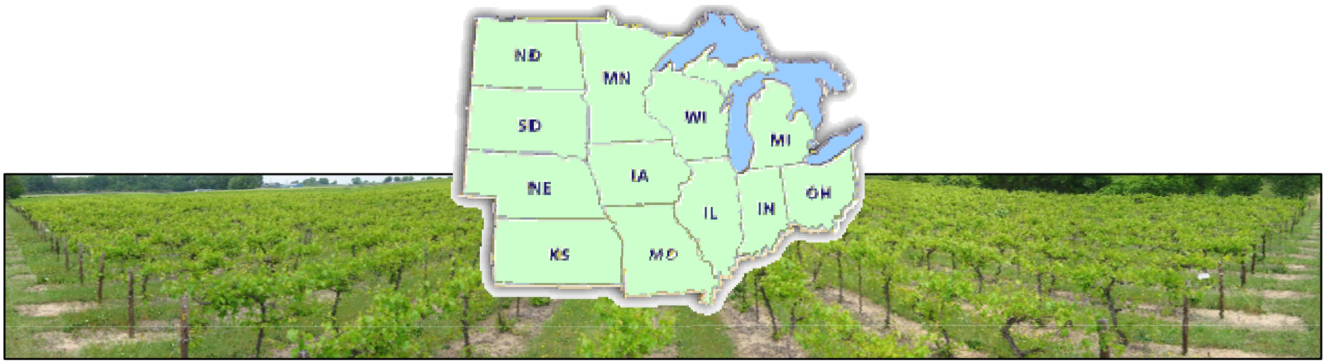
Pest Management Strategic Plan for the North Central Region Grape Industry



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NORTH CENTRAL REGION PEST MANAGEMENT STRATEGIC PLAN

2007

EXECUTIVE SUMMARY

A Pest Management Strategic Plan (PMSP) was developed in 2007 to describe the current utility of pesticides and pest management strategies for grape production in the North Central region. This PMSP encompasses pest management approaches for growing grapes for wine, juice and the fresh market. The states represented in this document are Michigan, Indiana, Illinois, Ohio, Wisconsin, Iowa, Minnesota, Missouri and Arkansas. The meeting was organized as a round table discussion with a moderator and was held on March 22-23, 2007 at the Michigan State University Berrien County Extension Office and Southwest Michigan Research and Extension Center in Benton Harbor, Michigan. The meeting was attended by juice and wine grape growers from across the region, research and extension personnel from universities, and representatives of state and federal government. During this meeting the moderator initiated discussion among the meeting participants to establish pest management, research, regulatory and educational priorities for grape production in the North Central region. The various methods of control of the major diseases, insects, nematodes and weeds that are pests of grapes in the North Central region were discussed in detail and the effectiveness of each method was rated on a scale of excellent to poor by the group. The responses of the group were recorded at the meeting and during the spring and summer of 2007 the first draft of this document was written. In September 2007 the draft was sent to all meeting participants and other growers, industry representatives, and university extension personnel for review. Final edits were made to the document in October 2007 and it was submitted to the national PMSP database in November 2007.

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N.C. REGION GRAPE P.M.S.P. TIMELINE

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PMSP Meeting	March 22-23 2007
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Submission to national PMSP database	October 2007

SETTING PEST MANAGEMENT PRIORITIES

The purpose of a Pest Management Strategic Plan (PMSP) is to communicate, from an industry perspective, the role of pesticides and pest management strategies in crop production. To obtain broad-based industry input, PMSPs are developed for a specific commodity through the use of workshops which bring together producers, crop consultants, commodity groups and pest management specialists from across the production region. Although PMSPs were originally intended for use by the Environmental Protection Agency (EPA), they have also proved valuable to the United States Department of Agriculture (USDA), Land Grant Universities, and pest management stakeholders at all levels.

There are almost one million acres of grape vineyards planted nationwide, with the majority of that acreage in the west coast states and in New York. The acreage of grape production in the North Central states is dominated by labrusca grapes in Michigan and Ohio, but there is an increasing number of wineries and plantings of hybrid and vinifera grapes being established in this region. Within Michigan alone, almost $100 million dollars is contributed to the state's economy annually by the various components of the grape industry.

Pest management in these vineyards is made challenging by the humid climate of the North Central region and the profusion of native wild grapevines in natural habitats surrounding vineyards. While there is variation in pest susceptibility among different types of grape (labrusca, hybrid, and vinifera), vineyards of all types are susceptible to economic losses if weeds, diseases, nematodes and insects are not managed. It is critical that these pests be managed economically and effectively for growers to be able to harvest grapes that are acceptable by processors, wine makers, or consumers. To achieve this standard, vineyard production systems have developed that rely on multiple applications of broad-spectrum pesticides to control these pests. For many years these products were effective and provided good pest control. Recent changes in the pest management landscape have stimulated increased interest in the development and implementation of alternative pest management options. These changes include urban encroachment and proximity to farms, public pressure to reduce pesticide use, industry concern about minimizing environmental contamination, EPA restrictions on pesticide availability, the difficulty in registering new compounds, worker and food safety, pest resistance to pesticides and increasing production costs.

As part of the long-term strategic planning for the continued success of the grape industry, re-evaluation of the pest management programs has been underway, and the grape industry has supported development of new pest management approaches, and implementation of IPM programs that reduce pesticide use, improve operator safety, and protect the environment, while maintaining the stringent quality standards demanded by the marketplace. The Grape Pest Management Strategic Plan was conducted by the North Central grape industry to help identify the need for alternatives to replace pesticides at risk due to resistance, regulatory, and consumer-driven pressures. The research, regulatory, and education priorities listed below were identified by the meeting participants.

GRAPE PEST MANAGEMENT PRIORITIES FOR THE NORTH CENTRAL REGION

Top Six Pest Management Research Priorities

- Sustainable vineyard management programs
- Insect and disease control models based on growing-degree days (GDDs) and economic thresholds
- Clean plant materials to minimize bacterial and virus diseases
- Cause and prevention of sour rot, especially in thin-skinned varieties
- Crown gall-resistance and other control methods
- Develop more effective scouting protocols, and pest management strategies to control the grape berry moth, including a growing-degree day model.

Other Pest Management Research Priorities

- Effect of late-season fungicides and insecticides (short pre-harvest intervals) on fermentation and wine quality
- Control of fruit-infesting insects, especially yellow jackets and wasps, multicolored Asian lady beetle, fruit flies, green June beetles (southern half of the North Central Region)
- Control and avoidance of diseases and virus
- Effective organic pest control
- Non-chemical weed control

Top Four Regulatory Priorities

- Review of pre-harvest intervals (PHIs) and re-entry intervals (REIs) including Capture, Captan, Imidan and Lorsban
- Plant tissue regulation (nursery certification and quality control)
- Address the problem of off target drift of 2,4-D or Dicamba in grape-growing regions
- Continued support of the IR-4 (EPA Interregional Project 4) program

Other Regulatory Priorities

- Packaging size of pesticides for small growers
- Conservation program incentives
- Necessity for short PHI products close to harvest
- Expedited registration of alternatives to Food Quality Protection Agency (FQPA)-targeted products
- Wildlife regulation that is more responsive to grower needs
- Concerns about claims of efficacy against pests and truth in advertising for products exempt from the federal registration process
- Continue development of new crop protection materials and pest management strategies that will enable producers to manage pests in a cost-effective, environmentally sound, and sustainable manner

Top Educational Priorities

- Funding for extension to work directly with growers
- Training programs oriented to Midwest grape growers
- New pest control products and their efficacy.
- Communication networks to facilitate knowledge and technology transfer and utilization
- IPM training/workshops including proper pest diagnosis
- Mineral nutritional diagnostics and analysis, and interpretation of those analyses
- New grower education/workshops/teaching tools-awareness of the complexities involved in growing grapes including financial management, pesticide regulations, etc.
- Develop a field group network of grower, extension, industry and university personnel to facilitate delivery of consistent and timely pest management recommendations and information on viticulture practices
- Evaluate/review the latest research on pesticides to enable improved spray recommendations to be developed for publication by university extension offices

Although not pest management related, the group identified seven research priorities in the area of crop management, or horticulture. These are included here to ensure that they are documented.

Top Seven Research Priorities for Crop Management

- Cold-hardy varieties
- Crop load management
- Understanding of wine grape rootstocks and scions and how they work together
- Vine vigor control, especially late in the season
- Mechanization to reduce labor costs
- Continue research to optimize the yield and quality of ‘Concord’ and ‘Niagara’ grapes under varying climatic and soil conditions that leads to the development of a Seasonal Crop Load Management system which will enable grape producers to achieve optimal sustainable yields of mature fruit on a yearly basis.
- Continue the development of sustainable mechanized pruning and crop-thinning equipment and techniques that optimize yield and quality.

BACKGROUND ON THE GRAPE INDUSTRY

- Grapes are the fruit crop with greatest value nationally, at $3.5 billion.
- There are about 934,750 acres of grape nationwide and grape vineyards in all 50 states.
- Vineyards are owned by 23,856 growers and there are 4,929 wineries in the US.
- The North Central region contains regions producing juice grapes grown under contract for processing into jams and juice and for blending into other food products. There are approximately 12,000 juice grape acres in Michigan and 1,500 in Ohio, with almost all of these grown under contract with Welch's.
- Each state in the region also contains multiple wineries that require large capital investment to establish, and the associated vineyards to produce grapes for this industry.
- It is critical that several key insect, disease, and weed pests be effectively controlled to maintain adequate yields of quality fruit that is acceptable to winemakers and consumers.
- Vine growth and vigor, and fruit ripening must be managed to maintain the health and longevity of vineyards.
- Over time, a grape production system has evolved that relies on pesticide applications for pest control.
- Industry concerns about environmental quality, worker and food safety, pest resistance to pesticides, increasing production costs, potential loss of important pesticide tools, and the encroachment of urban area on prime grape production sites, have caused the industry to carefully re-evaluate the standard production system.
- Grape growers have responded by adopting integrated pest management (IPM) and other cultural practices that reduce pesticide use, improve worker safety and protect the environment, yet maintain the stringent quality standards demanded by the marketplace.
- Many regulatory decisions related to the grape industry are dominated by issues relevant to the California industry, yet there are region-specific pest problems in the North Central Region that require solutions for this region.

GRAPE PEST MANAGEMENT CHALLENGES

Vineyard insect pests are primarily controlled by broad-spectrum insecticides, such as organophosphate, carbamate, and pyrethroid compounds, while broad-spectrum fungicides are commonly used to control fungal diseases. These materials have provided good control for over 35 years, but many factors acting together have heightened interest in alternative control tactics. Pest resistance to insecticides, fungicides, and herbicides appears to be on the increase in some fruit growing areas in the North Central region. Broad-spectrum insecticides are toxic to natural enemies of some pests, thus limiting the potential of biological control. Some fungicides, such as the ethylene bisdithiocarbamates (EBDCs), used in vineyards have been classified by the US-EPA as suspected carcinogens. In addition, certain new pests and diseases are becoming more prevalent posing a problem for growers and requiring additional research and extension for effective management. Regulations governing pesticides, particularly the Food Quality Protection Act, and the public interest in reducing the use of pesticides will likely limit the availability of conventional insecticides, fungicides and herbicides in the future.

This grape pest management strategic planning process was initiated to help identify and prioritize the need for alternatives to replace pesticide control tools (initial focus on organophosphate and carbamate insecticides, and fungicides classified as B2 carcinogens) at risk due to the above factors. The loss of the organophosphate insecticide, azinphosmethyl, and other restrictions on pesticides expected in the future requires urgent development of effective alternatives.

It is hoped that through strategic planning the pest management issues that have the greatest potential impact on this industry viability can be identified. Focus on these issues should help the grape industry continue to deliver the quality fruit demanded by the marketplace.

To set the stage for the review of pest management tools below, the most economically-important insect pests, plant-parasitic nematodes, and diseases of grape in the North Central Region are listed in Table 1. This provides a description of the potential risk of loss if that pest is not controlled in an infested vineyard, and it also provides a description of the damage caused by that particular pest.

TABLE 1. GRAPE PEST AND DISEASE PROBLEMS IN THE NORTH CENTRAL REGION

Pests	Loss without control	Type of damage
Diseases		
Powdery mildew	Up to 100% loss is possible if fruit is badly infected and cannot be used for wine or juice. If strictly leaf infection, losses will be mainly in juice quality and increased winter injury, which affects vineyard longevity.	Cracking of berries, off-flavors in wine, reduction in photosynthesis of leaves, premature defoliation, poor fruit quality, weak vines and increased winter injury, predisposition of fruit clusters to Botrytis and sour rot
Downy mildew	Up to 100% loss is possible. If strictly leaf infection, losses will be mainly in juice quality and increased winter injury, which affects vineyard longevity.	Destruction of fruit clusters, reduction in photosynthesis of leaves, premature defoliation, weak vines and increased winter injury, poor fruit quality
Black rot	Up to 100% loss for fruit is possible. Leaf infection is usually not a concern.	Rotting and mummification of fruit, leaf spots
Phomopsis cane and leaf spot	Up to 40-50% loss is possible due to premature fruit drop; in some cultivars, fruit rot may destroy up to 75% of clusters.	Lesions on leaves, shoots, and rachises, fruit rot
Botrytis bunch rot	Up to 100% loss is possible if fruit is badly infected and cannot be used for wine or juice.	Fruit rot, blossom blight
Sour rot	Up to 100% loss is possible if fruit is badly infected and cannot be used for wine or juice.	Fruit rot, off-flavors, insect infestation
Other rots (bitter rot, ripe rot, macrophoma, etc.)	Up to 100% loss is possible if fruit is badly infected and cannot be used for wine or juice.	Fruit rot, off-flavors
Eutypa dieback	Up to 25% yield loss may occur over a whole vineyard; however, individual vines can be killed over several years' time; also vine replacement costs.	Vine dieback, reduced yields, vine death
Anthracnose	Up to 100% loss is possible if fruit is badly infected and cannot be sold (mostly in table grapes)	Lesions on and cracking of berries, table grapes unmarketable, shoot death, leaf lesions
Crown gall	Up to 100% loss of vines is possible, especially young vines that get infected; also vine replacement costs	Galls on crown and canes of vine, weak vines, increased winter injury
Viruses and virus-like diseases	Losses mostly low, but up to 100% loss is possible as vines slowly die off in the vineyard; also vine replacement costs	Vine decline and dieback, stunting, low yields
Pierce's Disease	Up to 100% vine loss is possible	Death of susceptible varieties
Plant-parasitic nematodes		
Lesion nematode, root knot nematode, sting nematode, etc.	Generally low losses, but up to 100% loss of vines is possible if young vines are replanted in areas with high nematode counts and fail to establish	Root stunting, root lesions, root rot; weak vines, nutritional deficiencies, drought stress, increased winter injury
Dagger nematode	Generally low, but up to 100% loss of vines is possible if vines get infected with nematode-transmitted viruses	In addition to symptoms above, vines can go in decline due to virus infections

TABLE 1 (con't). GRAPE PEST AND DISEASE PROBLEMS IN THE NORTH CENTRAL REGION

Pests	Loss without control	Type of damage
Insect pests		
Grape berry moth	Up to 100% loss. Most damaging insect pest, feeding directly in fruit and allowing rot fungi to enter. Can cause complete rejection of crop by processors or wine makers.	Rejection of crop due to infestation with larvae, reduced yield, increased disease.
Grape leafhopper	This can cause complete loss of crop since it will not reach the sugar targets. Feeding on leaves can prevent fruit ripening in heavily-infested vineyards.	In sensitive cultivars, loss of active leaf area, unripe fruit
Potato leafhopper	Severe	In sensitive cultivars, shoot stunting and poor canopy development
Japanese beetle	Severe	Leaf area loss, especially in vinifera grapes
Rose chafer	Severe	Leaf area loss, especially in vinifera grapes. Feeding on flower clusters reduces yield.
Climbing cutworm	30% of potential crop	Eats young buds
Flea beetle	Sporadic	Eats young buds
Multicolored Asian ladybeetle	Severe	Contamination and loss of wine quality
Grape phylloxera	Severe	In sensitive cultivars with vinifera parentage, kills roots and can damage leaves
Grape root borer	Severe	Feeding on roots leads to vigor loss, loss of cordon and eventual vine death
Green June beetle	Severe	Beetles aggregate and devour fruit and ruin clusters

CURRENT AND FUTURE PEST MANAGEMENT OPTIONS FOR THE NORTH CENTRAL REGION GRAPE INDUSTRIES

This section is a pest-by-pest analysis of the current role and efficacy of insecticides, fungicides, nematicides, and herbicides in the management of vineyards across the North Central region of the United States. We also review current management practices (chemical, cultural and otherwise) and potential new pest management tools that are promising for management of these pests.

Diseases of Grapes in the North Central Region

Most diseases that affect grapes in the North Central region are caused by fungi, although bacteria, viruses, and nematodes also take their toll. Many factors affect the prevalence of diseases in a vineyard. The most obvious of these is cultivar, since innate resistance determines to what degree a vine is attacked by a particular pathogen. In general, vinifera grapes are more susceptible to diseases and require more intensive disease management than labrusca-type grapes. Other important factors are temperature, relative humidity and hours of leaf wetness from rainfall or dew, as most fungi and bacteria have minimum temperature and moisture needs for growth and infection. Wounds or freeze injury may also predispose vines to diseases such as crown gall and Eutypa dieback.

Non-chemical Management approaches

Host plant resistance can be very helpful in controlling diseases (see Table 1). If it is not possible to choose a resistant cultivar, at least avoid highly susceptible cultivars. Choosing a cultivar that is adapted to the local soils and climate is important to ensure that the vines are not stressed and weakened by environmental factors. Certain cultivars are more suitable for organic production because they won't require heavy doses of fungicides to produce an acceptable crop.

Cultural control includes: selecting sites with good drainage and air circulation, avoiding sites with previous soilborne disease problems, planting in the direction of the prevailing wind to encourage air circulation, pruning to create open canopies to hasten drying and reduce humidity build-up, pruning out infected plant parts to remove sources of inoculum, shoot and leaf removal to promote sun exposure and drying of clusters, shoot positioning, and using a training system that provides good light and air penetration. Most of these methods assist in controlling the fungal diseases mentioned above. Pruning out and destroying dead canes and vines are especially important for control of Phomopsis and Eutypa dieback. It is important to remove and burn infected plant material since spores can be released for a long time and can travel quite far by wind. Leaf and shoot removal around clusters is practiced to reduce humidity and incidence of Botrytis bunch rot and sour rot. Buying virus-tested planting material helps prevent virus diseases, since virus diseases can't be treated or cured. In contrast, control of crown gall requires planting varieties with adequate hardiness for the area in good sites, and avoiding wounding of the vines. Galltroll or Norbac root dips prior to planting do not work against the grape strain of the crown gall bacterium. At this time, no nursery stock is guaranteed to be free from crown gall. However, buying vines from a reputable nursery in the northeastern US is recommended.

Scale used to rate effectiveness of materials listed below:

Poor ---------- Fair ----------- Good ----------Excellent

POWDERY MILDEW (*Uncinula necator*)



The powdery mildew fungus can infect all green tissues, resulting in a whitish gray, dusty or powdery appearance. Powdery mildew colonies are mostly present on the upper leaf surface. Infections of young, expanding leaves can result in distortion or stunting. Early berry infections can result in splitting of berries, secondary rots, and undesirable flavors in wine. Late infections are largely invisible except for a web-like necrotic pattern on the berry surface, which can still predispose the berries to rots. Severe infections reduce vine growth, yield, fruit quality, and winter-hardiness. In late summer, the fungus produces small golden-brown to black fruiting bodies (cleistothecia) on infected plant parts. The cleistothecia overwinter in bark crevices of the vine and release wind-disseminated ascospores in the spring. Leaves in proximity of the bark tend to get infected first. Powdery mildew is favored by high humidity and moderately high temperatures (68-81ºF). Temperatures above 95ºF inhibit new infections.

- **Carbamate and B2 carcinogen fungicides currently registered:**
  - thiophanate methyl (Topsin M)
    - Efficacy: good; not used in IN, WI, IL (very little), MO, northern MI
    - Other comments: not used because growers have other options and no experience with the product; used because of low cost, rotation for resistance management; usually used in mid-shoot growth (between two sterol inhibitor sprays); not listed as "suggested for use" in Midwest Spray Guide; mainly growers did not consider it when it became available after Benlate was lost.

- **Sterol Inhibitor Fungicides**
  - myclobutanil (Nova):
    - Efficacy: good/excellent
    - Other comments: used for black rot as well; base of spray program; a little cheaper; where high usage may be losing efficacy; easily available.

