THE OHIO STATE UNIVERSITY

Bulletin

Extension

# Midwest Small Fruit Pest Management Handbook

## Bulletin 861

**Edited by**

**Richard C. Funt, Michael A. Ellis, Celeste Welty**
The Ohio State University

**Acknowledgments**

We extend grateful appreciation to the following persons who have contributed their talent to this publication:

**David E. Scardena**
OSU, Editor, Communications and Technology

**Jane Hoffelt/Pageworks**
Graphic Designer

**Shirley M. Funt**
OSU Continuing Education Assistant

**Additional Copies**

Additional copies of this handbook, either soft or hard bound, can be purchased from your land grant university listed in the front. If you live outside of the Midwest region you may write or call Extension Publications 385, Kottman Hall, 2021 Coffey Rd., Columbus, Ohio 43210-1044. 614/292-1607.

**Trade Names**

The use of trade names, suppliers, or other private labels are used for identification. No product endorsement is implied nor is discrimination intended toward similar products or materials not mentioned or listed. Extension and the participating universities make no warranty or guidance of any kind, expressed or implied, concerning the use of these products.

# Table of Contents

## Prepared by:

**University of Arkansas, Fayetteville, AR 72701**
**Horticulture** J. N. Moore, J. R. Clark, W. K. Patterson
**Entomology** D. T. Johnson, B. F. Jones
**Plant Pathology** P. Fenn

**Iowa State University, Ames IA 50011**
**Horticulture** Paul Domoto, Gail Nonnecke
**Entomology** Donald Lewis
**Plant Pathology** Mark Gleason

**Kansas State University, Manhattan KS 66506**
**Horticulture** Frank Morrison, Allan Erb
**Entomology** Robert Bauernfeind
**Plant Pathology** N. A. Tisserat

**The Ohio State University, Columbus OH 43210**
**Horticulture** Richard C. Funt, Tom Wall
**Entomology** Celeste Welty, Roger Williams
**Plant Pathology** Mike Ellis

**Purdue University, West Lafayette IN 47907**
**Horticulture** Bruce P. Bordelon, Steve C. Weller
**Entomology** Rick E. Foster
**Plant Pathology** Paul C. Pecknold

**University of Illinois, Urbana IL 61808**
**Horticulture** Jeff Kindhart, Mosbah Kushad, Allen Otterbacher, Bob Skirvin
**Entomology** Rick Weinzierl
**Plant Pathology** Steve Ries

**University of Kentucky, Lexington KY 40546**
**Horticulture** G. R. Brown, J. G. Strang, R. T. Jones, L. A. Weston
**Entomology** R. T. Bessin
**Plant Pathology** J. R. Hartman

**University of Missouri, Columbia MO 65211**
**Horticulture** Patrick Byers (SMSU), Michele Warmund (UMC)
**Entomology** Bruce Barret (UMC), Howard Townsend (SMSU)
**Plant Pathology** James Moore (SMSU), Hal Shaffer (UMC)

University of Wisconsin, Madison WI 53706
Horticulture Terryl R. Roper
Entomology Daniel L. Mahr
Plant Pathology Patricia S. McManu

## Strategies of Pest Management

Some of the strategies that are used in integrated pest management programs are summarized here. For specific examples of how these apply to management of specific diseases and insect pests, see the summary at the end of the disease section and the insect section within each crop chapter.

**Cultural controls:** minimize infestations and infections by choosing appropriate cultural practices.

When establishing a new planting:

- site selection
- crop rotation
- soil preparation
- variety selection
- disease-free planting stock
- row spacing and plant density

When maintaining a planting:

- mulch: apply at times and in amounts that prevent diseases and slugs.
- pruning: cut and remove branches to mechanically kill some cane pests.
- fertilizer: provide plants with optimum nutrient levels.
- cultivation: turn under the soil to mechanically kill some soil pests.
- irrigation: provide water at times and by methods that minimize disease development.
- sanitation: clean up crop debris, especially after harvest.
- renovation: mow or plow under plants after harvest to mechanically kill some foliar pests and disease inoculum.
- habitat modification: remove weeds and alternate hosts of pests.

**Mechanical controls:**

- prevent pests from reaching crop: use traps, row covers or netting.
- remove pests: hosing, vacuums, or hand removal.
- roguing of diseased plants.

**Biological controls:**

- natural enemies: encourage predators, parasitoids, and antagonists that attack pests.
- microbial pesticides: treat crops with beneficial pathogens that kill pests.

