbicides.						

Efficacy Issues:	The use of post emergence herbicides is limited in Vinifera and French Hybrid vineyards where sucker growth is required for training system maintenance. Tank mixes with appropriate residual herbicides are recommended for broad-spectrum control and residual activity. Rely herbicide is not registered for use in Nassau and Suffolk Counties and must not be used in these locations.						
glyphosate (Roundup)		Weed foliage, ground	0.5-5 qt per surface acre sprayed in 40 or fewer gal of water. Proper rate is dependent upon many factors including weed species present, growth stage, and environmental factors.	Roundup applications should not be made when green shoots, canes or foliage are in the spray zone. Roundup should be applied prior to the end of bloom stage to avoid injury, or with shielded sprayers or wiper equipment, but not within 14 days of harvest. Perennial grasses can be controlled with fall Roundup applications which can be made after 100 percent natural grape leaf fall after harvest. Roundup applications should not be made when green shoots, canes, or foliage are in the spray zone. Roundup should be applied prior to	0-2	14	12

				the end of bloom stage to avoid injury, or with shielded sprayers or wiper equipment, but not within 14 days of harvest. Perennial grasses can be controlled with fall Roundup applications which can be made after 100 percent natural grape leaf fall after harvest.			
Use in IPM Programs:	Roundup can be used as a substitute for cultivation of the vineyard row middles (see Pool, R.M., R.M. Dunst, and J.S. Kamas. 1990. Managing Weeds in New York Vineyards. V. Managing Vineyard Floors Using No-tillage. Cornell GrapeFacts I-5).						
Use in Resistance Management:	Roundup may be tank mixed with preemergence herbicides according to label instructions to control both emerged and non-emerged weeds.						
Efficacy Issues:	Efficacy depends upon absorption into mature leaves. Addition of dry ammonium sulfate at 8.5 to 17 pounds per 100 gallons water may increase performance of Roundup when tank-mixed with residual herbicides. Roundup is most effective applied at lower gallonage and higher concentration.						
oryzalin (Surflan A.S.)		soil applied, ground	2-6 qt per acre surface sprayed.	May be applied in the fall or spring prior to weed germination.	0-1	0	12
Efficacy Issues:	Provides control of only some of the broadleaf weeds. Length of control depends on rate applied. It is not recommended for use on soils with organic matter content greater than 5 percent. Do not apply to newly planted vines until soil has settled.						

sulfosate (Touchdown)		weed foliage, ground	0.8-6.4 pt in 3 to 30 gal of water per surface acre sprayed. Proper rate is dependent upon many factors including weed species present, growth stage, and environmental factors.	Touchdown applications should not be made when green shoots, canes, or foliage are in the spray zone. Touchdown should be applied prior to the end of bloom stage to avoid injury, or with shielded equipment after bloom, but not within 14 days of harvest.	0-2	14	12
Efficacy Issues:	Addition of 8.5 to 17 lb dry ammonium sulfate (AMS), or equivalent rate of a liquid formulation of AMS, may improve control of annual and perennial weeds.						

Grasses:

Type of Pest: Weed
Frequency of Occurrence: Yearly, throughout the season
Damage Caused: Weeds compete directly with the vine for water and nutrients. Weed growth under, and between, the row in vineyards has been shown to be responsible for stunted vine size and crop reduction.
% Acres Affected: 100%
Pest Life Cycles: Variable due to species of grass
Timing of Control: Prior to emergence, prebloom
Yield Losses: Up to 30% dependent on species of weeds present and degree of ground surface covered. Reduction in vine size due to competition of weeds for water and nutrients can result in decreased yield capacity over the next several growing seasons.
Regional Differences: None
Cultural Control Practices:
Biological Control Practices: None available
Post-Harvest Control Practices: Not applicable
Chemical Controls:

Pesticide	% Trt.	Type of Appl.	Typical Rates	Timing	# of Appl.	PHI	REI
oxyfluorfen (Goal 2X)		Soil applied, ground, prior to weed emergence	5-8 pt per acre surface sprayed	prior to bud swell	1	N/A	">24
Efficacy Issues:	Tank mix with Solicam or Surflan for improved annual grass control. Cannot be applied to vines established less than 3 years unless vines are on a trellis wire at least 3 feet above the soil surface.						
paraquat (Gramoxone Extra)		Soil applied, ground	2-3 pt per sprayed acre	Gramoxone should be applied to emerged weed when they are small. Weeds 1 to 6-inches tall are easiest to control.	1-2	0	48
Use in IPM Programs:	Gramoxone has been successfully used in a post emergence weed management program which uses no preemergence herbicides. Weeds are allowed to grow to an average height of 6 inches prior to the first application of Gramoxone. A second application of Gramoxone is applied when regrowth of weeds reaches 6-inches in height. This program has been shown to provide weed management comparable to that of a conventional weed management program that uses both pre- and postemergence herbicides.						
Efficacy Issues:	The use of post emergence herbicides is limited in Vinifera and French Hybrid vineyards where sucker growth is required for training system maintenance.						
diuron (Karmex DF)		Soil applied, ground	2-6 lb per acre surface sprayed	Apply in the spring just prior to germination and growth of annual weeds.	0-1	0	12
Efficacy Issues:	The label urges caution for use on soils low in clay or organic matter (1-2%) and limits the rate to 2-3 lb/A on soils high in clay or organic matter. Tank mix with Solicam or Surflan for improved annual grass control. Use only in vineyards established for at least 3 years.						