  - tebuconazole (Elite)
    - Efficacy: good-excellent
    - Other comments: somewhat cheaper than Nova; very common, similar to Nova; used more than Nova sometimes because of water-soluble package.

- fenarimol (Rubigan, Vintage)
  - Efficacy: fair (however, in small plot efficacy trials in MI, it was rated as good-excellent against powdery mildew)
  - Other comments: Rubigan has a strong odor (not used around winery with visitors), Vintage is less smelly but not used yet because it is a new formulation; not used in juice grapes because it is not as effective on black rot (Nova and Elite are more effective on black rot); used as a rotation product (with Nova as a frontline product), where it will fit.

- triflumizole (Procure)
  - Efficacy: not strong against black rot; (in small plot efficacy trials in MI, it was rated as good-excellent against powdery mildew)
  - Other comments: Not used.

- tiradimefon (Bayleton)
  - Efficacy: good
  - Other comments: older product; not as strong against black rot as it once was.

- **Strobilurin Fungicides**
  - azoxystrobin (Abound)
    - Efficacy: good-excellent
    - Reduced-risk fungicide
    - Highly phytotoxic to apples
    - Requires fungicide resistance management
    - Other comments: Big concern in MI (diverse growers [with grapes and apples], growers with neighbors don't use it); good industry communication on phytotoxicity.

  - trifloxystrobin (Flint)
    - Efficacy: good-excellent
    - Reduced-risk fungicide
    - Phytotoxic on Concord, Fredonia grapes
    - Requires fungicide resistance management
    - Other comments: Not used widely (mainly used in wine grapes); Sovran and Abound are the strobilurins mostly used.

  - kresoxym-methyl (Sovran)
    - Efficacy: excellent
    - Reduced-risk fungicide
    - Phytotoxic to certain sweet cherry varieties
    - Requires fungicide resistance management
    - Other comments: little used in IL (because of cost); Used instead of Abound (for phytotoxicity issues); a little more effective on downy mildew than Flint is; some growers using airblast sprayer may reduce rate (~20% lower).

- pyraclostrobin + boscalid (Pristine)
  - Efficacy: excellent
  - Reduced-risk fungicide
  - Phytotoxic to labrusca-type grapes (on label – not seen in MI, seen in WI)
  - Requires fungicide resistance management
  - Other comments: used quite a bit (because of its broad-spectrum of activity, and has two active ingredients that help with resistance management); used more liberally than Abound (because there are not as many resistance concerns); locally systemic and systemic components; can be used multiple times through the season; used when the maximum number of Mancozeb sprays per season is reached.

- **Other Fungicides** (unique chemistries)
  - quinoxifen (Quintec)
    - Efficacy: excellent
    - Other comments: pretty new, not used as much yet; expensive, but quite effective for varieties that are susceptible.

  - boscalid (Endura)
    - Efficacy: good-excellent
    - Reduced-risk fungicide
    - Other comments: new, not used much; not able to be used for fungicide resistance management with Pristine.

- **Inorganic Fungicides**
  - sulfur (multiple formulations)
    - Efficacy: good-excellent
    - May be phytotoxic
    - Relatively inexpensive
    - Some formulations can be used in organic production
    - Cannot be applied late in season due to adverse effects on wine-making
    - Other comments: used a lot in Vinifera; not used as much in hotter regions,
    - especially in sensitive varieties; not used late in season because of potential for residues in wineries; cheap; some workers more sensitive to it (burning of eyes, etc.); non-liquid formulations can plug Airblast sprayers; micronutrient properties; not rain-fast (protectant only); many growers mix sulfur in with every spray (because it is inexpensive); microfine formulation most often used.

  - calcium polysulfide (Lime Sulfur, Sulforix)
    - Efficacy: hard to tell
    - May be phytotoxic
    - Usually applied as a dormant
    - Some formulations can be used in organic production
    - Cannot be applied late in season due to adverse effects on wine-making
    - Other comments: not specifically used for powdery mildew.

- copper (multiple formulations)
  - Efficacy: fair
  - May be phytotoxic
  - Relatively inexpensive
  - Some formulations can be used in organic production
  - hydrated lime is added as a safener for copper; may cause problems with alkaline hydrolyzed breakdown of tank-mixed insecticides
  - Other comments: not used for powdery mildew.

- potassium bicarbonate (Armicarb, Kaligreen, MilStop)
  - Efficacy: fair-good
  - Reduced-risk, can be used in organic production
  - Other comments: Armicarb, Kaligreen used most often; important for organic growers; used primarily as an eradicant (high volumes as soon as powdery is seen in the vineyard).

- paraffinic oil (JMS Stylet Oil)
  - Efficacy: hard to tell (because it is used in mixtures)
  - Reduced-risk, can be used in organic production
  - May reduce brix if applied too often
  - Other comments: used a little bit; used up to berry closure; mixed with other compounds; don't use over 93 degrees.
- sodium tetraborohydrate decahydrate (Prev-Am)
  - Efficacy: works pretty well in small plot trials
  - Reduced-risk
  - Other comments: new product; too new to assess from grower standpoint; needs more testing (eradicant properties?); not certified organic.

- hydrogen peroxide (Oxidate)
  - Efficacy: not effective
  - Reduced-risk, can be used in organic production
  - Other comments: not used much.

- **Biocontrol agents**
  - *Bacillus subtilis* (Serenade)
    - Efficacy: hard to assess
    - Reduced-risk, biocontrol product, can be used in organic production
    - Other comments: organic; some usage (especially organic); comparable pricing to other products.

  - *Bacillus pumilis* (Sonata)
    - Efficacy: not known
    - Reduced-risk, biocontrol product, can be used in organic production.
    - Other comments: not used much

- **Other disease management aids:**
  - Reduce humidity by canopy management, leaf pulling (used mainly in wine grapes; not cost-effective in juice grapes)
  - Powdery mildew disease forecasting model for grape (available with Spectrum Technologies weather stations) works well
  - Host plant resistance (resistant varieties don't receive sprays targeted specifically for powdery mildew [don't have to worry about it]).

PIPELINE

Various products are in the pipeline for control of powdery mildew on grapes, e.g., V10118 (Valent product), which has been very effective in small plot trials. This product has a novel mode of action. Citrex (Citrex, Inc) is ascorbic acid and other acids and is currently labeled in some South American countries for disease control in organic and conventional grapes. The registration in the USA is pending. Various companies have pre-mixes of existing chemistries, including sterol inhibitors, becoming available in the next couple of years.

"To do" list for powdery mildew:

Research needs:

- Efficacy testing of fungicides with novel modes of action (somebody has to do this)
- Testing for fungicide resistance before it becomes a problem and products lose efficacy
- Develop and validate disease prediction models - including the powdery mildew model from Spectrum Technologies (disease models would be used if they were available)
- Need more local (state) research
- Variable spray programs based on varietal resistance/susceptibility

Regulatory needs:

- Expedite registration of new alternatives as they become available

Education needs:

- As products and/or disease management strategies become available, educate users
- Once fungicide resistance is found, education is needed to get the word out to growers
- Newer grape growing states need education of extension agents, etc.; transfer of knowledge from experienced states
- Grower education in using disease prediction models, including the powdery mildew model from Spectrum Technologies.

DOWNY MILDEW (*Plasmopara viticola)*



Downy mildew can infect leaves as well as flower and fruit clusters. Initial leaf symptoms show up as light green or yellow spots. These are termed “oil spots” because of their sometimes greasy appearance. The lesions eventually turn brown as the infected tissue dies. On older leaves, lesions are typically smaller and more angular as they are delimited by leaf veins. Leaf infections may lead to premature defoliation, which can reduce winter hardiness in severe cases. Under warm, humid conditions (>98% humidity and > 55°F) at night, white, fluffy sporulation develops on the lower surface of the leaf. White spore masses also develop on infected flower and fruit clusters. Infected clusters or berries eventually wither and die. The fungus overwinters in leaves on the ground. Spores are spread to new leaves and clusters by wind and rain. The fungus requires a film of water for infection. Lesions appear within 5-17 days after infection. The disease can spread rapidly under warm conditions with frequent rain or dew. Use the 10-10-10 rule to decide when to first start scouting for downy mildew: 10 cm (4 in.) of shoot growth, 10 mm (0.4 in.) rainfall and temperatures of at least 10°C (50°F) during a 24-hour period. Monitor especially leaves close to the ground as well as in the top of the canopy.

- **Carbamate and B2 carcinogen fungicides currently registered:**
  - <u>mancozeb (Dithane, Penncozeb, Manzate)</u>
    - Efficacy: excellent
    - Other comments: one of the standards; used early in the year (because of long PHI [66 days]); not used after bloom in juice grapes; processors limit use; inexpensive; covers multiple diseases (black rot, Phomopsis); long PHI is a big concern; protectant only; some growers don’t use because it is a carbamate; Dithane Rainshield not trusted completely.
  - <u>captan (Captan)</u>
    - Efficacy: good-excellent
    - Other comments: listed as suppression; not used in juice grapes; late-season spray (replaces mancozeb); northern MI growers do not want it used at all (hard to nail down why – effect on wine making process?); four day REI complicates things (if you need to do shoot positioning, etc.); REI/PHI mismatch.

- ziram (Ziram)
  - Efficacy: good-excellent
  - Other comments: used a lot in MI and southern region (one of the standards), not used in IL, used little in IA; replaces Captan after bloom; PHI and REI are limiting factors;

- **Strobilurin Fungicides**
  - azoxystrobin (Abound)
    - Reduced-risk fungicide
    - Highly phytotoxic to apples
    - Requires fungicide resistance management
    - Efficacy:good-excellent
    - Other comments: used everywhere; somewhat expensive but have to use it

  - trifloxystrobin (Flint)
    - Reduced-risk fungicide
    - Phytotoxic on Concord grapes
    - Requires fungicide resistance management
    - Efficacy: poor-fair
    - Other comments: not as effective as Sovran and Abound;

  - kresoxym-methyl (Sovran)
    - Reduced-risk fungicide
    - Phytotoxic to certain sweet cherry varieties
    - Requires fungicide resistance management
    - Efficacy:good-excellent
    - Other comments: the one to use if you're worried about phytotoxicity of apples, neighbors; but Sovran is too costly sometimes

  - pyraclostrobin + boscalid (Pristine)
    - Reduced risk fungicide
    - Phytotoxic to Labrusca-type grapes (on label but not seen in MI at 8-10.5 oz rate – Concord reportedly more affected than Niagara)
    - Requires fungicide resistance management
    - Efficacy: excellent
    - Other comments: used because of its broad spectrum activity (cuts mixing time)

- **Other Fungicides**
  - mefenoxam and mancozeb (Ridomil Gold MZ)
    - Efficacy: Excellent
    - Other comments: eradicant; "Cadillac" in effectiveness and cost; MZ formulation is not used as much as Ridomil Gold copper (because of 66-day PHI for mancozeb component); not used much in juice grape (used a little bit before bloom)

- mefenoxam and copper (Ridomil Gold Copper)
  - Efficacy: excellent
  - Other comments: used as soon as MZ formulation can't be used; would be nice if PHI was shorter, but it's used while you can; targeted to varieties that need it the most; expensive; mostly used as an eradicant after symptoms are seen

- Fosetyl-Al (Aliette)
  - Efficacy: good
  - Other comments: not used (expensive?)

- **Inorganic Fungicides**
  - copper (multiple formulations)
    - May be phytotoxic
    - Relatively inexpensive
    - Hydrated lime is added as a softener for Copper; may cause problems with alkaline hydrolysis breakdown of tank-mixed insecticides
    - Efficacy: excellent
    - Other comments: fixed copper is used; alternated with phosphorous acid; certain areas need it (along Mississippi river); used especially because of price; lime added to prevent phytotoxicity

  - phosphorous acid (ProPhyt, Phostrol, Agri-Fos)
    - Reduced-risk
    - Efficacy: excellent
    - Other comments: used quite a bit (all are used with same frequency); used as an eradicant; inexpensive; easy to use; it's newer but it's becoming more popular

  - sodium tetraborohydrate decahydrate (Prev-Am)
    - Reduced-risk
    - Efficacy: moderate in small plot field trials
    - Other comments: new, not used much; growers not aware of product

  - hydrogen peroxide (Oxidate)\
    - Reduced-risk
    - Efficacy: hasn't been tested in small plot trials yet
    - Other comments: not used much

- **Biocontrol agents**
  - *Bacillus subtilis* (Serenade)
    - Reduced-risk
    - Efficacy: fair
    - Other comments: not used

- **Other disease management aids: similar to powdery mildew aids (see above)**
  - Leaf removal to reduce humidity within the canopy.
  - Downy mildew disease forecasting models from Spectrum Technologies
  - Host plant resistance

PIPELINE
There are several fungicides in the pipeline for control of downy mildew, for example V10161 (fluopicolide – a Valent product). Most of these will take several years to come on the market. In addition, Gavel (zoxamide and mancozeb) has just gotten a label for downy mildew control in grapes. However, it will probably not be used much in juice grapes due to the restrictions on mancozeb use.

"To do" list for downy mildew:
Research needs:
- Efficacy testing of fungicides with novel modes of action
- Testing for fungicide resistance before it becomes a problem and products lose efficacy
- Develop and/or validate disease prediction models e.g. the downy mildew predictive model from Spectrum Technologies
- Need more local (state) research

Regulatory needs:
- Expedite registration of new alternatives as they become available

Education needs:
- As products and/or disease management strategies become available, educate users
- Once fungicide resistance is found, education is needed to get the word out to growers
- Newer grape growing states need education of extension agents, etc.; transfer of knowledge from experienced states
- Grower education in using downy mildew disease prediction models

BOTRYTIS BUNCH ROT (*Botrytis cinerea*)


Botrytis cinerea can infect all green parts of the vine, though bunch rot tends to be the biggest problem. In early spring, buds and young shoots may be infected and turn brown. In late spring, V-shaped or irregular brown patches may appear on leaves. Inflorescences may also be blighted and wither away. Some flower infections can remain latent until veraison. From veraison onward, the fungus can infect grape berries directly through the epidermis or through wounds, and may continue to invade the entire cluster. Compact clusters, powdery mildew infection, hail and insect damage (e.g., grape berry moth), can predispose grapes to Botrytis infection. Infected white grapes turn brown and purple grapes become reddish. During dry weather, infected berries dry out; in wet weather, they tend to burst and become covered with a grayish mold, which contains millions of spores. These spores are spread by wind to new infection sites. The disease spreads rapidly during moist periods, especially close to harvest. In certain cultivars, slow-developing, late-season infections are termed "noble rot" because they contribute to the production of exceptionally sweet wines. The fungus overwinters as mycelium or sclerotia (small black structures) in mummified fruit and other infected plant parts. The disease is favored by temperatures of 59-68ºF and free water or at least 90% humidity.

- **Carbamate and B2 carcinogen fungicides currently registered:**
  - thiophanate methyl (Topsin M)
    - Efficacy: moderate
    - Other comments: not used (better options available)

  - captan (Captan)
    - Efficacy: poor
    - Other comments: not used much specifically for Botrytis

  - mancozeb (Dithane, Penncozeb)
    - Efficacy: ineffective
    - Other comments: not used much (PHI too long)

- **Strobilurin Fungicides**
  - azoxystrobin (Abound)
    - Reduced-risk fungicide
    - Highly phytotoxic to apples
    - Requires fungicide resistance management
    - Efficacy: poor (suppression)
    - Other comments: not used much
  - trifloxystrobin (Flint)
    - Reduced-risk fungicide
    - Phytotoxic on Concord grapes
    - Requires fungicide resistance management
    - Efficacy: Fair - need to apply at higher rate for Botrytis control
    - Other comments: not used much

  - kresoxym-methyl (Sovran)
    - Reduced-risk fungicide
    - Phytotoxic to certain sweet cherry varieties
    - Requires fungicide resistance management
    - Efficacy: poor (suppression)
    - Other comments: not used much

  - pyraclostrobin-boscalid (Pristine)
    - Reduced risk fungicide
    - Phytotoxic to labrusca-type grapes (on label – not seen in MI)
    - Requires fungicide resistance management
    - Efficacy: good at high rate (apply at 18-23 oz for Botrytis control)
    - Other comments: used some (for protectant activity post-bloom)

- **Other Fungicides**
  - iprodione (Rovral)
    - Efficacy: Good
    - Other comments: used some; rotated with Elevate (part of resistance management); surfactant needed; protectant, not a systemic

  - cyprodinil (Vangard)
    - Efficacy: Good-Excellent
    - Other comments: used more in northern areas than southern areas; only two sprays allowed; rotated with other materials; rainy conditions, etc. the two sprays may not be enough; may be some resistance in southern IL; expensive

  - fenhexamid (Elevate)
    - Efficacy: Good-Excellent; can depend on climatic conditions
    - Other comments: used quite a bit; expensive (similar to Vangard)

  - pyrimethanil (Scala)
    - Efficacy: Good-Excellent
    - Other comments: used sometimes; cheaper than Vangard; fairly new

- boscalid (Endura)
  - Efficacy: Good
  - Other comments: Used some/occasionally; Needs a higher rate for Botryis; Pristine used instead of Endura (same active ingredient)

- **Inorganic Fungicides**
  - potassium bicarbonate (Armicarb, Kaligreen, MilStop)
    - Reduced-risk
    - Efficacy: poor
    - Other comments: Not used

  - paraffinic oil (JMS Stylet Oil)
    - Reduced-risk
    - May reduce brix if applied too often
    - Efficacy: poor
    - Other comments: Not used

  - sodium tetraborohydrate decahydrate (Prev-Am)
    - Reduced-risk
    - Efficacy: unknown
    - Other comments: Not used; new

  - hydrogen peroxide (Oxidate)
    - Reduced-risk
    - Efficacy: poor
    - Other comments: Not used

- **Biocontrol agents**
  - *Bacillus subtilis* (Serenade)
    - Reduced-risk
    - Efficacy: Good (moderate under high disease pressure)
    - Other comments: Used to cut use of other products (split vineyard), but overall not used much; expensive

- **Other disease management aids:**
  - Reduce humidity by canopy management
  - Leaf removal to increase sun exposure and reduce humidity (one of the standards for Botrytis control; done at veraison or before)
  - Other canopy management practices to aid in cluster exposure (lateral removal, etc.)
  - Botrytis disease forecasting model from Spectrum Technologies
  - Host plant resistance
  - Modifying cluster architecture to reduce cluster compactness

PIPELINE
There are several fungicides in the pipeline for Botrytis control in grapes, for example V10135, a new product from Valent. It will be several years before this product comes on the market.

"To do" list for Botrytis bunch rot:
Research needs:
- Efficacy testing of fungicides with novel mode of action
- Validation of botrytis disease prediction model from Spectrum Technologies.

Regulatory needs:
- Expedite registration of new alternatives as they become available

Education needs:
- As products and/or disease management strategies become available, educate users
- Education on the difference between sour rot, other rots and Botrytis (growers sometimes will spray for the wrong disease) and botryticides are not effective against the other diseases
- Grower education in the use of the botrytis disease prediction model from Spectrum Technologies.

BLACK ROT (*Guignardia bidwellii*)



The black rot fungus can attack all new growth, including leaves, petioles, shoots, tendrils, and berries. On the leaves, light brown, roughly circular spots appear in the spring and summer. These can be distinguished from herbicide damage by the presence of a ring of small black fruiting bodies, visible with the naked eye or a hand lens. Even though peak fruit infection occurs around mid-bloom in 'Concord' grapes in the North Central region, symptoms only become apparent weeks later. The first symptom of berry infection is a small whitish dot within a rapidly expanding brown area that sometimes contains distinct "growth rings". Within a few days, the berry starts to shrivel and becomes a hard, blue-black mummy. Berries actually become resistant to infection about 3-5 weeks after bloom. If berries are infected close to the time of natural resistance development, lesions remain localized. The fungus overwinters in fruit mummies, within the vine or on the ground. Ascospores are released from shortly after bud break until about 2 weeks after bloom, and are dispersed by wind and rain. Leaf spots and newly infected berries can also yield infectious conidia, which are rainsplash-dispersed. The optimum temperature for disease development is 80°F, at which the wetness period required for infection is only 6 hours. At higher or lower temperatures, the wetness requirement increases.

- **Carbamate and B2 carcinogen fungicides currently registered:**
  - thiophanate methyl (Topsin M)
    - Efficacy: moderate
    - Other comments: Not used
  - mancozeb (Dithane, Penncozeb)
    - Efficacy: Excellent
    - Other comments: used quite a bit; mancozeb used early
  - captan (Captan)
    - Efficacy: Good-Excellent
    - Other comments: same as before

- ziram (Ziram)
  - Efficacy: hard to tell because it is used in mixtures
  - Other comments: used sometimes, mixed with SI

- ferbam (Ferbam)
  - Efficacy: moderate
  - Other comments: May leave black residues on fruit; not used

- **Sterol Inhibitor Fungicides**
  - myclobutanil (Nova)
    - Efficacy: excellent
    - Other comments: similar to powdery mildew

  - tebuconazole (Elite)
    - Efficacy: excellent
    - Other comments: similar to powdery mildew
  - tiradimefon (Bayleton)
    - Efficacy: good to excellent
    - Other comments: similar to powdery mildew; not used as much for black rot

- **Strobilurin Fungicides**
  - azoxystrobin (Abound)
    - Reduced risk fungicide
    - Highly phytotoxic to apples
    - Requires fungicide resistance management
    - Efficacy: Good to excellent
    - Other comments: used quite a bit

  - trifloxystrobin (Flint)
    - Reduced risk fungicide
    - Phytotoxic on Concord grapes
    - Requires fungicide resistance management
    - Efficacy: Good to excellent
    - Other comments: Same as powdery mildew

  - kresoxym-methyl (Sovran)
    - Reduced risk fungicide
    - Phytotoxic to certain sweet cherry varieties
    - Requires fungicide resistance management
    - Efficacy: Good to excellent
    - Other comments: Same as powdery mildew

  - Pyraclostrobin + boscalid (Pristine)
    - Reduced risk fungicide
    - Phytotoxic to labrusca-type grapes (on label – not seen in MI)
    - Requires fungicide resistance management
    - Efficacy: Good to excellent
    - Other comments: Same as powdery mildew

- **Inorganic Fungicides**
  - copper (multiple formulations)
    - May be phytotoxic
    - Relatively inexpensive
    - hydrated lime is added as a safener for Cu; may cause problems with alkaline
    - hydrolyzed breakdown of tank-mixed insecticides
    - Efficacy: poor to fair
    - Other comments: not used, except for organic growers; other (better) compounds coming in have resulted in it not being used as much

  - hydrogen peroxide (Oxidate)
    - Reduced-risk
    - Efficacy: unknown
    - Other comments: Not used

- **Other disease management aids:**
  - Reduce humidity by canopy management
  - Remove mummies from canopy (highly recommended; old clusters cut out)
  - Black rot disease forecasting model from Spectrum Technologies
  - Host plant resistance

PIPELINE

"To do" list for black rot:
Research needs:
- Efficacy testing of fungicides with novel mode of action
- Organic growers need effective products
- Copper and sulfur use as dormant fungicides
- Validate the black rot disease forecasting model from Spectrum Technologies

Regulatory needs:
- Expedite registration of new alternatives as they become available

Education needs:
- As products and/or disease management strategies become available, educate users
- Education on disease biology and when to spray
- Grower education in using the black rot disease forecasting model from Spectrum Technologies

PHOMOPSIS CANE AND LEAF SPOT (*Phomopsis viticola*)



Phomopsis viticola can infect all green parts of the vine, but infections of the fruit clusters are economically most important. Infected leaf blades show small irregular light green or yellow spots with dark centers and may be puckered. On petioles, shoots, and rachises, chlorotic spots with dark centers develop into elongated black streaks or blotches, which make the tissue brittle and prone to cracking or breakage. Most shoot lesions occur on the basal three to six internodes. Actively growing tissues are most susceptible to infection. Rachis and berry infections become apparent several weeks before harvest and continue to get worse over time. Rachis infections can lead to withering of the rachis, causing berries or sometimes entire clusters to drop prematurely. The fungus can also infect berries, either directly through the skin or through the berry stem. Infected berries turn brown and become soft and rubbery. Pycnidia may appear as numerous small black specks on the berry surface, sometimes oozing cream-colored droplets of spores. The fungus overwinters as in bark of infected canes. Bleached areas, sometimes delineated by black lines, on dormant canes are indicative of infection. In spring and early summer, conidia are rain-splash dispersed from pycnidia on the overwintered canes. Prolonged periods of rainy, cold weather in spring promote disease development. At least 6 hours of wetness are needed for infection at the optimum temperature (59-68ºF). Symptoms may appear 21-30 days after infection. Monitor carefully within 3-6 weeks from bud break. Many spots on the leaves and canes indicate high inoculum levels for rachis and berry infection. Flower clusters are susceptible to infection from the moment they are exposed until harvest.

- **Carbamate and B2 carcinogen fungicides currently registered:**
  - thiophanate methyl (Topsin M)
    - Efficacy: Poor
    - Other comments: same as for other diseases
  - mancozeb (Dithane, Penncozeb)
    - Efficacy: Excellent
    - Other comments: used a lot; same comments as for other diseases

- captan (Captan)
  - Efficacy: Good-Excellent (early season), but other materials more effective
  - Other comments: used sometimes (later in season, but more research needed in this area)

- ziram (Ziram)
  - Efficacy: moderate to good (4 lb better than 3 lb)
  - Other comments: used after bloom; tank mixed with an SI; only used in MI (juice grapes [used instead of Captan])

- **Strobilurin Fungicides**
  - azoxystrobin (Abound)
    - Reduced risk fungicide
    - Highly phytotoxic to apples
    - Requires fungicide resistance management
    - Efficacy: excellent
    - Other comments: used, but not necessarily as the primary target; same comments as before

  - trifloxystrobin (Flint)
    - Reduced risk fungicide
    - Phytotoxic on Concord grapes
    - Requires fungicide resistance management
    - Efficacy: good to excellent
    - Other comments: same comments as before

  - kresoxym-methyl (Sovran)
    - Reduced risk fungicide
    - Phytotoxic to certain sweet cherry varieties
    - Requires fungicide resistance management
    - Efficacy: good to excellent
    - Other comments: same comments as before

  - pyraclostrobin + boscalid (Pristine)
    - Reduced risk fungicide
    - Phytotoxic to labrusca-type grapes (on label – not seen in MI)
    - Requires fungicide resistance management
    - Efficacy: good to excellent
    - Other comments: same comments as before

- **Inorganic Fungicides**
  - copper (multiple formulations)
    - May be phytotoxic
    - Relatively inexpensive
    - hydrated lime is added as a safener for Cu; may cause problems with alkaline
    - hydrolyzed breakdown of tank-mixed insecticides
    - Efficacy: Fair-Poor
    - Other comments: Not used; not very effective; some dormant use

- **Biocontrol Agents**
  - *Bacillus subtilis* (Serenade)
    - Reduced-risk
    - Efficacy: fair
    - Other comments: Same comments as before, not used.

- **Other disease management aids:**
  - Prune out dead canes
  - Avoid dormant hedging and minimal mechanical pruning
  - Host plant resistance

PIPELINE

There are no fungicide products in the pipeline specifically for Phomopsis cane and leaf spot. The phosphorous acid products work well and need more demonstration.

"To do" list for Phomopsis cane and leaf spot:

Research needs:

- Efficacy testing of fungicides with novel mode of action
- Late season infections of Phomopsis, spore release/infection times
- Study overall epidemiology of the disease and maturation triggers to develop a disease forecasting model
- Use of phosphorous acids (protectant and maybe eradicant activity)

Regulatory needs:

- Expedite registration of new alternatives as they become available
- Adding Phomopsis to phosphorous acid product labels

Education needs:

- As products and/or disease management strategies become available, educate users
- Education on disease epidemiology and disease forecasting

SOUR BUNCH ROT – fungi, yeasts and bacteria

 

Sour bunch rot is caused by a variety of fungi, yeasts and acetic acid bacteria. Diffuse powdery mildew infections, cracking of the berries due to internal pressure, hail damage, or grape berry moth infestations can predispose clusters to infection. Insects, especially fruit flies, can also spread the sour rot organisms on their feet and mouthparts. Sour bunch rot is a wet rot which can spread rapidly throughout the cluster and cause the berries to smell like vinegar. Fruit flies and fruit fly larvae are often present. Unlike with Botrytis bunch rot, mold is usually absent. Prolonged periods of wetness or high relative humidity are conducive to sour bunch rot development. Some cultivars are more susceptible than others, particularly tight-clustered varieties.

- **Carbamate and B2 carcinogen fungicides currently registered: none**

- **Strobilurin Fungicides**
  - trifloxystrobin-boscalid (Pristine)
    - Reduced risk fungicide
    - Phytotoxic to labrusca-type grapes (on label – not seen in MI)
    - Requires fungicide resistance management
    - Efficacy: Only mentions Bunch rot complex (*Aspergillus, Penicillium*); may be effective but unknown
    - Other comments: this fungicide not effective against bacteria

- **Inorganic Fungicides**
  - hydrogen peroxide (Oxidate)
    - Reduced-risk
    - Efficacy: unknown
    - Other comments: not used

- **Biocontrol agents**
  - *Pseudomonas fluorescens A506* (BlightBan 506)
    - Reduced-risk
    - Efficacy: unknown
    - Other comments: not used; protectant; might be affected by sulfur/copper; may affect wine making

- *Bacillus subtilis* (Serenade)
  - Reduced-risk
  - Efficacy: unknown
  - Other comments: not used; not enough known (didn't work for one grower who used it).

- **Other disease management aids:**
  - Avoid wounding, birdfeeding (hard to accomplish)
  - Leaf removal to increase sun exposure and reduce humidity (used some)
  - Insect control
  - Host plant resistance
  - Avoidance of powdery mildew

PIPELINE
No products are known to be in pipeline for this disease.

"To do" list for Sour rot:
Research needs:
- Efficacy testing of fungicides with novel mode of action
- Study overall epidemiology of the disease to develop a forecasting model
- Wasp, yellow jacket, etc. role in spread of sour rot; bees in southern IL
- Calcium research (to increase skin firmness)
- Leaf removal to increase berry drop (open cluster up)
- Efficacy of ozonated water sprays
- Components of sour rot complex
- Cluster architecture modification to reduce cluster compactness

Regulatory needs:
- Expedite registration of new alternatives as they become available

Education needs:
- As products and/or disease management strategies become available, educate users
- Education on how to tell sour rot apart from other rots, contributing factors, etc.
- Education on disease epidemiology and forecasting models

OTHER CLUSTER ROTS

 

In the warmer areas of the North Central Region (Arkansas, Missouri, southern Illinois, etc.), the bunch rot complex is composed of several non-Botrytis rots, also sometimes called the summer bunch rot complex. Among these are sour rot, macrophoma rot (*Botryosphaeria dothidea*), bitter rot (*Greeneria uvicola*) and ripe rot (*Colletotrichum spp*.). Little is known of the biology and epidemiology of these rot disease organisms on bunch grapes, particularly in the North Central Region where they have only recently been identified in area vineyards.

"To do" list for Non-Botrytis Rots:
Research needs:
- Rot disease surveys throughout NC Region
- Efficacy testing of fungicides
- Optimal spray timings
- Basic biology, etiology of Macrophoma
- Modeling for non-Botrytis rots

Education needs:
- Instruct growers in disease recognition
- Education in fungicide spray programs for non-Botrytis rots

ANTHRACNOSE (*Elsinoë ampelina*)



Anthracnose is more common in the southern part of the North Central Region and occurs sporadically in Michigan. Table grape varieties are particularly susceptible. This fungal disease affects most above-ground parts of the vine, and actively growing plant parts are most susceptible. On leaves, numerous circular to angular, chocolate brown spots (1/25-1/5 inch (1-5 mm) diam.) develop. The centers of older lesions become bleached and fall out, leaving a "shot hole" appearance. Lesions along the veins may cause curling and distortion as the leaves expand. On shoots, spots are oval, sunken, and purplish-brown spots with gray centers and raised edges, and can blight entire shoot tips. On older wood, infections look like small craters with raised edges. On berries, purplish brown "bird's-eye" spots form. Depending on the cultivar and possibly the fungus, spots on berries can also look light gray with a dark edge. Lesions may cause berry cracking. The causal fungi overwinter in infected parts of the vine, and conidia are rain-splash dispersed in the spring. Anthracnose is especially severe in years with heavy rainfall early in the season. Start monitoring in the period 2-8 weeks from budburst.

- **Carbamate and B2 carcinogen fungicides currently registered:**
  - Calcium polysulfide (Lime Sulfur)
    - Efficacy: Good
    - Other comments: Apply as dormant spray; widely used; In IA directed spray on cordon;
  - Sulforix
    - Efficacy: Good
    - Other comments: easier to work with, but still messy. Can use stylet oil or soap on the sprayer before spraying to prevent from sticking to spray equipment.

- **Sterol Inhibitor Fungicides**
  - myclobutanil (Nova)
    - Efficacy: unknown
    - Other comments: not used specifically for anthracnose

- **Strobilurin Fungicides**
  - pyraclostrobin + boscalid (Pristine)
    - Reduced-risk fungicide
    - Phytotoxic to labrusca-type grapes (on label – phytotoxicity not seen in MI)
    - Requires fungicide resistance management
    - Efficacy: Very Good
    - Other comments: phytotoxicity can be an issue

- **Other Fungicides**
  - Mancozeb:
    - Efficacy: Good
    - Other comments: not labeled specifically for anthracnose

- **Inorganic Fungicides**
  - potassium bicarbonate (Armicarb)
    - Reduced-risk
    - Efficacy: unknown
    - Other comments: not used

  - hydrogen peroxide (Oxidate)
    - Reduced-risk
    - Efficacy: unknown
    - Other comments: not used

  - sulfur (Sulfur)
    - Efficacy: Good (poor to fair in small plot trial in MI).

- **Other disease management aids:**
  - Reduce humidity by canopy management
  - Remove mummies and diseased canes
  - Host plant resistance

PIPELINE

There are relatively few trial results on fungicide efficacy against anthracnose. In Michigan trials, Dithane Rainshield, Sovran, Elite and Endura worked best for control of cane infections; Dithane, Pristine, Sovran, Endura, and Captec worked well for control of fruit infections (Dithane, Pristine, and Sovran worked numerically the best). Some fungicides may need to have anthracnose added to the label if efficacy is confirmed.

"To do" list for Anthracnose:

Research needs:
- Efficacy testing of fungicides with novel mode of action
- Optimal spray timings
- Basic biology, etiology
- What to apply, when to apply, rates, etc.
- Study overall epidemiology of the disease to develop a forecasting model

Regulatory needs:

- Expedite registration of new alternatives as they become available
- Add anthracnose to the labels of effective fungicides

Education needs:

- As products and/or disease management strategies become available, educate users
- Varietal susceptibility (especially newer varieties)
- Distinguishing the difference between anthracnose and Phomopsis
- Education on disease epidemiology and forecasting models

EUTYPA DIEBACK (*Eutypa lata*)



Eutypa dieback is a progressive disease of the woody tissues of the grapevine commonly found in older vineyards. The disease develops slowly and symptoms may not be visible for several years after infection. Shoot symptoms are best observed in mid- to late spring. Symptoms typically show up on one arm. The leaves are smaller than normal, cupped upwards, and chlorotic. As the leaves expand, the edges become tattered. Chlorotic streaks may be present between veins and along margins. Shoots are stunted to varying degrees and have fewer and smaller fruit clusters, sometimes with a mixture of large and small berries. Eventually the affected arm or entire vine will fail to develop shoots altogether and die. Upon close examination of the perennial wood bearing symptomatic shoots, a canker can usually be found surrounding an old pruning wound (the fungus infects the vine through pruning wounds). Removal of the bark may be necessary to see the canker. When cut across, a wedge-shaped area of dead wood may be present. Shoot symptoms are thought to be induced by a toxin in the sap flowing from the canker. Most Eutypa infections take place at pruning time. Spores of the fungus are released from fruiting bodies in old cankers during late winter and early spring when temperatures are above freezing and rainfall of 1/25 inch or more has occurred. Moisture from melting snow may be sufficient.

**Variable symptoms make diagnosis, etc. difficult (year to year variability, slow onset of symptoms, etc.)

- **Fungicides**

Paint fungicides on wounds; boric acid, Topsin M? Too labor intensive, but can be done on large wounds perhaps. Spraying fungicides to try and cover pruning wounds during pruning time is difficult to do as it is hard to get through the snow, or the sprayer can freeze up and pruning takes place over an extended period of time.

- **Biocontrol Agents**
  - *Bacillus subtilis* (Serenade) – apply as a paint
    - Reduced-risk
    - Efficacy: not known
    - Other comments: not used

- **Other disease management aids:**
  - Good sanitation is crucial
  - Remove dead vines and dead wood and burn
  - Vine renewal
  - Host plant resistance

PIPELINE
Research at MSU is ongoing on disease severity-yield loss relationships and development of decision guide for deciding when to pull out vines.

"To do" list for Eutypa dieback:
Research needs:
- Efficacy testing of fungicides with novel mode of action
- Spread of Eutypa through pruning (how prevalent is it? How to prevent it? Is treatment of pruning shears with bleach or other fungicides between cuts effective?
- Does WD-40 affect fungi?
- Source of infections, nursery stock as a source of infection, means of sterilizing plants
- Other pathogens that cause cankers (*Botryosphaeria*)

Regulatory needs:
- Expedite registration of new alternatives as they become available

Education needs:
- As products and/or disease management strategies become available, educate users
- Integration of PCR technique into Diagnostics labs; how to take proper samples to be able detect Eutypa
- Canker identification

CROWN GALL (*Agrobacterium vitis*)



Crown gall is a problem in areas where climatic conditions favor freeze injury**. It is particularly damaging to *Vitis vinifera* and interspecific hybrids. The major symptom is fleshy galls on the lower trunk near the soil line. Aerial galls may also form as high as three ft up the vine. Young vines may be completely girdled by galls in one season. Young galls are cream colored and fleshy but turn brown and woody with age. Affected vines appear weak and portions of the vines above the galls may die. Crown gall is caused by the bacterium *Agrobacterium vitis*, which is a different strain from *A. tumefaciens,* the cause of crown gall on fruit trees and many other plants. The bacterium lives in the soil and enters the plants through wounds caused by mechanical damage, grafting, or freeze injury. The bacterium may also be present on the surface of planting material, which could explain sudden and severe outbreaks of crown gall in young vineyards after frost events. Contaminated pruning or grafting tools may contribute to spread. Removing galls usually does not cure the plant as new galls will continue to form. Sometimes, galls may be confused with abundant callus growth at graft unions. Isolation of the pathogen will be needed to confirm the cause of the galls in this case.

** A big problem for most growers in the region**

- **Bactericides**
  - Gallex-creosote compound that “dries” up galls
    - Efficacy: Unknown
    - Other comments: Hard to assess efficacy, not used

- **Other disease management aids:**
  - Planting of symptom/disease free nursery stock.
  - Remove diseased vines
  - Vine renewal
  - Host plant resistance

PIPELINE
Research is going on at MSU to develop certified crowngall- free planting material. In addition, an experimental biocontrol bacterium is being tested as a root dip at planting for control of grape crown gall.

"To do" list for Crown gall:
Research needs:
- Testing other bacteria for control of crown gall
- Infectivity of clean versus dirty planted materials (will a clean vine be infected less than dirty materials)
- Necessity of crown gall free plants available from nurseries
- Cultural techniques, cover crops to decrease crown gall spread
- Economics of crown gall (preventing spread and having to pull the whole vineyard out)
- Crown gall resistant root stocks?

Regulatory needs:
- Expedite registration of new alternatives as they become available
- Crown gall free certification from nurseries

Education needs:
- As products and/or disease management strategies become available, educate users
- Education of nurseries to the importance of crown gall free materials

VIRUS AND VIRUS-LIKE DISEASES - Tomato ringspot virus (TomRSV) or Tobacco ringspot virus (TRSV), Leaf Roll virus, Pierce's disease, etc.



Tobacco/tomato ringspot decline occurs sporadically in *V. vinifera* cultivars and interspecific hybrids. *Vitis labrusca* cultivars are resistant. A typical symptom in older vineyards is missing or dead vines in a roughly circular pattern. In the first year of infection, the disease is difficult to detect. A few shoots may show leaves with mottling or an oak leaf pattern. In the second year, the disease becomes more evident. New growth is generally sparse because many infected buds are prone to winterkill. Diagnostic symptoms are shortened internodes with small distorted leaves, and sparse fruit clusters with uneven ripening of berries. In the third year, growth is very stunted and limited to basal suckers. The vine continues to decline and eventually dies. The disease is caused by either of two nepoviruses (tomato ringspot virus and tobacco ringspot virus) which are transmitted by dagger nematodes (*Xiphinema* spp.). Both can also be transmitted via seed and cuttings. The nematode vectors retain the virus for long periods of time and can acquire it from roots of infected grape or weeds. Tomato ringspot virus infects a wide range of fruit crops, whereas both tomato ringspot virus and tobacco ringspot virus both infect many common weeds in vineyards, including dandelions, sheep sorrel, common chickweed, and red clover. Because of this, is it not uncommon for these viruses to be present in land used to establish new vineyards.