sethoxydim (Poast)		Soil, ground	1.5-2.5 pt per acre surface sprayed	Application timing and rates are adjusted according to the species and growth stage of the weed.	1	50	12
Efficacy Issues:	Control is best when the weeds have not exceeded recommended growth stages and are not subject to environmental stresses. Addition of crop oil concentrate is recommended.						
simazine (Princep Caliber 90, Princep 4L)		Soil, ground	2.2-5.3 lb or 2.0-4.8 qt depending on formulation	Apply between harvest and early spring.	1	0	12
glufosinate (Rely)		Soil, ground	3-6 qt per acre surface sprayed. Rate is based on height and species of weeds present.	Best results are obtained when applications are made to actively growing weeds. Repeat applications may be necessary.	0-1	14	12
Use in IPM Programs:	Rely has been successfully used in a post emergence weed management program which uses no preemergence herbicides. Weeds are allowed to grow to an average height of 6 inches prior to the first application of Gramoxone. A second application of Gramoxone is applied when regrowth of weeds reaches 6-inches in height. This program has been shown to provide weed management comparable to that of a conventional weed management program that uses both pre- and postemergence herbicides.						
Efficacy Issues:	The use of post emergence herbicides is limited in Vinifera and French Hybrid vineyards where sucker growth is required for training system maintenance. Tank mixes with appropriate residual herbicides are recommended for broad-spectrum control and residual activity. Rely herbicide is not registered for use in Nassau and Suffolk Counties and must not be used in these locations.						

glyphosate (Roundup)		Soil, ground	0.5-5 qt per surface acre sprayed in 40 or fewer gal of water. Proper rate is dependent upon many factors including weed species present, growth stage, and environmental factors.	Roundup applications should not be made when green shoots, canes, or foliage are in the spray zone. Roundup should be applied prior to the end of blooms stage to avoid injury, or with shielded sprayers or wiper equipment, but not within 14 days of harvest. Perennial grasses can be controlled with fall Roundup applications which can be made after 100 percent natural grape leaf fall after harvest. Roundup applications should not be made when green shoots, canes, or foliage are in the spray zone. Roundup should be applied prior to the end of blooms stage to avoid injury, or with shielded	0-1	14	12

				sprayers or wiper equipment, but not within 14 days of harvest. Perennial grasses can be controlled with fall Roundup applications which can be made after 100 percent natural grape leaf fall after harvest.			
Use in IPM Programs:	Roundup can be used as a substitute for cultivation of the vineyard row middles (see Pool, R.M., R.M. Dunst, and J.S. Kamas. 1990. Managing Weeds in New York Vineyards. V. Managing Vineyard Floors Using No-tillage. Cornell GrapeFacts I-5).						
Use in Resistance Management:	Roundup may be tank mixed with preemergence herbicides according to label instructions to control both emerged and non-emerged weeds.						
Efficacy Issues:	Efficacy depends upon absorption into mature leaves. Addition of dry ammonium sulfate at 8.5 to 17 pounds per 100 gallons may increase performance of Roundup when tank-mixed with residual herbicides. Roundup is most effective when applied at lower gallonage and higher concentration.						
norflurazon (Solicam DF)		soil, ground	2.5-5.0 lb per acre surface sprayed. Rate is dependent upon soil texture.	Apply in fall or early spring prior to weed germination.	0-1	0	12
Efficacy Issues:	Solicam provides excellent season-long control of annual grasses and will also control several annual broadleaf species and provide some suppression of yellow nutsedge, plantains, and perennial grasses. Tank mixes with Karmex, Princep, or Surflan are needed to attain season-long, broad-spectrum weed control. Vines must be established at least 2 years.						
oryzalin (Surflan A.S.)		soil, ground	2-6 qt per surface acre sprayed.	May be applied in the fall or spring prior to weed germination.	0-1	0	12

Efficacy Issues:	Length of control depends on rate applied. It is not recommended for use on soils with organic matter content greater than 5 percent. Do not apply to newly planted vines until soil has settled.						
sulfosate (Touchdown)		weed foliage, ground	0.8-6.4 pt in 3 to 30 gal of water per surface acre sprayed. Proper rate is dependent upon many factors including weed species present, growth stage, and environmental factors.	Touchdown applications should not be made when greens hoots, canes, or foliage are in the spray zone. Touchdown should be applied prior to the end of bloom stage to avoid injury, or with shielded equipment after bloom, but not within 14 days of harvest.	0-2	14	12
Efficacy Issues:	Addition of 8.5 to 17 lb dry ammonium sulfate (AMS), or equivalent rate of a liquid formulation of AMS, may improve control of annual and perennial weeds.						

References

1. 1999 New York and Pennsylvania Pest Management Recommendations for Grapes.

2. Weigle, T., et al. New York Crop Profile: Vinifera & French Hybrid Grapes in New York.

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