Leaf Roll is found in most areas where grapevines are grown. Symptoms are most obvious in the fall. Infected vines are slightly smaller than healthy vines. While leaves look normal early in the season, they start to show a yellow or reddish-purple discoloration as the season progresses while the main veins in the leaf remain green. By late summer the leaves start rolling downward (Photo), starting with the leaves at the base of the shoot. At harvest, fruit clusters are small, poorly colored and low in sugar. The disease does not kill the vine but will remain chronic. Not all infected vines show symptoms. Leaf Roll is caused by a virus that spreads primarily via infected nursery stock. No vector has been established for the virus and natural spread is slow in commercial vineyards.

- **Chemical control measures:**

  There are no chemicals that can cure virus diseases. However, nematicides and insecticides can be used and are sometimes recommended to kill nematode and insect vectors of viruses and virus-like organisms. The spread of Pierce's disease may be slowed by the use of insecticides but since Pierce's disease is not (yet) present in the North Central region, this is not applicable.

- **Organophosphate nematicides currently used for control of nematode vectors:**
  - fenamiphos (Nemacur 3)
    - provides fair control.
    - the only registered OP nematicide available in Michigan.
    - the only non-fumigant nematicide registered for grapes (?)

- **Carbamate nematicides currently used for control of nematode vectors:**
  - oxamyl (Vydate)
    - provides fair control.
    - the only non-fumigant nematicide that can be applied as a foliar spray.
    - the limitation is it is only registered for non-bearing vineyards.

- **B2 carcinogenic nematicides currently used for control of nematode vectors:**
  - dichloropropene (Telone II, Telone C-17) (fumigant)
    - provides very good control.
    - soil fumigation equipment required.
    - pre-plant only.

  - metam sodium (various) (fumigant)
    - provides good control.
    - must be diluted three to one or more with water.
    - soil fumigation equipment required.
    - pre-plant only.

- **Non-chemical alternatives currently used:**
  - Buy plants from reputable nurseries
  - Removing and destroying infected plants
  - Raising a cover crop that is not a nematode host before new vineyard establishment.
  - Work on soil organic matter and overall soil quality

PIPELINE:
Miscellaneous soil amendments and biological agents for control of nematode vectors of viruses.

"To do" list for viruses:
Research needs:
- Survey of what viruses are out there, how prevalent they are, and what vectors (mealybugs, etc.) are spreading them
- Evaluation of biological control agents and soil amendments for control of dagger nematode
- Need to know more about host preference of nematode vectors in relation to cover crops

Regulatory needs:
- Certified disease-free planting material
- Be sure nursery stock is free of tomato ringspot virus.

Education needs:
- Education on virus symptoms, vectors, sampling.
- Identification of different virus diseases as compared to nutrient deficiencies, etc.
- Continue periodic updates at annual IPM school.

PIERCE'S DISEASE

  

Pierce's disease is caused by a bacterium (*Xyllela fastidiousa*) that lives in the plant xylem tissues and is vectored by sharpshooter leafhoppers and spittlebugs. The bacterium is present in native plants such as grasses, sedges, bushes and trees. Pierce's disease occurs primarily in the southern United States from California to Florida and was recently confirmed in vines growing along the Arkansas River in central AR, and has been suspected in vineyards as far north as southern Missouri. It has not yet been found in the North Central region. Its northern range is limited by winter temperatures below 5°F.

Initially, only a few shoots start to show symptoms in mid to late summer. Leaves show scorching from the margin inwards and drop off, leaving the petiole attached to the shoot. Flower clusters may set berries, but these tend to dry up. In fall, infected shoots mature in a patchy manner, leaving "islands" of green tissue surrounded by dark brown mature wood. In spring, bud break on infected vines may be delayed as much as two weeks, and new shoots are stunted. An infected vine may die the first year after infection or may live for five or more years, depending on the cultivar, the vine's age and climatic conditions.

- **Chemical control measures:**
  The spread of Pierce's disease may be slowed by the use of insecticides but since Pierce's disease is not (yet) present in the North Central region, this is not applicable.

"To do" list for Pierce's disease:
Research needs:
- Survey of vineyards in southern areas of North Central Region for presence of Pierce's disease-infected vines
- Survey vineyards in at-risk areas for potential vectors
- Determine if vectors are carrying *Xylella fastidiosa* bacteria
- Determine resistance/susceptibility of varieties commonly grown in North Central Region
- Evaluation of potential control methods (dormant pruning severity, removal of infected vines, spray programs for vector control) for containing spread of disease within vineyards and within region

Education needs:
- Education of growers to recognize Pierce's disease
- Educate growers in methods for dealing with infected vines

TABLE 2. Relative Effectiveness of Fungicides for Grape Disease Control.†

Fungicide	Black Rot	Downy Mildew	Powdery Mildew	Botrytis Rot	Phomopsis
Abound (azoxystrobin)	+++	+++	++	+	+++
Agri-Fos (potassium phosphite)	++	++ / +++	+	?	++ / +++
Alliette (fosetyl-AL)	?	+++	?	?	?
Armicarb (potassium bicarbonate)	++	0	+ / ++	+	+
Basic Copper Sulfate (copper)	+	+++	++	+	+
Bayleton (triadimefon)	+++	0	+++	0	+
Captan (captan)	++	+++	0	+	++
Ferbam (ferbam)	++	+	0	0	0
Copper hydroxide (copper)	+	++	+	+	+
EBDCs (mancozeb)	+++	+++	0	0	++ / +++
Elevate (fenhexamid)	0	0	0	+++	0
Elite (tebuconazole)	+++	0	+++	0	++
Endura (boscalid)	?	?	++	+++	?
Flint (trifloxystrobin)	+++	++	+++	+	+++
JMS Stylet Oil (paraffinic oil)	0	0	++	+	0
Kaligreen (potassium bicarbonate)	++	?	+ / ++	?	?
Lime sulfur (calcium polysulfide)	0	0	+	0	++
Messenger (harpin)	?	?	+ / ++	+	+
Nova (myclobutanil)	+++	0	+++	0	++
Oxidate (hydrogen peroxide)	?	?	+	+	?
Phostrol (Na, K, NH3 phosPHItes)	++	+++	+	?	++ / +++
Prev-Am (boric acid)	++ / +++	+ / ++	+ / ++	?	+ / ++
Pristine (pyraclostrobin + boscalid)	+++	+++	+++	+ / ++	+++
Procure (triflumizole)	++	0	+++	+	++
ProPhyt (potassium phosPHIte)	++	+++	+	?	++ / +++
Quintec (quinoxifen)	++	?	+++	?	?
Ridomil Gold MZ (mefenoxam + mancozeb)	++	+++*	0	0	++
Ridomil Gold/Copper (mefenoxam + copper)	+	+++	++	+	+
Rubigan (fenarimol)	++	0	+++	0	0
Rovral (iprodione)	+	0	0	++	?
Scala (pyrimethanil)	+	?	++	+++	+/++
Serenade (*Bacillus subtilis*)	?	+ / ++	+	+ / ++	+ / ++
Sulfur (elemental sulfur)	0	0	++	0	+
Sovran (kresoxim methyl)	+++	+++	+++	+	+++
Topsin M (thiophanate methyl)	++	0	+++**	++	+
Vangard (cyprodinil)	?	?	+	+++	+
Vintage (fenarimol)	++	0	+++	0	0
Ziram (ziram)	++	++	+	+	++

0 = not effective, + = slightly effective, ++ = moderately effective, +++ = highly effective,
? = effectiveness not known.
Efficacy is based on applications in total spray volumes of 50-100 gal/acre.
*Ridomil also has eradicative properties.
**If benzimidazole-resistant strains are present, efficacy will be reduced.

† *Taken from Michigan State University 2007 Fruit Management Guide (Bulletin E-154).*

Table 1. Relative susceptibility to disease and sulfur and copper sensitivity of grape varieties. (The ratings apply to an average growing season under conditions favorable for disease development. Any given cultivar may be more severely affected).

	Black Rot	Downy Milde	Powdery Mildev	Phom-opsis	Botrytis	Eutypa	Crown gall	Sulfur Sensitive[3]	Copper Sensitive[3]
Aurore	+++[1]	++[2]	+++	++	+++	+++	++	No	++
Baco Noir	+++	+	++	+	++	++	++	No	?
Cabernet Franc	+++	+++	+++	?	+	?	+++	No	+
Cabernet Sauvignon	+++	+++	+++	+++	+	+++	+++	No	+
Canadice	+++	++	+	?	++	?	++	No	?
Cascade	+	+	++	++	+	++	+	No	?
Catawba	+++	+++	++	+++	+	+	+	No	++
Cayuga White	+	++	+	+	+	+	++	No	+
Chambourcin	+++	++	+	?	++	?	++	Yes	?
Chancellor	+	+++	+++	+++	+	+	++	Yes	+++
Chardonnel	++	++	++	++	++	?	++	No	?
Chardonnay	+++	+++	+++	+++	+++	++	+++	No	+
Chelois	+	+	+++	+++	+++	+++	++	No	+
Concord	+++	+	++	+++	+	+++	+	Yes	+
DeChaunac	+	++	++	+++	+	+++	++	Yes	+
Delaware	++	+++[2]	++	+++	+	+	+	No	+
Dutchess	+++	++	++	++	+	+	++	No	?
Elvira	+	++	++	+	+++	+	+	No	++
Einset Seedless	+++	+++	++	?	+	?	+	?	?
Foch	++	+	++	?	+	+++	+	Yes	?
Fredonia	++	+++	++	++	+	?	+	No	?
Gewürztraminer	+++	+++	+++	?	+++	?	+++	No	+
Himrod	++	+	++	?	+	?	?	No	?
Ives	+	+++	+	?	+	++	+	Yes	?
Limberger	+++	+++	+++	?	+	+++	+++	No	?
Marechal Foch	++	+	++	?	+	+++	?	Yes	?
Melody	+++	++	+	?	+	?	+	No	?
Merlot	++	+++	+++	+	++	+++	+++	No	++
Moore's Diamond	+++	+	+++	?	++	++	?	No	?
Muscat Ottonel	+++	+++	+++	?	++	+++	+++	No	?
Niagara	+++	+++	++	+++	+	+	++	No	+
Pinot gris	+++	+++	+++	?	++	+++	+++	No	?
Pinot Meunier	+++	+++	+++	?	+++	+++	+++	No	?
Pinot blanc	+++	+++	+++	?	++	?	+++	No	+
Pinot noir	+++	+++	+++	?	+++	?	+++	No	+
Reliance	+++	+++	++	++	+	?	?	No	+
Riesling	+++	+++	+++	++	+++	++	+++	No	+
Rosette	++	++	+++	++	+	++	++	No	+++
Rougeon	++	+++	+++	+++	++	+	++	Yes	+++
Sauvignon blanc	+++	+++	+++	?	+++	?	+++	No	+
Seyval	++	++	+++	++	+++	+	++	No	+
Steuben	++	+	+	?	+	?	+	No	?
Vanessa	+++	++	++	+	+	?	+	?	?
Ventura	++	++	++	+	+	?	++	No	?
Verdelet	+	?	?	?	+	?	?	No	?
Vidal 256	+	++	+++	+	+	+	++	No	+
Vignoles	+	++	+++	+++	+++	++	++	No	?
Villard noir	?	+	+++	?	+	?	?	?	?

1+ = slightly susceptible or sensitive, ++ = moderately susceptible or sensitive, +++ = very susceptible or sensitive. ? = relative susceptibility not established.
2Berries are not susceptible.
Most of the data in this table were obtained from the New York Cooperative Extension Service.
3Even tolerant cultivars can be injured by sulfur when the temperature is >85F and by copper under cool, slow-drying conditions.

Insect Pests of Grapes in the North Central Region

Grapevines in the North Central region of the United States are affected by a complex of native and invasive exotic insect pests. The most damaging of these, in order of economic importance, are the grape berry moth, grape and potato leafhoppers, Japanese beetle, grape root borer and grape phylloxera. These insects are the focus of pest management programs and are responsible for the majority of insecticide applications, but there are other sporadic insect pests that are also of economic importance. These are all listed below, along with the current management strategies, potential gaps in available management tools, and needs for further research.

GRAPE BERRY MOTH (*Paralobesia viteana*[1])

Biology and management

- Berry moth is the most common internal-feeding insect in the region's vineyards.
- Has 2-4 generations per year depending on the location and season. The later generations create a risk of contamination in the harvested fruit.
- There is a USDA standard for larvae during inspection at all processing plants. Winemakers may have more strict thresholds, because larvae can introduce pathogens into the fruit.
- Truckload quantities of grapes have been rejected in recent years due to uncontrolled infestations ($300,000 value in Michigan during 2002).
- Population densities of grape berry moth have increased in the region's vineyards over the past 10 years, resulting in a greater number of vineyards with un-harvested fruit, especially at the vineyard borders. This is further suspected of contributing to the increase.
- Fruit infested with this insect is more susceptible to sour rots and botrytis, so more fungicides are used to control these diseases in the vineyards affected.
- Control is needed through the season, so extending REI's and PHI's of organophosphatess and carbamates would have a negative impact and necessitate a switch to less effective chemistries, which could upset current IPM programs.
- Penncap-M and Guthion are now restricted from use in vineyards due to FQPA, but new reduced-risk insecticides are more expensive and complicated to use, requiring more accurate timing. These products also tend to be active on some, but not all, life-stages of this pest.

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[1] Recently renamed from *Endopiza viteana* by J. Brown, USDA-ARS Beltsville, MD.

- Wild grapevines are alternate hosts, and these are common in the woods around vineyards creating a continual source of moths.
- Note: Worker re-entry is important for shoot positioning, leaf pulling, and harvest of wine grapes but not juice grapes. Increased REI values for insecticides used in-season will make it difficult to integrate insecticides into management of vineyards grown for wine.
- Grape berry moth tends to be less of a problem in areas with low grape acreage, but wild grape is distributed across the eastern US and wild grape berry moth populations are likely endemic in all parts of the region and likely to find commercial vineyards.

Registered insecticide efficacy

- **Organophosphates**
  - azinphos-methyl (Guthion)
    - Grapes taken off the label in 2005, but still has a tolerance. All old supplies are being used up.

  - phosmet (Imidan)
    - Main remaining organophosphate used in vineyards.
    - Shorter residual control than Guthion.
    - Efficacy: Good-Very Good
    - -Requires high rate (2lb) and pH 6 spray water for optimal performance.
    - 7-day PHI but 14 day REI; makes use in season more challenging (this is a recent change); REI is causing problems (makes management in vineyards more difficult)

  - Diazinon (Diazinon)
    - not used much (because other products are more effective)

  - malathion (Malathion)
    - not used

- **Carbamates**
  - carbaryl (Sevin)
    - Efficacy: Fair to Good
    - Widely used for grape berry moth control, active on other pests.
    - Provides good control of larvae, but with relatively short residual for the 80S formulation (needs to be used more often), XLR Plus formulation tends to have a longer residual; due to its greater washoff resistance; solupaks make use easier.

  - methomyl (Lannate)
    - Efficacy: Good (with proper timing)
    - Short residual control, so main use is early season; material is very toxic to non target organisms.

- **Pyrethroids** (resistance is a potential issue for all of these)
  - fenpropathrin (Danitol)
    - Efficacy: Good-Excellent
    - Has received wide adoption as the use of organophosphates is restricted
    - Common insecticide for grape berry moth control
    - Broad activity on other pests
    - No mite outbreaks reported to date (over five years use)
    - Restricted use pesticide
    - Cutworm damage much less since this used for grape berry moth control
    - 8-10 oz rates used

  - bifenthrin (Capture, being changed to Brigade for 2007 season)
    - Efficacy: Good-Excellent
    - Recently registered (2006)
    - Cheaper than many alternatives
    - Two sprays allowed per season at the 3.2oz rate

  - beta-cyfluthrin (Baythroid XL)
    - Efficacy: excellent on grape berry moth at the higher labeled rate. Shorter residual at half rate.
    - Recently registered (2006); not widely used yet

  - zeta-cypermethrin (Mustang Max)
    - Efficacy: not tested yet for grape berry moth
    - Recently registered (2007); not widely used yet

- **Other insecticides**
  - methoxyfenozide (Intrepid)
    - Efficacy: Good-Excellent (if good cluster coverage)
    - Growth regulator
    - Should be applied just before, during or just after egg hatch
    - Highly selective to moth pests
    - No disruption of natural enemies
    - Needs good cluster coverage to be effective
    - Usage later in the season (within PHI)
    - Expensive
    - Not widely used

  - spinosad (Spintor, Entrust)
    - Efficacy: Good
    - Requires ingestion to be lethal, not fast acting
    - Expensive
    - Susceptible to washing off
    - Entrust registered for use in organic production, 7-10 day residual control
    - Not used

- spinetoram (Delegate)
  - Expected to be more active than Spinosad, with broader activity
  - Trials conducted in 2007 showing good activity
  - Registered for 2008 season, but limited experience in commercial vineyards

- indoxacarb (Avaunt)
  - Active on GBM, beetles, leafhoppers
  - Registered for 2008, but limited experience in commercial vineyards

- acetamiprid (Assail)
  - Efficacy: Good
  - Not widely used but growers in Ohio report good control

- *Bacillus thuringiensis* = *B.t.* (Dipel, Javelin, etc.)
  - Efficacy: good if repeat applications
  - Small plot trials indicate high activity
  - Adoption low due to short residual, meaning multiple applications needed.
  - May be useful for organic growers, late season?

- kaolin (Surround)
  - Efficacy: good
  - Not used in most North Central region vineyards.
  - Requires many applications.
  - Maintaining coverage is difficult with rainfall.
  - Expensive
  - Used by organic growers

- **Mating disruption**
  - Sprayable pheromone no longer produced by 3M Company

  - Season-long twist ties (Isomate grape berry moth) available from Pacific Biocontrol
    - Population size and vineyard characteristics are important for efficacy: works best in large blocks, isolated from adjacent woods, and with low grape berry moth populations

  - Development of wax-based pheromone formulations underway in Michigan. Shows promise for grape berry moth control. Because the composition of grape berry moth pheromone may be different in different areas the North Central Region, this research should be replicated in several locations across the region.

PIPELINE:

Company and IR-4 projects are bringing new products to grapes for grape berry moth control.

- rynaxypyr (Altacor)
  - Very effective against grape berry moth
  - Expected EPA registration 2009

- thiacloprid (Calypso)
  - Preliminary data from small plot vineyard trials are promising for grape berry moth and grape leafhopper
  - Registration delayed/prevented

- metaflumizone (Alverde)
  - Effectiveness for grape berry moth control unknown – 2007 trials planned

- flubendiamide (Belt)
  - Effectiveness for grape berry moth control unknown – 2007 trials planned

- ***Pest management aids***
  - Vineyard monitoring using pheromone traps and scouting for grape berry moth eggs and damage can reduce need for insecticides or improve timing of sprays.
  - Treating vineyard perimeters rather than entire vineyards can be an effective way to reduce insecticide use, if the distribution of GBM is known.
  - Optimizing coverage of clusters is critical for control.
  - No commercially available biological control agents are effective, but 4-5 native parasitic wasps that parasitize larvae have been identified in Michigan and a *Trichogramma* egg parasitoid is under investigation.
  - Removal of wild grape from woods shown to have no effect on adjacent vineyard populations.

"To do" list for grape berry moth management

Research needs:

- Test new insecticides to find alternatives to organophosphate, carbamate and pyrethroid insecticides.
- Develop and validate a pest phenology model for grape berry moth.
- Continue to evaluate spray application strategies designed to reduce pesticide use.
- Determine the role of moth movement in creating border effects – when do moths move from woods to vineyards?
- Evaluate new mating disruption formulations that may reduce labor, time and costs
- Varietal differences with regards to grape berry moth infestation

Regulatory needs:

- Engage the IR-4 Pesticide Clearance Report (PCR) process to accelerate registration of candidate new insecticides that can economically and effectively control grape berry moth.
- Imidan 14-day REI is restrictive. More data are needed from North Central Region to support return to 7 day REI

Education needs:

- As products and/or insect management strategies become available, educate users and crop consultants.
- Proper use of mating disruption in vineyards.

GRAPE LEAFHOPPER (*Erythroneura comes*)


Biology and management

Grape leafhopper adults are orange-yellow colored with some dark spots and yellow lines on the forewings, and are about 1/8 inch long. The grape leafhopper has 1.5-2 generations per year, with peak abundance of adults in late July and again in late August. Adults overwinter in leaf litter in or around vineyards, and feed on weeds as temperatures exceed 60 ^{o}F in the spring. After mating, they move to young grape foliage in late May and early July to lay clear crescent shaped eggs. These are inserted singly under the lower leaf surface. Eggs of the first generation hatch in mid-late June, and the flightless nymphs take a month to develop to adults. Cold, wet springs and winters are damaging to leafhoppers, and egg parasites are rare. Grapevines can tolerate populations of up to 15 hoppers per leaf with little or no economic damage. However, heavy leafhopper feeding can result in premature leaf drop, lowered sugar content, increased acid, and poor color of the fruit. Ripening fruit is often smutted or stained by the sticky excrement ("honeydew") of the hoppers, which affects appearance and supports the growth of sooty molds (NY State IPM: http://www.nysipm.cornell.edu/factsheets/grapes/pests/glh/glh.asp). Researchers in New York have created a conservative provisional action threshold in juice grapes of five nymphs per leaf before August 1, and ten nymphs per leaf thereafter. Sprays should be directed when mostly nymphs are present (nymphs are more susceptible to pesticides than adults). This insect is typically a pest of native labrusca and some hybrid varieties, and is less of a pest in winegrapes.

Registered insecticide efficacy

- **Organophosphates**
  - azinphos-methyl (Guthion)
    - Efficacy:
    - Grapes taken off the label in 2005, but still has a tolerance. Not used
  - phosmet (Imidan)
    - Main remaining OP used in vineyards.
    - Shorter residual control than Guthion.
    - Fair control,
    - Requires high rate and pH 6 spray water for optimal performance.
    - 7-day PHI but 14-day REI; makes use in season more challenging.
    - Not used
  - Diazinon (Diazinon)
    - Not used.

- Malathion (Malathion)
  - Not used

- **Carbamates**
  - carbaryl (Sevin)
    - Widely used for grape leafhopper control, active on other pests.
    - Provides good control of adults, but with relatively short residual.
    - Efficacy: Good-Fair (may show resistance)

  - methomyl (Lannate)
    - Short residual control; may be used, not used as much anymore (replaced by pyrethroids)

- **Pyrethroids**
  - fenpropathrin (Danitol)
    - Efficacy: Excellent
    - Broad activity on other pests
    - No mite outbreaks reported to date (over five years use)

  - bifenthrin (Capture)
    - Efficacy: Excellent
    - Recently registered (2006)

  - beta-cyfluthrin (Baythroid XL)
    - Efficacy: Excellent
    - Recently registered (2006)

  - zeta-cypermethrin (Mustang Max)
    - Efficacy: Excellent
    - Recently registered (2007)
    -

- **Other insecticides**
  - imidacloprid (Provado Pro)
    - Efficacy: Excellent
    - Neonicotinoid insecticide
    - Reduced-risk, systemic insecticide
    - Expensive and primarily controls leafhopper

  - imidacloprid (Admire)
    - Efficacy: good in recent research trials.
    - Soil formulation of Provado (imidacloprid)
    - Not used due to price?

  - acetamiprid (Assail)
    - Efficacy: Excellent
    - New neonicotinoid insecticide
    - Soil and foliar application allowed

- dinotefuran (Venom)
  - New neonicotinoid insecticide
  - Efficacy: Not known

- azadiractin (Neemix, Ecozin)
  - Efficacy: Not known

- spinosad (Spintor)
  - Efficacy: Not known

- spinosad (Entrust)
  - Efficacy: Not known

- pyrethrum (Pyganic)
  - Efficacy: Not known

- pyrethrum (Evergreen)
  - Pyrethrum plus PBO (PBO = piperonyl butoxide which is a pesticide synergist that increases the activity of pyrethrum insecticides)
  - Efficacy: Not known

- kaolin (Surround)
  - Not used in most North Central region vineyards.
  - Requires many applications.
  - Maintaining coverage is difficult with rainfall.
  - Expensive

PIPELINE:

- indoxacarb (Avaunt)
  - Reduced risk
  - Active on grape leafhopper
  - Registration for 2008 season

- thiamethoxam (Actara)
  - High efficacy expected
  - Registered for 2008 season

- thiamethoxam (Platinum – soil formulation)
  - High efficacy expected
  - Timing issues need to be worked out
  - Registered for 2008 season

- thiacloprid (Calypso)
  - Neonicotinoid
  - High efficacy expected, with wide spectrum of activity

- clothianidin (Belay)
  - Soil applied formulation
  - Neonicotinoid
  - Effective in small plot and potted vine studies

- ***Pest management aids***
  - Yellow sticky traps, combined with examination of foliage, can help detect infestation.

"To do" list for grape leafhopper

Research needs:

- Determine range of susceptibility of cultivars
- Determine efficacy of soil-applied insecticides and foliar insecticides
- Determine thresholds for moderately and highly susceptible cultivars
- New chemicals for resistance management

Regulatory needs:

Education needs:

- Demonstrate use of action thresholds for leafhopper nymphs to time sprays on moderately and highly susceptible cultivars

POTATO LEAFHOPPER (*Empoasca fabae*)

Biology and management
The adult leafhopper is pale to bright green, and about 1/8 inch long. The adults are very active, jumping, flying or running when disturbed. The immature forms, or nymphs, are pale green and wingless. They are distinctive in moving sideways rapidly when disturbed. The potato leafhopper does not overwinter north of the Gulf states, but adults migrate each spring on southerly winds and are deposited from May-June in spring rains.

Potato leafhopper can be very destructive in hybrid or vinifera varieties that are sensitive to the toxins it injects while feeding. These cause leaf yellowing and cupping, with different levels of these symptoms among varieties. Feeding is concentrated on young tissues at the shoot tips, and can also lead to shortened shoot internodes. Few insects are needed to cause these symptoms. This insect is typically not a pest in native juice grapes.

Because these insects preferentially feed on the tips of new shoots, it is difficult to retain coverage of insecticides. In infested vineyards with sensitive cultivars, potato leafhopper control may require multiple applications of an effective insecticide.

Registered insecticide efficacy
- **Organophosphates**
  - azinphos-methyl (Guthion)
    - Efficacy:
    - Grapes taken off the label in 2004 (?), but still has a tolerance. Not used

  - phosmet (Imidan)
    - Main remaining OP used in vineyards.
    - Shorter residual control than Guthion.
    - Fair control,
    - Requires high rate and pH 6 spray water for optimal performance.
    - 7-day PHI but 14 day REI; makes use in season more challenging.
    - Not used

- Diazinon (Diazinon)
  - Not used

- Malathion (Malathion)
  - Not used

- **Carbamates**
  - carbaryl (Sevin)
    - Widely used for potato leafhopper control in northern MI, active on other pests.
    - Provides good control of adults, but with relatively short residual.
    - Efficacy: Excellent

  - methomyl (Lannate)
    - Short residual control
    - Not used much.

- **Pyrethroids**
  - fenpropathrin (Danitol)
    - Efficacy: Excellent
    - Broad activity on other pests
    - No mite outbreaks reported to date (over five years use)

  - bifenthrin (Capture)
    - Efficacy:
    - Recently registered (2006).
    - Not used

  - beta-cyfluthrin (Baythroid XL)
    - Efficacy:
    - Recently registered (2006).
    - Not used

  - zeta-cypermethrin (Mustang Max)
    - Efficacy: Still largely untested in grape, but Mustang Max (at 2.24 to 4.0 oz/acre rates) is very effective at potato leafhopper control in alfalfa.
    - Recently registered (2007).
    - Not used

- **Other insecticides**
  - imidacloprid (Provado Pro)
    - Efficacy: Excellent
    - Neonicotinoid insecticide
    - Reduced-risk, systemic insecticide

  - imidacloprid (Admire)
    - Efficacy: good in recent research trials.
    - Soil formulation of Provado (imidacloprid)
    - Not used due to price?

- acetamiprid (Assail)
  - Efficacy: Poor in first experiences of 30SG formulation for potato leafhopper control
  - New neonicotinoid insecticide
  - Soil and foliar application allowed

- dinotefuran (Venom)
  - New neonicotinoid insecticide
  - Efficacy:not used

- azadiractin (Neemix, Ecozin)
  - Efficacy: not used

- spinosad (Spintor)
  - Efficacy: not used

- spinosad (Entrust)
  - Efficacy: not used

- pyrethrum (Pyganic)
  - Efficacy: not widely used, but it is used by organic growers in Iowa.

- pyrethrum (Evergreen)
  - Pyrethrum plus PBO (PBO = piperonyl butoxide which is a pesticide synergist that increases the activity of pyrethrum insecticides)
  - Efficacy: not widely used, but it is used by some growers in Iowa.

- kaolin (Surround)
  - Not used in most North Central region vineyards.
  - Requires many applications.
  - Maintaining coverage is difficult with rainfall.
  - Expensive (drive slow, high volumes needed)
  - Efficacy: Good; doesn't have the residual activity of Provado

PIPELINE:

- indoxacarb (Avaunt)
  - Reduced risk
  - Active on grape leafhopper, no data on potato leafhopper in grape
  - Registration expected for 2007 season

- thiamethoxam (Actara)
  - High efficacy expected
  - Registered for 2008 season

- thiamethoxam (Platinum)
  - High efficacy expected
  - Registered for 2008 season

- thiacloprid (Calypso)
  - Neonicotinoid
  - High efficacy expected, with wide spectrum of activity

- clothianidin (Belay)
  - Soil applied formulation
  - Neonicotinoid
  - Effective in small plot and potted vine studies

- ***Pest management aids***

  Yellow sticky traps can help detect infestation, but examining foliage is usually required too. Watch adjacent alfalfa field mowing for immigration of potato leafhopper

"To do" list for potato leafhopper

Research needs:

- Determine efficacy of soil-applied insecticides and foliar insecticides for potato leafhopper control
- Determine thresholds for moderately and highly susceptible cultivars
- Investigate fungal disease for control of potato leafhopper
- Collaborative research between entomologists and meteorologists in the southern U.S. to determine when potato leafhopper are likely to be carried into the North Central Region by storm fronts.

Regulatory needs:

Education needs:

- Early warning of when potato leafhopper appears based on weather

JAPANESE BEETLE (*Popillia japonica*)

Biology and management

Japanese beetle is an invasive insect pest that has been in the US for about 90 years. In that time it has spread from the site of introduction in New Jersey out to all states east of the Mississippi except Florida. It is moving further into the North Central region each year, with populations established in southwestern and eastern Missouri, Iowa and moving north in Michigan.

This pest has a single generation per year, although in the northern extremes of its distribution it may take two years to complete development. Beetles defoliate vines during the summer, with the degree of leaf removal based on population size, leaf toughness, and chemical control of the beetles. In highly infested winegrape vineyards, especially of Chardonel, Norton, Vidal, Vignoles and the table grape Reliance, vines can be heavily defoliated, reducing vine establishment and potentially harming the vine's winter hardiness.

Beetle activity is during July and August, when vines have typically completed most of their leaf growth. In established vineyards, high levels of leaf removal at this time can compromise the vines ability to ripen fruit.

- **Organophosphates**
  - azinphos-methyl (Guthion)
    - Efficacy:
    - Grapes taken off the label in 2004 (?), but still has a tolerance.
    - Not used

  - phosmet (Imidan)
    - Efficacy: Good
    - Main remaining OP used in vineyards.
    - Shorter residual control than Guthion.
    - Requires high rate and pH 6 spray water for optimal performance.
    - 7-day PHI but 14-day REI; makes use in season more challenging, especially for Japanese beetle control.
    - Not used much

- diazinon (Diazinon)
  - Not used

- malathion (Malathion)
  - Not used

- **Carbamates**
  - carbaryl (Sevin)
    - Efficacy: Good-Excellent
    - Widely used for Japanese beetle control, active on other co-occurring pests.
    - Provides good control of adults, one week of activity.
    - Compound of choice in some areas; not a restricted use pesticide
    - Directed spray at top of canopy (cuts costs)

  - methomyl (Lannate)
    - Active, but short residual control.
    - Not used much (maybe some in MI)

- **Pyrethroids**
  - fenpropathrin (Danitol)
    - Efficacy: Excellent
    - Broad activity on other pests
    - No mite outbreaks reported to date (over five years use)
    - The other main compound for Japanese beetle control (along with Sevin)
    - Northern IL not used for Japanese beetle (because it's used for phylloxera earlier in season)
    - Some allergies shown in some workers

  - bifenthrin (Capture)
    - Efficacy: Not known
    - Recently registered (2006)
    - Not tried yet

  - beta-cyfluthrin (Baythroid XL)
    - Efficacy: Not known
    - Recently registered (2006)
    - Not tried yet
    -
  - zeta-cypermethrin (Mustang Max)
    - Efficacy: Not known
    - Recently registered (2007)
    - Not tried yet

- **Other insecticides**
  - imidacloprid (Provado Pro)
    - Neonicotinoid insecticide
    - Reduced-risk, systemic insecticide
    - Efficacy: Excellent, but Sevin is cheaper

  - imidacloprid (Admire)
    - Soil formulation of Provado (imidacloprid)
    - Efficacy:
    - Slow updake and price may limit utility
    - Could be used for killing grubs if an isolated infestation
    - Could be used as a systemic soil drench (along with phylloxera control)

  - acetamiprid (Assail)
    - Neonicotinoid insecticide
    - Foliar application allowed
    - Efficacy: Not used

  - dinotefuran (Venom)
    - New (2006) neonicotinoid insecticide
    - Soil and foliar application allowed
    - Efficacy: Not used not labeled for Japanese beetle

  - azadiractin (Neemix, Ecozin)
    - Efficacy: Not used

  - pyrethrum (Pyganic)
    - Efficacy: Not used

  - pyrethrum (Evergreen)
    - Pyrethrum plus PBO (PBO = piperonyl butoxide which is a pesticide synergist that increases the activity of pyrethrum insecticides)
    - short residual activity
    - Efficacy: Not used

  - kaolin (Surround)
    - Not used in most North Central region vineyards, but it was shown to reduce Concord foliar in Arkansas
    - Requires many applications.
    - Maintaining coverage is difficult with rainfall.
    - Expensive
    - Efficacy: Works well with application after every rainfall

PIPELINE:

- thiamethoxam (Actara)
  - High efficacy expected

- thiamethoxam (Platinum)
  - High efficacy expected
  - Soil application needs correct timing

- thiacloprid (Calypso)
  - Neonicotinoid
  - High efficacy expected, with wide spectrum of activity

- clothianidin (Belay)
  - Soil applied formulation
  - Neonicotinoid
  - Efficacy:

- metaflumizone (Alverde)

- spirotetramat (Movento)

- indoxacarb (Avaunt)

- ***Pest management aids***
  Japanese beetle traps may draw beetles to the vineyard. However, modified Japanese beetle traps funneling beetles into a 3 gal. capture bucket are highly effective to mass trap Japanese beetles when several traps are placed 100’ away from the vineyard.
  Beetles and their damage are easy to see so monitoring traps are not necessary.

“To do” list for Japanese beetle

Research needs:
- Determine efficacy of soil-applied and foliar insecticides
- Determine percentage foliar loss thresholds for different types of grape cultivars, under various crop loads
- Demonstrate usefulness of Surround to prevent foliar damage

Regulatory needs:
- Better monitoring for infestation by United States Department of Agriculture

Education needs:
- Information on cultivar tolerance, pesticide efficacy, biology
- Threshold education
- Trap placement in relation to vineyard and adjacent habitats for mass trapping

GRAPE ROOT BORER (*Vitacea polistiformis*)

The grape root borer is a clearwing moth with a dark brown body with yellow-orange bands on the abdomen. Adult moths are active during the day, and are seen on vines in July. The female moths lay up to 300 eggs on or near the vine, and newly hatched larvae find their way into the soil and then to a root. Larvae feed on the roots for up to two years (perhaps longer), moving to larger roots as they grow. Damaged vines have reduced vigor and may eventually die. This species is found throughout the eastern US, but is more damaging in southeastern states.

- **Control measures**
  - chlorpyriphos (Lorsban) application timing is an issue because the PHI is 35 days which restricts effective use on early maturing cultivars harvested in July and August
  - Mating disruption works
  - Cultural controls (good weed control) to reduce populations
  - Mass trapping males to reduce mating and subsequent population level

PIPELINE:
  - Nematodes for control of larvae
  - Need to test new chemistries for efficacy on grape root borer

"To do" list for grape root borer
Research needs:
- Test new chemicals for root borer control
- Determine efficacy of soil-applied neonicotinoids

Education needs:
- Proper identification of adults
- How to check for larvae in roots to assess extent of infestation

GRAPE PHYLLOXERA (*Daktulosphaira vitifoliae*)

Biology and management

Phylloxera are small, yellow aphid-like insects that live on vine roots and leaves. The root form of this pest prefers heavy, clay soils that crack during dry weather allowing pest to move to other vines. Phylloxera damages the root systems of grapevines by feeding on growing rootlets, which then swell and turn yellowish, or on mature hardened roots where the swellings are often hard to see. Necrotic spots (areas of dead tissue) develop at the feeding sites and become infected with secondary fungal pathogens that kill the vines. Labrusca grapes can tolerate phylloxera feeding on roots, particularly in well-watered vineyards. This form is effectively managed by using resistant or tolerant rootstocks. In the eastern US, the foliar form of phylloxera can be seen on wild grape, labrusca, and several hybrid varieties as raised galls on the undersides of leaves. Grape varieties from crosses of *V. vinifera* and various American *Vitis* species when grown in the NorthCentral Region were highly susceptible to leaf galling including: Aurora, Cascade, Cayuga White, Chambourcin, Chancellor, Chelois, DeChaunac, Delaware, Himrod, Lakemont, Norton/Cynthiana, Rayon D'Or, Reliance (table grape), Rougeon, Seibel, Seyval, Vidal, Vidal Blanc and Vignoles. Well timed insecticide sprays control the foliar form on susceptible varieties.

Registered insecticide efficacy

- **Products for control of the aerial form**
  - endosulfan (thiodan)
    - Efficacy: Good (not as good as Danitol)
    - Used more before Danitol came out; not restricted; cheaper than Danitol; the liquid formulation (EC) can cause phytotoxicity on some varieties

  - fenpropathrin (Danitol)
    - Efficacy: Excellent
    - Product of choice; timing is important in different areas (spray when leaf galls appear; spray around bloom can knock down populations for the season; timing by crawler emergence from galls)

  - acetamiprid (Assail)
    - Efficacy: Good-Excellent
    - Starting to use; not as effective as Danitol (shorter residual); not restricted use pesticide

- dinotefuran (Venom)
  - Efficacy: Not used but high efficacy expected

- imidacloprid (Admire)
  - Efficacy: Good
  - Learning how to use it, timing (needs to be applied before crawler activity); systemic

- bifenthrin (Capture)
  - Efficacy: Good-Excellent in recent trials in Ohio

- beta-cyfluthrin (Baythroid XL)
  - Efficacy: Good-Excellent in recent trials in Ohio

PIPELINE
Neonicotinoids and other systemic insecticide under development for grape (thiamethoxam, spirotetramat, etc.) may have a good fit. Development of soil-applied formulations has promise.

- ***Pest management aids***
  - Resistant rootstock is the main cultural control

"To do" list for grape phylloxera
Research needs:
- Determine relative resistance of varieties grown in North Central Region to both foliar form and root form of grape phylloxera
- Describe basic seasonal biology of root and foliar phylloxera in the North Central Region
- Develop damage thresholds for varieties that are moderately to highly susceptible to foliar phylloxera
- Compare vigor and yields of susceptible varieties grafted to regionally adapted phylloxera resistance rootstocks
- Evaluate various soil amendments (vermicompost, compost tea, compost, fungi, nematodes) as to suppression of root grape phylloxera and/or antagonistic interactions of introduced soil microbes in reducing root pathogenic fungi associated with grape phylloxera attack.
- Evaluate soil-applied insecticides and other new pesticide options for efficacy at controlling infestations

Regulatory needs:
- Registration of effective insecticides for phylloxera control

Education needs
- Learn to detect the crawler emergence period near bloom to time sprays to control crawlers on varieties known to be suffer yield or vigor loss by foliar phylloxera leaf galling.
- Do not spray varieties resistant to foliar phylloxera
- Necessity to graft resistant rootstocks to varieties moderately to highly susceptible to root phylloxera

MULTICOLORED ASIAN LADYBEETLE (*Harmonia axyridis*)

Biology and management
A biological control agent, the multi-colored Asian ladybeetle was introduced into the US for control of various aphid pests in crops. It is now well-established and is likely to be present in the northcentral region for many years, particularly because it is beneficial to some crops. However, the grape industry and other fruit crops have had some severe problems with juice quality in recent years caused by this insect.

During the summer, multi-colored Asian ladybeetle provides suppression of soft-bodied insects, but in the fall (during grape harvest time), the beetles change behavior and search for sources of carbohydrate, and also search for tight spaces for overwintering. This results in beetles infesting grape clusters during harvest in states north of Missouri. When crushed, beetles in clusters release defense secretions that taint the wine or juice. Such products may be unmarketable, and in recent years there have been some massive losses of potential wine sales because tainted juice had to be dumped.

This is a relatively new pest and there are active research programs learning about its biology and control. Because of the timing of multi-colored Asian ladybeetle infestation, products with short PHIs are most valuable for control.

Registered insecticide efficacy

- dinotefuran (Venom)
  - Effectiveness: Good-Excellent
  - Specifically labeled for Asian ladybeetle
  - 1-day PHI; not used much yet (just got label this year) but expected to be used
  - The 2ee label for multicolored Asian ladybeetle does not include IA, MO, SD, ND, NE and KS of the North Central Region

- imidacloprid (Provado)
  - Effectiveness: Good-Excellent
  - Not always the most effective treatment (from side by side trials)
  - 0-day PHI
  - Sublethal paralysis could be a concern for wine-making since the insect could still be in the cluster

- acetamiprid (Assail)
  - Efficacy:
  - 7-day PHI; not widely used; some use in Iowa because it is shows good to excellent efficacy against multicolored Asian ladybeetle, is not a restricted use pesticide and can also be used against phylloxera

- Bifenthrin (Capture / Brigade)
  - Efficacy: Applications 7 days before harvest have been highly effective in vineyard trials (in MN)
  - Pyrethroid. Potential concerns of residue on grapes?

- beta-cyfluthrin (Baythroid XL)
  - Efficacy: Low rates have been highly effective in vineyard and laboratory trials
  - Pyrethroid. Potential concerns of residue on grapes?
  - 3-day PHI
  - Not used, may have potential for use due to efficacy and relatively short PHI

- zeta-cypermethrin (Mustang Max)
  - Efficacy: Excellent
  - Supplemental label with MALB
  - 1-day PHI
  - Not used, due to registration during 2007. Short PHI provides flexibility for growers.

- pyrethrum (Evergreen)
  - Pyrethrum plus PBO (PBO = piperonyl butoxide which is a pesticide synergist that increases the activity of pyrethrum insecticides)
  - Most effective biological insecticide tested in recent trials
  - Provides one day of beetle control in lab and field studies
  - 12 h PHI
  - Not used due to low MALB populations recently

- pyrethrum (Pyganic)
  - Pyrethrum only
  - Active, but short residual control
  - Organic registration
  - 12 h PHI
  - Not used

- neem (Aza-Direct, Ecozin, Neemix etc.)
  - Organic option
  - Efficacy: Good-Excellent, but only knockdown for 24-36 hours
  - Has a potent odor and can be oily, which could potentially be a problem for wine makers if applied too close to harvest

PIPELINE
Neonicotinoids and pyrethroids should all be active, but PHI is most important issue when labeling due to the timing of infestation near harvest

- ***Pest management aids***
  - Floating row covers have been found to reduce MALB numbers in clusters
  - Traps in development, but not commercialized for agriculture
  - Binomial sampling scheme developed by Bill Hutchison at U. Minnesota predicts need to spray based on thresholds
  - Thresholds developed for juice and some winegrapes, for number of beetles in a volume/weight of grapes that can cause detectable residues in the juice or wine. However, there is wide variability in the human perception threshold
  - Studies underway at Brock University, Ontario and elsewhere to strip the beetle taint from wine and juice

"To do" list for multicolored Asian ladybeetle
Research needs
- Determine link between soybean aphid and multi-colored Asian ladybeetle populations – predicting risk of infestation
- Test new products with short PHI for removing infestations
- Identify deterrents for preventing infestation or attractants for mass trapping
- Weather based prediction of risk
- Tank mixing repellants or attractants with contact insecticides
- Oxidate as a repellant just before harvest
- Interference of insecticides with fermentation, overall wine quality
- Control of soybean aphid to decrease multi-colored Asian ladybeetle populations
- Remediation of taint in wine during/after wine production
- Spray timing for multi-colored Asian ladybeetle (suppress overall population when they first show up or just spray the day before harvest)
- What triggers Fall aggregation and feeding behavior (temperature, kairomone, etc.)?
- Role of grape damage (cracking, bird damage, etc.) on feeding and aggregation behavior
- Development of physical methods (washing the conveyor system, floating, etc.) that wineries can use to remove multicolored Asian ladybeetle from grapes.
- Testing to show there are no off flavors in wine made from grapes that have been sprayed to control multicolored Asian ladybeetle close to harvest

Regulatory needs
- Stop importing biocontrol agents!
- Getting multi-colored Asian ladybeetle on label of effective insecticides in different chemical classes, with short PHIs
- Reduce 30-day PHI in Capture/Brigade (this is a research priority as well)

Education needs
- Grower/winemaker training on sampling plan, thresholds, and control options

GRAPE FLEA BEETLE (A*ltica chalybea*)


Biology and management

Beetles feed on swelling buds, and larvae can be active feeding on clusters and leaves up to bloom. Damage is usually worse on the edge of vineyards, adjacent to woods. Pest can move to the vineyard quickly. The grape flea beetle (or steely beetle) is 4-5mm long and a shiny metallic dark blue. It is capable of jumping when disturbed. The insect overwinters as an adult, and this stage causes damage when conditions warm in the spring by direct feeding on young buds. The borders of vineyards adjacent to woods or other protected areas are most affected. Adults damage swelling buds, hollowing them out. Their damage can easily be confused with cutworm damage, and both species feed during bud swell. The level of injury varies between years, and is worse when bud development is slowed by cool temperatures.

Registered insecticide efficacy

- carbaryl (Sevin)
  - Efficacy: Good-Excellent; preferred product

- danitol
  - Efficacy: Good-Excellent

- pyrethrum (Pyganic)
  - Efficacy: Not used

- pyrethrum (Evergreen)
  - Pyrethrum plus PBO (PBO = piperonyl butoxide which is a pesticide synergist that increases the activity of pyrethrum insecticides)
  - Efficacy: Not used

- beta-cyfluthrin (Baythroid XL)
  - Efficacy: Not used

- zeta-cypermethrin (Mustang Max))
  - Efficacy: Not used, because it was just labeled in May of 2007.
  - Has grape flea beetle on the label

- ***Pest management aids***
  - Scouting for cutworms and for flea beetles can detect risk of bud damage.

"To do" list for grape flea beetle

Research needs

- Determine weather conditions that bring beetles into vineyards
- Information on what pesticides are effective on this insect
- Damage thresholds (how much damage can buds handle before their fruiting and growth potential are compromised?)

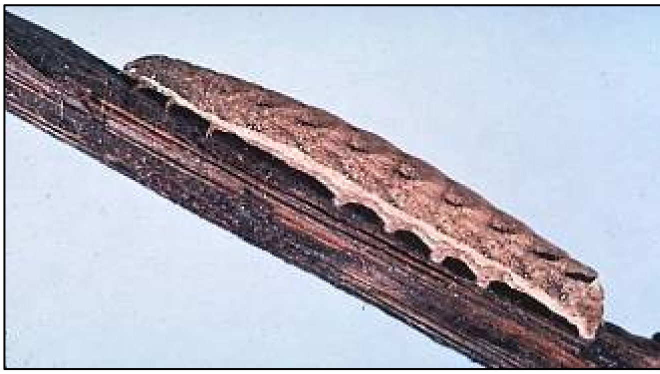
Regulatory needs

- Short REI products (to get workers back in the vineyard quickly)
- Information on what pesticides are effective on this insect

Education needs

- Identifying beetle damage compared with cutworm damage

CLIMBING CUTWORM (Family Noctuidae, multiple species)




Biology and management

The larvae of climbing cutworms are large, smooth caterpillars, measuring 1.2-1.6 inches (30-40 mm) when fully grown. The head capsule is usually dark, and the body is a dull gray-brown color marked with dots or stripes. Climbing cutworm larvae overwinter in the soil of the vineyard floor, and first become active in the spring when vine buds begin to expand. Larvae feed on young buds at night, hiding beneath the vines in topsoil beneath leaf litter during the day. Buds may be removed completely by feeding, or an area of chewing damage may remain. Cutworms are mainly a pest in areas with sandy soils, and in vineyards with weeds under the vines. Vineyards with a history of cutworm damage should be scouted regularly during bud expansion, particularly after warmer nights. Once shoot expansion begins, vines are no longer at risk. The level of injury varies depending on growing conditions in the spring and is worse when bud development and shoot growth are slowed by cool temperatures.

Registered insecticide efficacy

- chlorpyriphos (Lorsban)
  - Efficacy: Excellent
  - Labeled as a 24c Special Local Needs label in Michigan for use on cutworms
  - 24c SLN label expires in early 2009

- fenpropathrin (Danitol)
  - Efficacy: Good-Excellent
  - Some usage

- bifenthrin (Capture)
  - Efficacy: Good-Excellent
  - Newly registered, not widely used yet

- beta-cyfluthrin (Baythroid XL)
  - Efficacy: Not known in grapes, excellent control of cutworms observed in corn.
  - Newly registered, not widely used yet

- zeta-cypermethrin (Mustang Max)
  - Efficacy: Not known in grapes, excellent control of cutworms observed in corn.

- carbaryl (Sevin)
  - Efficacy: Good
  - Sometimes used in order to save Danitol sprays for later in the season; usually used in conjunction with flea beetle spray

- spinetoram (Delegate)
  - Efficacy: Good, but little experience so far
  - Registered in late 2007

"To do" list for climbing cutworm

Research needs

- Identify local habitat factors (weed species, soil types, etc.) in and around vineyards that contribute to cutworm outbreaks so scouting can be concentrated in those locales
- Determine species of cutworm causing damage

Education needs

- Weed control to reduce cutworms

ROSE CHAFER (*Macrodactylus subspinosus*)


Biology and management

The rose chafer is a light tan beetle with a darker brown head. It has long legs, and is about 12 mm long. There is one generation per year. It emerges from the ground in late May or June, near the time of grape bloom, and lives for three weeks. The adults feed on leaves and flowers of grapes. Females lay groups of eggs just below the surface in grassy areas of sandy, well drained soils. The larvae (grubs) spend the winter underground, and move up in the soil to feed on grass roots, followed by pupation in the spring. A few weeks later they emerge from the soil and disperse by flight. Male beetles are attracted to females and they congregate on plants to mate and feed. Rose chafer adults are strongly attracted to the blossom buds and can destroy a crop in June if not controlled.

- **Organophosphates**
  - azinphos-methyl (Guthion)
    - Efficacy: Good
    - Grapes taken off the label in 2005, but still has a tolerance.

  - phosmet (Imidan)
    - Efficacy: Good - excellent
    - Main remaining OP used in vineyards.
    - Shorter residual control than Guthion.
    - Requires high rate and pH 6 spray water for optimal performance.
    - 7-day PHI but 14-day REI; makes use in season more challenging, especially for Japanese beetle control.

  - diazinon (Diazinon)
    - Not used

  - malathion (Malathion)
    - Not used

- **Carbamates**
  - carbaryl (Sevin)
    - Efficacy:
    - Widely used for Japanese beetle control, active on other co-occurring pests.
    - Provides good control of adults, one week of activity.

- methomyl (Lannate)
  - Active, but short residual control.

- **Pyrethroids**
  - fenpropathrin (Danitol)
    - Efficacy: Very good in Ohio and should be very good else as well
    - Broad activity on other pests
    - No mite outbreaks reported to date (over five years use)
  - bifenthrin (Capture)
    - Efficacy:
    - Recently registered (2006)
  - beta-cyfluthrin (Baythroid XL)
    - Efficacy:
    - Recently registered (2006)
  - zeta-cypermethrin (Mustang Max)
    - Efficacy:
    - Recently registered (2007).

- **Other insecticides**
  - imidacloprid (Provado Pro)
    - Neonicotinoid insecticide
    - Reduced-risk, systemic insecticide
    - Efficacy: Not known
  - imidacloprid (Admire)
    - Soil formulation of Provado (imidacloprid)
    - Efficacy: Not known
    - Slow updake and price may limit utility
    - Could be used for killing grubs if an isolated infestation
  - acetamiprid (Assail)
    - Neonicotinoid insecticide
    - Foliar application allowed
    - Efficacy: Not known
  - dinotefuran (Venom)
    - New (2006) neonicotinoid insecticide
    - Soil and foliar application allowed
    - Efficacy: Not known
  - azadiractin (Neemix, Ecozin)
    - Efficacy: Not known
    - Not used

- pyrethrum (Pyganic)
  - Efficacy: Not known
  - Not used

- pyrethrum (Evergreen)
  - Pyrethrum plus PBO (PBO = piperonyl butoxide which is a pesticide synergist that increases the activity of pyrethrum insecticides)
  - Short residual activity
  - Efficacy: Not known
  - Not used

- kaolin (Surround)
  - Not used in most North Central region vineyards.
  - Requires many applications.
  - Maintaining coverage is difficult with rainfall.
  - Expensive

- thiamethoxam (Actara)
  - High efficacy expected
  - Registered in late 2007

PIPELINE

- thiacloprid (Calypso)
  - Neonicotinoid
  - High efficacy expected, with wide spectrum of activity

- clothianidin (Belay)
  - Soil applied formulation
  - Neonicotinoid
  - Efficacy: Not known

- metaflumizone (Alverde)

- spirotetramat (Movento)

- ***Pest management aids***
  - Traps are highly effective, but may draw beetles to the vineyard.
  - Beetles and their damage are easy to see.

"To do" list for rose chafer

Research needs:

- Determine efficacy of soil-applied and foliar insecticides
- Determine thresholds for different types of grape cultivars, under various crop loads

Education needs:

- Information on vine tolerance, pesticide efficacy, biology

MITES (European red mite, *Panonychus ulmi*; two spotted spider mite; *Tetranychus urticae*; Grape Erineum mite, *Colomerus vitis*)



Biology and management
Mites are generally not a primary pest management concern of grape growers in the northcentral region. However, in some sites and in some years, conditions conducive to their growth occur and high populations can be found that cause leaf bronzing. For this reason, mites and their symptoms are monitored during regular vineyard scouting and growers aim to minimize the risk of flaring their populations through selection of insecticides that minimize toxicity to predatory mites.

The adult female of the **European red mite** (*Panonychus ulmi)* is about 1/50 inch long and is dark red with eight legs. Adult male mites are smaller than females and have a pointed abdomen; they are usually dull green to brown. Mites hatch in the spring from tiny spherical eggs that are laid around cane nodes. These eggs can be detected by scouting in early spring. Although several generations can occur each season, populations rarely increase enough to cause significant damage, as predatory mites prevent their growth. If predatory mite suppression is reduced by weather or pesticides, red mites can increase and cause bronzing that reduces vine photosynthesis. Red mites can be pests on juice and wine grape varieties.

The **two spotted spider mite** (*Tetranychus urticae*) can cause severe damage to wine grapes if pest mite populations reach high densities. Leaf tissue is removed by the mite's feeding, causing yellowing, and then bronzing, with thin-leaved varieties most susceptible. These mites overwinter in leaf litter, develop on weeds in spring, and move onto the vine as the ground cover dries in the summer. Water-stressed vines are most at risk. Protection of predatory mites is the most effective method of control, with biological control achieved with an average of one predatory mite per 10 two-spotted mites.

Erineum mites are very small and a microscope is needed to see this species. It overwinters beneath bark of one-year old canes and in spring the mites move to leaves where they cause an "erineum" (a mite-induced growth of high density of leaf surface hairs). The the lower surface, beneath the erineum, has a dense, white growth of abnormally curled plant hairs and the mites feed and reproduce in this patch of hairs. The best time for control is when shoots are growing or when erinea are just starting to form.

Registered insecticide efficacy

- Fenbutatin-oxide (Vendex)
  - Efficacy: Excellent on two-spotted mite and red mite.

- abamectin (Agri-mek)
  - Efficacy: Good on two-spotted, poor on grape erinium mite

- dicifol (Kelthane)
  - Efficacy: Good on European red mite

- JMS Stylet Oil
  - Efficacy: Fair-Good
  - Used in vineyards with history of mites

- fenpropathrin (Danitol)
  - Efficacy: Good-Excellent
  - Danger of killing predatory mites, so not used for mite control

- pyridaben (Nexter)
  - Efficacy: Fair-Good
  - Not used by growers

- bifenazate (Acramite)
  - Recently registered
  - High activity expected

- etoxazole (Zeal)
  - Efficacy: Excellent
  - Performs well on TSSM and ERM
  - Can be slow acting but long residual control

- spirodiclofen (Envidor)
  - Efficacy: Excellent
  - Performs well on TSSM, ERM, and rust mite species such as Erinium Mite
  - New mode of action, registered in 2007

- fenpyroximate (Fujimite)
  - Efficacy: Fair-Good
  - Broad activity on different mite species

- ***Pest management aids***
  - Predatory mites

"To do" list for mites

Research needs:

- Effective spray timing and products for grape erinium mite control
- Side-by-side comparison of new miticides; need data from vineyards not apple
- Species composition of predatory mites in NC region vineyards

Education needs:

- Grower education on pest and predatory mite identification
- Importance of predatory mite conservation through ground cover management and pesticide selection

OTHER INSECT/MITE PESTS

GRAPE ROOTWORM (*Fidia viticida*)
This beetle is light brown with yellow hairs, and is 6 mm long. It feeds on grape foliage as an adult, making a chain-like damage pattern. Immature stages feed on grape roots and can lead to vineyard decline over many years if left untreated. Grape rootworm adults begin appearing in vineyards in mid-to late-May, and then lay eggs on the vine trunk. Larvae later crawl into the soil and attach themselves to grape roots, developing there for one to two years while completing their development. Larvae eat small roots and bore into larger ones. Adult beetles and their foliage feeding have been found statewide in IA recently, but no economic root damage has been documented to date. This insect can be hard to eliminate once established.

Control Measures:
- carbaryl (Sevin)
  - Efficacy: Good

Research needs:
- Basic biology and timing of development
- Varietal susceptibility
- Damage thresholds

GRAPE CANE GIRDLER (*Ampeloglypter ater*)
The grape cane girdler is common in central and eastern United States but it rarely causes economic damage to vineyards. Adults girdle current-season canes with a row of punctures that causes canes to break off above the girdled areas. The adult is a black snouted beetle about 1/8 inch (4mm) long. The legless grub is slightly larger when full grown, and is white with a brown head. It is very similar in appearance to the closely related grape cane gall maker. Eggs are laid in late spring in a series of holes encircling the cane made by the female using its mouthparts. After eggs are laid, the female continues to make another series of punctures a few inches below the first girdle until the cane is encircled, but eggs are placed only in the holes of the first girdle. Grubs feed in the cane pith between the girdles. After larval development is completed, pupation occurs. Adults appear in late summer, go into hibernation, and reappear in late spring.

GRAPE CANE GALLMAKER (*Ampeloglypter sesostris*)
Grape cane gallmaker is a sporadic pest of grapes in the eastern US. Its damage is rarely abundant enough to cause economic injury, but young vineyards can be at risk because its damage can delay development of the trunk or cordon. This insect produces noticeable red galls on new shoot growth just above nodes. The majority of galls are beyond the fruit clusters and usually cause no serious yield loss. Canes with galls are capable of producing a crop the following year. The adult is a dark brown snout beetle about 1/8 inch (4mm) long and is very similar in appearance to the grape cane girdler. The legless grub is slightly larger when full grown, and is white with a brown head.

HORNWORMS (Family Sphingidae)
Sphingid larvae or "hornworms" are more commonly found in winegrape vineyards, where they feed on leaves. Larvae may be brown or green, with spots on the sides of the body, and a distinctive 'horn' on their posterior. The larvae can grow to 5 inches (12 cm) long, and feed voraciously during development. Because of this, hornworms are more of a concern in young vineyards with limited leaf area. Larger vines can usually tolerate some leaf area loss from their feeding. These insects are often parasitized by wasps that lay their eggs on the hornworms.

Control measures:

- carbaryl (Sevin)
  - Efficacy: Excellent
- *Bacillus thuringiensis* = *B. t.* (Dipel)
  - Efficacy: Excellent if high coverage is achieved and applications are made when larvae are young
- methoxyfenozide (Intrepid)
  - Efficacy: Excellent if high coverage is achieved and applications are made when larvae are young
- parasitic wasps
  - Not used commercially, but natural populations of wasps parasitize these larvae and kill them.

YELLOWJACKETS (*Vespula* spp. *or Dolichovespula* spp.)
Yellowjacket and other wasps may break open the skins of grape berries during late summer. In the early part of the growing season, wasps are mainly predatory, but toward the end of the season their behavior changes to searching for sugar, such as that found in ripe fruit. Control measures can be directed against the overwintering yellowjacket queens by establishing bait stations containing an attractant and a pesticide in early spring. Destruction of nearby nests is effective but difficult, because nests are often located underground.

Control measures:

- carbaryl (Sevin)
  - Efficacy: Excellent
  - 7 day PHI can be an issue
- phosmet (Imidan)
  - Efficacy: Fair-Good
  - 14 day REI makes use difficult for winegrape growers, or if insects are found close to harvest
- malathion (Malathion)
  - Efficacy: Good-Excellent
  - Lower rate used (as a repellent)
- zeta-cypermethrin (Mustang Max)
  - Efficacy: Good to Excellent – several growers in IA are using against multicolored Asian ladybeetle and are also repelling yellowjackets.

- o imidacloprid (Provado)
  - Efficacy: Good-Excellent
  - Can be used also to control multicolored Asian ladybeetle control

- o dinotefuran (Venom)
  - Efficacy: Not used enough yet to know possible use for control

Pest management aids
- o Elimination of nests using directed insecticides (if you can find the nests)
- o Minimize suitability of the farm for yellowjackets.
- o Implement control measures early and maintain program to attract and kill wasps

Research Needs:
- Baited poisons in traps targeted at wasps, yellowjackets

Education Needs:
- Biology of native and invasive yellowjackets
- Role in biocontrol
- Effective methods for nest control

FRUIT FLIES (*Drosophila* spp.)
Drosophila females lay eggs near the surface of fermenting fruits. Eggs take only 30 hours to hatch, and the larvae develop in fermenting material. They feed near the surface, mostly on yeast, for 5-6 days and go to drier places to pupate. The life cycle may be completed within 8-10 days at 85 F (29 C). Timely harvesting can help prevent outbreaks of fruit flies in the vineyard, though management in processing facilities can be challenging.

Research Needs:
- Relationship between fruit flies and sour rot (Are fruit flies a carrier or do they just come in later)
- What will control them?
- Useful products that have a short PHI (so they can be used close to harvest)

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

Control:
- o Keeping fruit rots in check could decrease ant populations

Research Needs:
- Baits for control (Esteem, for example)

GREEN JUNE BEETLES (*Cotinis nitida*)
Direct pest on ripening fruit in southern region of the Midwest, especially cultivars maturing in July and early August during adult flight
Zero tolerance in table grapes

Control Measures:
- o carbaryl (Sevin)
  - 7-day PHI is an issue since beetle attack ripe fruit near harvest

Research Needs:
- Need effective control measures close to harvest
- Work on identifying sex pheromone and kairomones that elicit feeding aggregations in order to develop baited trap or an attract and kill system

FALL ARMYWORM (*Spodoptera frugiperda*)
Seen in 2006 in very high numbers in northern MI
Erratic population cycles

Control Measures:
- o Trap for adults to keep an eye on populations
- o Expected to be controlled by many Lepidoptera-specific insecticides.
- o Beneficial Insects
  - Hard to make direct links between natural enemy presence and pest control
  - Make insecticide choices that will minimize natural enemy loss wherever possible

Education Needs:
- Educating growers on natural enemy preservation

PLANTHOPPERS
Potential issue in IA because it is common for planthoppers to move into vineyards in late summer when adjacent grasslands and borders are mowed. Species not known.

GRAPE CANE BORER ((*Amphicerus bicaudatus*)
Wood boring buprestid beetle that enters one year old canes and kills the wood distal to the entry point. Also called the apple twig borer. Populations tend to be very localized and it is more of a problem near abandoned vineyards or orchards. More of an economic problem in young vineyards where growers are trying to establish a training system and young shoots are killed.
- Imidan lists this pest on the label
- Best timing for control is not clear
- Some work underway at Cornell University

Research Needs:
- Effective controls to minimize entry or survival
- Natural enemies for this pest

Education Needs:
- Identifying the damage
- Potential for cutting out infestations during pruning

Table 3. Efficacy Ratings[1] of Broad Spectrum Insecticides for the Major Insect Pests of North Central Region Vineyards †

Management Tools	Vineyard insect and mite pests[2]										
	GFB	CC	GBM	RC	GP	GLH	PLH	JB	MALB	TSSM	ERM
Organophosphates											
Diazinon			G			G	F	F		-	-
Imidan	G		E	G		G	F	G		-	-
Guthion	G		E	G		G	F	G		-	-
Lorsban[3]		E								-	-
Organochlorine											
Thiodan					E					-	-
Carbamates											
Sevin	G		E	E		G	G	G-E		-	-
Lannate	G		G	F		G	G	F		-	-
Pyrethroids											
Danitol	E	E	G-E	G	E	E	G	G-E		G	G
Baythroid XL		E	G-E			E	E	G	E	F	F
Capture/Brigade		E	G-E			E		G	E	F	F
Mustang (Max)		E				E	E		E	F	F

1. Efficacy rating symbols: E = excellent, G = good, F = fair, P = poor, NC = not controlled, NU = not used

2. Insect/mite abbreviations: GFB = grape flea beetle, CC = climbing cutworm, GBM = grape berry moth, RC = rosechafer, GP = grape phylloxera, GLH = grape leafhopper, PLH = potato leafhopper, JB = Japanese beetle, MALB = multicolored Asian lady beetle, TSSM = two spotted spider mite, ERM = European red mite.

3. Registered under 24c Special Local Needs label in Michigan

† *From Michigan State University 2007 Fruit Management Guide (Bulletin E-154).*

Table 3 (con't). Efficacy Ratings[1] of Other Insecticides for Control of the Major Insect and Mite Pests of North Central Region Vineyards†

Other registered alternatives	GFB	CC	GBM	RC	GP	GLH	PLH	JB	MALB	TSSM	ERM
Neonicotinoids											
Provado			-	G		E	G	G	G		
Admire						G		F			
Assail			-	G	E	E	G	G	E		
Venom			F	G	G	E	G	G	E		
Biologicals											
Bacillus thuringiensis	---	---	F	---	---	---	---	---	---	----	-----
Surround			F	F		F	P	F-E	P	----	----
Neemix, Ecozin			F	F				F		----	-----
Spintor			F			F		F		----	----
Entrust			F			F		F		----	-----
Pyganic				F				F		----	----
Evergreen				F				F	F	----	-----
Pheromone mating disruption			F								
Miticides											
Agri-Mek										G	
Vendex										G	
Kelthane										G	
Acramite										G	
Nexter										F	
Zeal										G	
Envidor										E	
FujiMite										F	
Oberon										G	

1. Efficacy rating symbols: E = excellent, G = good, F = fair, P = poor, NC = not controlled, NU = not used

2. Insect/mite abbreviations: GFB = grape flea beetle, CC = climbing cutworm, GBM = grape berry moth, RC = rosechafer, GP = grape phylloxera, GLH = grape leafhopper, PLH = potato leafhopper, JB = Japanese beetle, MALB = multicolored Asian lady beetle, TSSM = two spotted spider mite, ERM = European red mite.

3. Registered under 24c Special Local Needs label in Michigan

† *From Michigan State University 2007 Fruit Management Guide (Bulletin E-154).*

Table 3 (con't). Efficacy Ratings[1] of Other Insecticides for Control of the Major Insect and Mite Pests of North Central Region Vineyards†

New Chemistries (PIPELINE)	**GFB**	**CC**	**GBM**	**RC**	**GP**	**GLH**	**PLH**	**JB**	**MALB**	**TSSM**	**ERM**	
rynaxypyr (Altacor)			G									
emamectin benzoate (Proclaim)												
indoxacarb (Avaunt)			G	G		G	G	G				
flubendiamide (Belt)			G									
metaflumizone (Alverde)			G									
clothianidin (Clutch/Belay)				G	G							
buprofezin (for scale)												
spinetoram (Delegate)			G			G	G					
Cultural Controls												
Resistant rootstocks					E							
Remove wild grape			NC									

1. Efficacy rating symbols: E = excellent, G = good, F = fair, P = poor, NC = not controlled, NU = not used

2. Insect/mite abbreviations: GFB = grape flea beetle, CC = climbing cutworm, GBM = grape berry moth, RC = rosechafer, GP = grape phylloxera, GLH = grape leafhopper, PLH = potato leafhopper, JB = Japanese beetle, MALB = multicolored Asian lady beetle, TSSM = two spotted spider mite, ERM = European red mite.

1. Registered under 24c Special Local Needs label in Michigan

† *From Michigan State University 2007 Fruit Management Guide (Bulletin E-154).*

Table 4. Compounds under Evaluation in the IR-4 Program:

Chemical Name	Trade Name	Chemical Class	Registrant	Mode of Action (MOA)	Pest Complex	Registration Status
Rynaxypyr	Altacor	Phthalic Acid Diamides	DuPont	Ryanodine receptor modulators	Lepidoptera, Diptera	IR-4 trials in 07, EPA registration 2009
Flubendiamide	BELT	Phthalic Acid Diamides	Bayer	Ryanodine receptor modulators	Lepidoptera, Diptera	EPA registration 2009
Spinetoram	Delegate	Spinosyns	DOW	Nicotinic acetylcholine receptor agonists	Lepidoptera, Coleoptera, Diptera	EPA may allow bridging data with SpinTor for fast track registration 2009
Metaflumizone	Alverde	Semicarbizone	BASF	Sodium Channel Blocker	Lepidoptera, Coleoptera, Diptera	
Flonicamid	Beleaf	Pyridinecarboxamide	FMC	Not known	Aphids, Plantbugs	EPA registration 2007

For more information about IR-4 please see: www.cook.rutgers.edu/~ir4

Nematode Pests of Grapes in the North Central Region

Root-knot nematode, dagger nematode, lesion nematode, ring nematode
- Nematode damage can be minor to moderate in vineyards.
- Damage is likely to be seen during the first few years following planting.
- Root-lesion nematodes penetrate into the roots, tunneling and feeding in the root tissues causing permanent damage to the vine. This activity predisposes grape roots to invasion by other plant pathogens.
- Nematodes can currently be controlled before and after planting using chemicals.

Plant-parasitic nematodes are microscopic roundworms that live in the soil and feed on plant roots. In addition to being directly damaging to grapevine roots, some nematodes are important as vectors of viruses. Nematode damage can also predispose roots to root rots. In newly established vineyards, nematodes may be responsible for poor establishment and weak growth of young vines, especially on sandy sites. Nematodes seldom kill vines, but cause a steady decline in vigor. Above-ground symptoms are not characteristic, e.g., poor growth, low yields, and “off” color. Infected plants are more susceptible to environmental and other stresses. Symptoms may also resemble certain nutrient deficiencies or virus diseases. Below-ground symptoms are poor root development, dark-colored root lesions, and stunting or death of feeder roots. Root-knot nematodes characteristically cause small swellings (galls) on young feeder roots or secondary roots. Nematodes are spread via infected planting material or movement of soil on farm equipment and in run-off or irrigation water. Once established in a vineyard, nematode infestations tend to be permanent, so care must be taken to prevent new infestations.

Dagger nematodes are widely distributed in IL. The nematode transmitted virus, peach rosette virus is a problem in some vineyards in MI and the current strategy is to pull out the vineyard and fumigate the land (Telone) and replant. Vineyards are typically not tested for nematodes unless vines are unthrifty. This often occurs after easy solutions are ruled out or if symptoms of viruses are evident suggesting the presence of nematodes. Submission of soil samples for nematode analysis prior to planting is essential, and should be done whenever symptoms suggest a potential for nematode infestation.

- . **Organophosphate nematicides currently used:**
  - fenamiphos (Nemacur 3)
    - Efficacy: Fair - Good
    - the only registered OP nematicide available in Michigan
    - the only non-fumigant nematicide registered for bearing vines

- **B2 carcinogenic nematicides currently used:**
  - dichloropropene (Telone II, Telone C-17) (fumigant)
    - Efficacy: Good - Excellent
    - soil fumigation equipment required
    - pre-plant only

- metam sodium (various) (fumigant)
  - Efficacy: Good
  - must be diluted three to one or more with water
  - soil fumigation equipment required
  - pre-plant only.

- **Non-chemical alternatives currently used:**
  - Raising a nematode-suppressing cover crop in vineyard before new vineyard establishment
  - Work on soil organic matter and over all soil quality

  PIPELINE:
  - Misc. soil amendments and biological agents

"To do" list for nematodes:
Research needs:
- Replanting strategies to minimize the impacts of nematodes in new vineyards.
- Resistant or tolerant varieties, rootstocks
- Diagnostic techniques, such as PCR, to determine if dagger nematodes harbor viruses.
- Companion plantings in replant situations to build soil quality, decrease harmful nematode populations, increase natural enemies
- Necessity for post-plant nematicides, as well as other post-plant nematode control procedures
- Nematode distribution surveys (to know what's out there)

Regulatory needs:
- Clean plant source certification
- Keeping Nemacur registered, or getting other effective compounds labeled on grapes (post-plant)

Education needs:
- Education on how to deal with nematode-infested vineyards (shallow and deep fumigation, how and when to collect samples, etc.)
- Choosing reputable nurseries for vines
- Necessity of knowing type of nematodes present at a location (sending in samples to Diagnostics, previous planting history, etc.);
- Necessity of nematode management pre-planting and not post-planting, along with what to do when you are planting;
- Minimizing conditions in vineyards that encourage nematodes (pH, metals, eliminating broadleaf and other weeds, etc.)

Table 5. Efficacy Ratings[1] of Pest Management Tools for the Major Nematode Pests of Grapes in the North Central Region.†

Management Tools	Nematodes in Vineyards			
Organophosphates registered in MI	Root knot nematode	Dagger nematode	Lesion nematode	Ring nematode
Fenamiphos (Nemacur 3)	G	F	G	F
Carbamates registered in MI				
None				
Alternative products registered in MI				
1,3-D (Telone)	E	G	E	G
Methyl bromide (Nursery Stock)	E	E	E	E
Metam sodium	E	G	E	G
Cultural Controls				
Cover crops	G	G	F	G
Soil Organic Matter	G		G	
Nematode free rootstocks	E		E	

[1] Efficacy rating symbols: E = excellent, G = good, F = fair, P = poor, N = Not labeled or no activity against this pest.
† *From Michigan State University 2007 Fruit Management Guide (Bulletin E-154)*

Weed Pests of Grapes in the North Central Region

Weeds and Weed Control: Weeds can cause tremendous problems in the vineyard. Besides competing with the grapevine for nutrients, light, and moisture, weeds provide shelter and food for other pests. Dense weed growth impairs air circulation in the vineyard, creating an environment where grape diseases can flourish. In addition many weeds, such as common dandelion, can be alternate hosts for nepoviruses. Weeds must be controlled to maintain a productive vineyard.

Weeds can be categorized as annuals or perennials. Annual weeds complete their life cycle, from emergence to setting seed and dying, in less than 12 months. Summer annuals (common lambsquarters, pigweed, green foxtail, for example) emerge in the spring or early summer and complete the cycle by fall. Winter annuals (such as shepherd's purse, red dead nettle, henbit) may germinate anywhere from mid-summer through fall (depending on the species), overwinter as a rosette, and resume growth in spring, typically setting seed and dying by May or June. With annuals, destroying the top growth usually kills the entire plant and prevents further seed production.

Perennial weeds complete their lifecycle over two or more years. Perennials can be some of the most difficult weeds to control in vineyards. Quackgrass, johnsongrass, yellow nutsedge, Canada thistle and field bindweed, bermudagrass (southern portion of North Central Region), and trumpetcreeper and other viney weedsa are specifically problematic. Perennials spread and reproduce mainly by underground vegetative structures.

Weed Management: Weed control in vineyards is usually accomplished through application of herbicides in a band under the vine row. Row middles are most often maintained in sod to support equipment and reduce erosion. Herbicides can be very useful and substantially reduce labor costs compared to hand cultivation. Some growers use mechanical cultivation to control weeds under the row, but equipment is expensive and soil moisture conditions must be perfect for this method to be successful. Non-chemical alternatives such as flaming are occasionally used to manage weeds.

Selective Herbicides: Herbicides are either selective or non-selective. A *selective herbicide* affects some plants but not others. A *non-selective herbicide* will kill any plant it contacts.

Contact Herbicides: Contact herbicides affect only the tissue sprayed. They do not move within the plant. Only above-ground tissues that are directly sprayed will be affected. Contact herbicides (e.g., Gramoxone) are useful for controlling small annuals and for temporarily reducing growth of perennials.

Systemic Herbicides: Systemic, or translocated, herbicides, are those that move within the plant. Systemic herbicides applied to the soil (e.g., Karmex) are absorbed by roots and translocated to leaves where they inhibit physiological processes such as photosynthesis. Systemic herbicides applied to the foliage (e.g., Roundup) translocate to the root system, provided the herbicide is applied at the correct growth stage.

Residual Herbicides: A residual herbicide or persistent herbicide (e.g., Princep) is one applied to the soil (may also be applied to leaves) where it slowly breaks down over time but continues to control germinating weeds for some time after application. Some residual herbicides may persist long enough to damage crops planted a year or more after application. Residual herbicides may or may not be selective, and they may or may not be systemic.

Proper Application: To be effective, herbicides must be selected properly for the weeds they are to control; they must be applied at the proper time, at the proper rate, and with the proper equipment. The degree of weed control depends largely on the skill of the operator. In most cases, herbicide rates given are for overall coverage (**broadcast rates**). For **band** treatment common in vineyards, the amount of herbicide applied is reduced according to the portion of area treated. For example, if a grower wants to control weeds in a 4-foot wide band beneath a crop planted in rows 10 feet apart, the rate of herbicide needed per acre of crop will be 4/10 of the broadcast rate per acre.

Herbicides can injure grape vines if used improperly. Therefore, sprayer adjustment and calibration should be as precise as possible to assure accurate and uniform applications. Growers must use nozzles appropriate for herbicide application at low pressures (20-40 psi) on a fixed boom-type applicator. This type of sprayer is calibrated easily and, when designed properly, will deposit herbicide uniformly. Calibrate the sprayer carefully, and apply herbicides according to the suggested rates. Continued use of the same herbicide can lead to resistance development in weeds, or the establishment of tolerant weeds. It is recommended that the same herbicide be used for no more than two consecutive years to avoid resistance problems and improve weed control spectrum.

Tank Mixes: Certain herbicides may be combined in suitable tank-mixes. Consult product labels for approved combinations and recommended rates. Do not use tank mixes that are not listed on the label. By using tank mixes, a preemergence herbicide can be applied together with a postemergence herbicide to provide improved weed control, or two preemergence herbicides may be applied at reduced rates, each to gain better weed control and reduce the risks of crop damage.

Use Restrictions: Herbicide use is controlled by federal regulations which prescribe the crops upon which the herbicides can be used and the timing and rates for which these materials are registered. Be sure to use only registered materials at the rates recommended. Herbicides are covered by Worker Protection Standards where they apply. Restricted-entry intervals (REI) and Personal Protective Equipment (PPE) information are included on the product label.

Herbicides registered for use in grapes:

- **Pre-emergent herbicides**
  - dichlobenil (Casoron)
    - Use: Annual and perennial grasses and broadleaves; not really used
    - Efficacy: Good to Excellent
    - Comments: Not used much. Expensive. Granular formulation difficult to use.
  - flumioxazin (Chateau)
    - Use: Annual broadleaves and suppression of grasses
    - Efficacy: Excellent
    - Comments: Recent grape registration (2005). Vines need to be 2 yrs unless trained or protected PHI=60 days; lasts 6-8 weeks, may wear out quick depending on conditions

- napropamide (Devrinol)
  - Use: Annual grasses and broadleaves; not really used
  - Efficacy: Fair
  - Comments: PHI=35 days; somewhat expensive; doesn't work as well

- isoxaben (Gallery) (non-bearing)
  - Use: Most broadleaves
  - Efficacy: Good-Excellent
  - Comments: Non-bearing vines only (12 month PHI); very expensive; only product that provides broad-leaf control on new plantings

- oxyfluorfen (Goal)
  - Use: Annual broadleaves and suppression of grasses
  - Efficacy: Excellent
  - Comments: Age Restriction: 3 years or trellised 3 ft off ground; Has some post-emergent activity; Good broad-leaf control; Not used as much

- diuron (Karmex)
  - Use: Annual grasses and broadleaves
  - Efficacy: Excellent
  - Comments: Age restriction: vines need to be at least 3 years old or at least 1.5 inch trunk diameter; widely used; great blend with Chateau; soil type concern (light soils may cause possible vine damage); inexpensive, may result in supply shortages

- pronamide (Kerb) (Restricted Use Pesticide)
  - Use: Annual and perennial grasses and certain broadleaves
  - Efficacy: Fair
  - Comments: not widely used; expensive; supplies are short; fall application not conducive to grape growers (who usually apply in spring)

- simazine (Princep)
  - Use: Annual grasses and broadleaves
  - Efficacy: Excellent
  - Comments: Age restriction: 3 years; widely used; economical; Princep/surflan is a standard tank mix

- pendimethalin (Prowl) (non-bearing)
  - Use: Annual grasses and certain broadleaves
  - Efficacy: excellent
  - Comments: Non bearing only (12 month PHI); widely used, especially in new plantings; economical; some reports of bad odor
- isoxaben + trifluralin (Snapshot)
  - Use: Annual grasses and certain broadleaves
  - Efficacy: Excellent
  - Comments: Non-bearing only (12 month PHI). Granular formulation difficult to apply (growers not set up for this as well); Expensive;

- norflurazon (Solicam)
  - Use: Annual grasses and broadleaves and suppression of yellow nutsedge
  - Efficacy: Good
  - Comments: Age restriction: 2 years; PHI=60 days; some usage

- oryzalin (Surflan)
  - Use: Annual grasses and certain broadleaves
  - Efficacy: Excellent, when tank mixed
  - Comments: widely used, although some growers have stopped using it; not really effective when used alone; needs to be watered in; works best when it is incorporated into soil

- trifluralin (Treflan)
  - Use: Annual grasses and broadleaves
  - Efficacy: Good
  - Comments: PHI=60 days; not widely used; inexpensive; needs to be incorporated within 24 hours

- **Post Emergent Herbicides**

  - carfentrazone (Aim)
    - Use: Annual broadleaves
    - Efficacy: Good; Excellent on suckering
    - Comments: PHI=3 days. Can be used for sucker control; some usage; Great tank mix with gramoxone, Roundup (enhances efficacy, gets the weeds that Roundup/gramoxone misses); Effective at low doses;

  - bentazon (Basagran)
    - Use: Annual broadleaves and yellow nutsedge
    - Efficacy: Good (for yellow nutsedge)
    - Comments: Non-bearing only (12 month PHI); minimally used (only if you have a yellow nutsedge problem)

  - fluazifop (Fusilade)
    - Use: Most annual and perennial grasses
    - Efficacy: Good (on grasses)
    - Comments: Non-bearing only (12 month PHI); some usage; soybean/grape growers may use it more

  - paraquat (Gramoxone) (restricted use pesticide)
    - Use: Most annual grasses and broadleaves and top kill of perennials.
    - Efficacy: Good
    - Comments: Can be used for sucker control; widely used; Adjuvant use improves performance; Needs careful usage (inhalation risk, permanent damage); Gramoxone/Princep is an inexpensive mix; used extensively for sucker control in juice grapes; instant gratification (see weeds die!)

- sethoxydim (Poast)
  - Use: Annual and perennial grasses
  - Efficacy: Good (on grasses with correct timing)
  - Comments: PHI-50 days; some usage; takes a while to see results; doesn't affect suckers

- diquat (Reglone)
  - Use: Annual grasses and broadleaves
  - Efficacy:
  - Comments: Non-bearing only (12 month PHI); relatively new; not widely used

- glufosinate (Rely)
  - Use: Annual and perennial grasses and broadleaves
  - Efficacy: Fair-Good
  - Comments: PHI=14 days. Can be used for sucker control; Age restriction 1 year; some usage; used later in season as a Roundup replacement;

- glyphosate (Roundup, Touchdown)
  - Use: Annual and some perennial grasses and broadleaves
  - Efficacy: Good-Excellent
  - Comments: PHI=14 days; widely used (#1 usage in IA); weed resistance concerns (especially because of the wide usage); often tank mixed; inexpensive; not volatile

- pelargonic acid (Scythe)
  - Use: Annual and perennial grasses and broadleaves
  - Efficacy: Poor
  - Comments: PHI=14 days; organically approved; stinks; not widely used; expensive

- clethodim (Select)
  - Use: Most annual and perennial grasses
  - Efficacy: Good
  - Comments: Non-bearing only (12 month PHI); not widely used; some usage if they have other crops (soybeans, etc.)

- vinegar
  - Efficacy: Poor
  - Comments: organic growers are trying to use it

"To do" list for weeds

Research needs

- Non-chemical weed control (mechanical, etc.)
- Effective weed control in organic production
- Technology transfer from other grape systems (Europe)
- Companion crops (issues with long-term competition with grapes)
- Mulches (efficient plastic mulches, etc.)
- Herbicides on new plantings
- Specific weeds that present problems: horsenettle, honeyvine bindweed, marestail, nutsedge, black nightshade, lambsquarters, ragweed, bermudagrass
- Research on herbicide resistance in vineyard weed populations

Regulatory needs

- Phenoxy herbicide (2,4-D, Dicamba) drift issues:
  - Especially as Roundup resistance leads to increased 2,4-D and dicamba usage (crop to crop spray drift specifically), and new Dicamba and 2,4-D "ready" soybean varieties are released
  - Especially an issue in areas of country (IL, IN, IA) with large areas of corn and soybeans etc.
  - Regulations vary from state to state
  - Definition of volatility and drift make enforcement difficult
  - The introduction of Dicamba resistant sybeans in 2009 may create additional risk for growing grapes in the Midwest

Education needs

- Education on off target damage (drift and volatility) management (for commercial applicators)
- Roundup resistance education (minimizing Roundup resistance)
- Pre-plant site selection in weed control
- Education on weed control, herbicides in general (because it's a complex topic)
- Education on managing herbicide resistance in weed populations

Table 6. Herbicide Effectiveness on Major Weeds in Vineyards†

	ANNUAL BROADLEAF								ANNUAL GRASSES							PERENNIAL WEEDS					
HERBICIDE	Chickweed	Lambsquarters	Mustard	Pigweed	Ragweed	Smartweed	Horseweed	Yellow Rocket	Barnyard Grass	Brome Grass	Crabgrass	Fall Panicum	Sanbur	Witchgrass	Foxtail	Bindweed	Chickeweed	Dandelion	Golderod	Wild Grape	Ground Ivy
Casoron	E[1]	E	E	E	E	E	F	G	G	P	F	F		G	G	P	G	G		P	F
Devrinol	G	G	P	G	P	F	P	P	E	E	E	E		E	E	N	G	P	N		
Gallery	E	G	F	F	G		E		P		P				P		E	P			
Goal	G	E	F	E	G	G	F	F	F		F	F			F	P	G	P	N		
Surflan	E	G	F	G	P	P	P	P	G		G	G		E	E	N	G	P	N		
Kerb	G	P	F	F	F	F	P	F	E	E	E	G	E	F	G	N	G	N			
Simazine	E	E	E	E	E	E	F	E	E	F	F	F		F	E	F	E	P	N		
Solicam	G	F	F	F	F	G	F	G	G	F	G	G		F	E	P	G	P	N		
Fusilade	N	N	N	N	N	N	N	N	E	F	G	G		E	E	N	N	N	N		
Gramoxone Extra	E	E	E	E	G	E	G	G	E	E	E	E		E	E	P	P	P	P	P	P
Poast	N	N	N	N	N	N	N	N	E	F	G	E		E	E	N	N	N	N		
Rely	G	F		G	F	G	E	G	G	F	F	G	F		G	F	G	G	F		
Roundup Ultra	E	E	E	E	E	E	G	G	E	E	E	E		E	E	E	E	G	E	F	G
Touchdown	E	G	G	F	G	G		G	E	G	G	G		E	E	F	E	N			
2,4-D	P	F	G	G	G	G	P	G	N	N	N	N		N	N	G	P	E	P	F	P

[1]Control ratings: E = excellent, G = good, F = fair, P = poor, and N = not labeled or no activity against this pest.
† *From Michigan State University 2007 Fruit Management Guide (Bulletin E-154).*

Table 6 (con't). Herbicide Effectiveness on Major Weeds in Vineyards†

HERBICIDE	PERENNIAL WEEDS (CONT.)														
	Mallow	Milkweed	Nightshade	Nutsedge	Quackgrass	Plantain	Poison Ivy	Sowthistle	Stinging Nettle	Canada Thistle	Velvetleaf	Vetches	Virginia Creeper	Horsenettle	Shephard's Purse
Gallery	P		G			G					G		N	P	G
Surflan	N	N	N	N	P		N	P		N	P		N	N	N
Simazine	N	P	G	P	F	P	N	F		P		P	N	P	G
Solicam	N	P		P	F	F	N	F		P	F		N	P	G
Fusilade	N	N	N	N	G	N	N			N	N		N	N	N
Gramoxone Extra	P	P	P	F	P	F	P	P	P	P	P	P	P	P	F
Poast	N	N	N	N	F	N	N	P		N	N		N	N	N
Rely	P	P	F	N	F	G	F	P	F	F	G	N	N	N	E
Roundup Ultra	F	E	E	F	E	F	E	G	F	E	G	F	G	F	G
Touchdown		F	G	F	G			E		F	F				G
2,4-D	P	P		P	N	E	F	F		G	G	F	P	P	G

[1] Control ratings: E = excellent, G = good, F = fair, P = poor, and N = not labeled or no activity against this pest.

† *From Michigan State University 2007 Fruit Management Guide (Bulletin E-154).*

Appendix 1. Timeline of Worker Activities in North Central Region Vineyards

(Note: In southernmost areas of North Central Region, these activities may begin about a month before listed here.)

Early Season Activities (no pesticides applied during this time period):
January/February: Pruning & trimming, equipment repair
March: Pruning, equipment repair, push & chop brush, dormant scouting (diseases, ERM)
April: Pruning, equipment repair, push & chop brush, planting, scouting for early insects – grape berry moth, CW, GFB), disease scouting (Phomopsis).

In-Season Activities (Pesticides applied & residues present during this time period)

- There are no aerial pesticide applications in regional vineyards
- Pest management activities from bud swell (April) to harvest in Sept-October
- Pesticides generally applied using covered cab tractors
- Alternate row application is common and volumes of water used are 20-50 per acre.
- Vineyards are scouted by growers, consultants or independent scouts. Scouting intensity varies widely among farms, but weekly scouting is recommended.
- Average time raking/pushing brush: In wine grapes 30 hrs/10 acres pushing and raking brush. This is generally not done in juice grapes. In juice grapes prunings are left in row middles and chopped with a mower.
- Herbicide applications performed on average 2-4 times per year during residue window; average application time = 3 hrs/10 ac; 90% applied with closed cab
- Irrigation activities = Used rarely in juice grapes (only on very sandy sites). Not widely used in wine grapes but becoming more common.
- In juice grapes, harvest is primarily by over the row machine. Average of 15 to 25 hrs per 10 acres (depending on crop load), with 2-3 people (driver, person directing the outflow, and additional tractor driver for transferring harvested grapes out of the vineyard).
- Crop load adjustment usually not done in juice grapes but it is becoming more common. If done, this is done mechanically, using a harvester without the grape catching mechanisms.
- In wine grapes hand harvesting is more common, and harvesting takes 10 to 100 worker hours per acre depending on crop load.
- Mowing in juice grapes takes 2 hrs per 10 acres; most vineyards are mowed 3 to 6 times per year. In wine grapes mowing is generally slower, 10 hrs per 10 acres, and most vineyards are mowed 5 to 10 times per season.

May: weekly insect and disease scouting begins, frost protection as needed (wind machines), mowing of drive rows

Potential Spray Applications (99% with closed cab)

1. Fungicides for black rot, Phomopsis, powdery mildew, downy mildew applied prophylactically at pre-bloom and bloom growth stages, also sprays for mildews if weather conditions are favorable for disease development. May weather is generally favorable for disease development with wet weather.
2. Insecticides for cutworm, flea beetle, potato leafhopper and rosechafer if needed in winegrapes.
3. Herbicides if weather conditions favorable for weed development

June: weekly insect and disease scouting continues, mowing of drive rows, check irrigation lines

Potential Spray Applications (99% with closed cab)

1. Fungicides for black rot, phomopsis, powdery mildew, downy mildew if weather conditions favorable for disease development
2. Insecticides for grape berry moth, grape leafhopper, potato leafhopper, GP if populations require control
3. Herbicides (clean-up sprays)

July: weekly insect and disease scouting continues, mowing.

Potential Spray Applications (99% with closed cab)
1. Fungicides for powdery and downy mildew if conditions favorable for disease
2. Insecticides for grape berry moth, Japanese beetle, grape leafhopper if needed
3. Herbicides (clean-up sprays)

August: weekly insect and disease scouting continues, mowing. Harvest begins in southernmost part of the region.

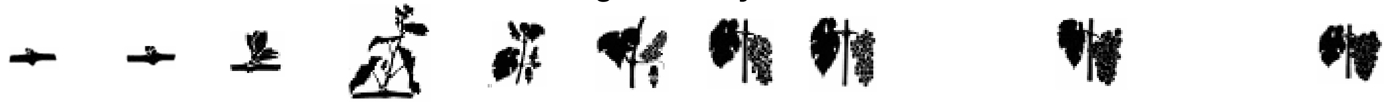
Potential Spray Applications (99% done with closed cab)
1. Fungicides for downy mildew, powdery mildew and developing cluster diseases
2. Insecticides for grape berry moth, Japanese beetle, leafhoppers
3. Herbicides (can help with air movement through canopy)
4. Netting applied before harvest as fruit ripens to minimize bird damage

Sept-October: weekly insect and disease scouting continues, mowing. Prepare machinery for harvest which typically begins in early September for juice grapes in MI and OH, with winegrapes starting later in the month.

Potential Spray Applications (99% done with closed cab)
1. Fungicides for Botrytis, mildews
2. Insecticides for grape berry moth, multicolored Asian ladybeetle, yellowjackets
3. Herbicides (applications if needed at this time to ensure air movement through canopy)

October: There is little pest management activity after harvest. Some late weed control and mowing may be done in preparation for winter.

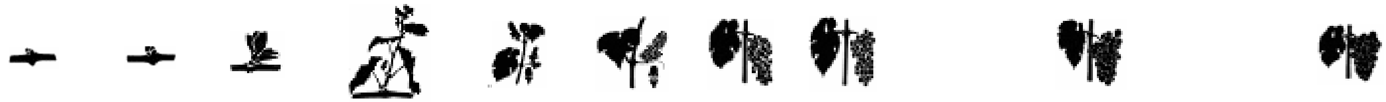
Appendix 2. Calendar of Worker Activities in North Central Region Vineyards



Vine Growth Stage	Dormant	Delayed dormant	Bud swell	1-5 inch shoot	8-12 inch shoot	Pre bloom	Bloom	Pea sized	Berry touch	Bunch closing	Veraison	Pre harvest	Harvest	Post harvest
		March	April/ May	May	May	June	June	July	July	July	August	Sept	Sept	Oct
Fungicide spray	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Insecticide spray			■		■	■	■	■	■	■	■	■	■	
Herbicides - wine	■	■	■	■			■	■	■	■				■
Herbicides - juice			■	■			■	■	■	■				
Scouting			■	■	■	■	■	■	■	■	■	■	■	
Pruning	■	■	■											
Shoot positioning					■	■	■	■	■	■				
Leaf pulling							■	■	■	■	■			
Weed Control-Mechanical		■	■	■	■	■	■	■	■	■	■	■	■	■
Cluster Thinning						■	■	■			■			
Mowing		■	■	■	■	■	■	■	■	■	■	■	■	■
Hand harvest													■	
Machine harvest													■	
Hedging								■	■					
Vertebrate Control				■	■						■	■	■	■
Netting											■	■	■	■
Foliar Fertilization					■	■	■	■	■	■				
Soil Fertlization				■		■	■							

Table developed from group discussions during the PMSP Meeting

Appendix 3. Calendar for Scouting Major Insect and Disease Pests of Vineyards in the North Central Region †



Vine Growth Stage	Dormant	Delayed dormant	Bud swell	1-5 inch shoot	8-12 inch shoot	Pre bloom	Bloom	Pea sized	Berry touch	Bunch closing	Veraison	Pre harvest	Harvest	Post harvest
		March	May	May	May	June	June	July	July	July	August	Sept	Sept	Oct
Insects														
Cutworm			+	+										
Rose Chafer						+	+	+						
Grape berry moth						+	+	+	+	+	+	+	+	+
Grape leafhopper						+	+		+	+	+	+	+	
Potato leafhopper					+	+	+		+	+	+			
Japanese beetle								+	+	+	+	+		
Diseases														
Phomopsis				+	+	+	+	+	+	+	+	+	+	
Black rot				+	+	+	+	+	+	+	+			
Downy mildew					+	+	+	+	+	+	+	+	+	+
Powdery mildew				+	+	+	+	+	+	+	+	+	+	+
Botrytis bunch rot							+			+	+	+	+	

Orange: Usual time for monitoring and control

Yellow: Lesser risk, but monitoring and control may still be required

+ Potential period of insect activity or disease infection risk

†*Adapted from A Pocket Guide for Grape IPM in the North Central and Eastern U.S. Michigan State University Extention Bulleitin E-2889.*

Appendix 4. Classification of Pesticides and their Human Toxicity Risk

Chemical group	Human Risk Assessment
Organochlorine	GABA-gated chloride channel antagonists
Carbamate	Acetylcholinesterase inhibitor; disrupts the nervous system.
Organophosphate	Acetylcholinesterase inhibitor; disrupts the nervous system.
Pyrethroid	Sodium channel modulators, disrupts the nervous system.
Neonicotinoid	Nicotinic Acetylcholine receptor agonists / antagonists
METI acaricide	Mitochondrial complex I electron transport inhibitors
Avermectin	Chloride channel activators, disrupts the nervous system.
Spinosad (No Class)	Nicotinic acetylcholine receptor agonists, disrupts the nervous system.
Juvenile hormone mimic	no effect on humans
Ecdysone agonist / molting disruptor	no effect on humans
B2 carcinogen	Likely human carcinogen.
C carcinogen	Possible human carcinogen for which there is limited animal evidence.
D carcinogen	There is inadequate evidence to determine carcinogenicity in humans.
E chemical	Evidence of non-carcinogenicity in humans.

Appendix 5. Reference Material and Additional Resources

MSU Grape Website – www.grapes.msu.edu

Isaacs, R., A. Schilder, T. Zabadal, and T. Weigle. A Pocket Guide for Grape IPM in the North Central and Eastern U.S. Michigan State University Extension Bulletin E-2889.

Michigan Fruit Management Guide 2007, Michigan State University Extension Bulletin E-154.

Midwest Grape Production Guide, Ohio State University Extension Bulletin 919.

Midwest Commercial Small Fruit and Grape Spray Guide, 2007.edited by: Bruce Bordelon, Purdue University; Mike Ellis, Ohio State University; and Rick Foster, Purdue University http://www.hort.purdue.edu/hort/ext/sfg/

Anderson, N., R. Bessin, M. Brown, W. Burr, J. Cranney, E. Dabaan, L. Giannessi, H. Hogmire, L. Hull, M. Lynd, B. Reid, J. Walgenbach, T. White.The Foundation for a Transition Strategy for Lessening Dependency on Organophosphate Insecticides in the Mid-Atlantic/Appalachian/Southeastern Apple Production Region, http://www.epa.gov/oppfead1/trac/appltran.pdf

Galvan, T.L., E.C.Burkness, and W.D. Hutchison. 2006 Wines grapes in the Midwest: Reducing the risk of the Multicolored Asian Lady Beetle. Public 08232. Univ. of Minnesota Extension Service, St. Paul MN.

NY State IPM Grape leafhopper fact sheet http://www.nysipm.cornell.edu/factsheets/grapes/pests/glh/glh.asp

Information about the IR-4 Pesticide Testing Program http://www.cook.rutgers.edu/~ir4