- behavior modification: use mating disruption pheromones or poisoned feeding stimulants to modify the behavior of pests to prevent infestation.

**Chemical control:** kill pests by treating crops with pesticides.

- conventional synthetic pesticides
- inorganic pesticides
- botanical pesticides
- soaps, oils
- insect growth regulators

**Biological Control**

**Natural enemies of disease-causing pathogens.** Biological control of insect pests has a longer and better-known history than biological control of disease-causing microorganisms, but research in both disciplines has been increasing recently. Beneficial microorganisms that have potential for incorporation into IPM programs include some fungi that attack pathogenic nematodes, and mycoparasitic fungi such as *Trichoderma* that are antagonistic to crop pathogens. Although biological control has great potential in the future, it plays a relatively small role in current management programs for small fruit crops.

**Types of natural enemies attacking arthropods.** All insects and mites have natural enemies that attack them. Many of these natural enemies are small, drab, and easily overlooked, but they can contribute greatly to pest management. In unmanaged fruit plantings, it can be difficult to find some pests because they are kept under control by natural enemies. In managed plantings, natural enemies are often absent because they are easily killed by pesticides. Natural enemies can be categorized as predators, parasitoids, and pathogens. For detailed information about natural enemies and their use in pest management, see the publications by Mahr and Ridgway (1993) and Henn and Weinzierl (1990) that are listed in Appendix D.

*Predators* are usually larger than their prey. Vertebrate predators of insect pests include birds and some mammals. Among insects, predators include lady beetle adults (also called ladybird beetles or ladybugs), lady beetle larvae, lacewing larvae, minute pirate bugs, hover fly larvae (also called flower fly or syrphid fly larvae), damsel bugs, assassin bugs, some stink bugs, ground beetles, and yellowjackets. Certain kinds of mites are also predators. Predators commonly attack pests that are slow movers, such as aphids and spider mites, or pests that are immobile, such as scales and the egg stage of caterpillars and other pests. See Appendix C.

*Parasitoids* (also called parasites) are usually smaller than their hosts, and include a variety of wasps and flies. Adult female parasitoids usually lay eggs inside the body of the host pest, and the egg hatches into a larva that slowly consumes the body of the host. The host pest does not die until the parasitoid completes its development. Parasitoids commonly attack soft-bodied insects such as caterpillars, or eggs or pupae.

*Beneficial pathogens* are bacteria, fungi, viruses, and nematodes that cause pest insects to become sick and die. These occur naturally, particularly when weather conditions are wet and warm. They are not the same pathogens that cause disease in plants. Some are commercially available, such as the bacterium *Bacillus thuringiensis* (B.t.), which is sold as Dipel, Javelin, Cutlass, MVP, Mattch, Agree, and XenTari. Some insect-attacking fungal pathogens such as *Beauvaria bassiana* are being developed commercially and may soon be available for fruit crops as products called Mycotrol and Naturalis-L.

**Biological Control Methods.** Biological control involves conserving and encouraging naturally occurring enemies, or releasing enemies that have been purchased from a commercial supplier. The best way to encourage the survival of natural enemies is to avoid exposing them to pesticides that are highly toxic to them. This can be done by refraining from applying broad-spectrum pesticides and instead choosing pesticides that are toxic to target pests but relatively nontoxic to predators. For example, B.t. insecticides are toxic only to caterpillars and not to any other types of insects. Some insecticides such as Guthion, Asana, Sevin, and Thiodan are toxic to a broad range of chewing and sucking pests. Other insecticides have a narrower range of activity, such as dimethoate and Metasystox-R, which are toxic primarily to sucking pests such as aphids. To attract and preserve a population of local beneficial insects, flowering plants such as dill and angelica can be grown and some weeds such as dandelions and wild carrot can be allowed to survive in the area. These flowering plants serve as nectar and pollen sources for natural enemies such as parasitoid wasps, lady beetles, hover flies, and minute pirate bugs.

If beneficial insects are not present, they can be purchased commercially from insectaries that mass-rear them (see Appendix C). The success of this approach depends on which type of predator is purchased. Lacewings sold as eggs or pre-fed larvae can be effective for controlling aphids and other soft-bodied pests. Lady beetles collected and shipped from distant states seem to be of lesser value for pest control than local populations, making their purchase uneconomical. Predatory mites can be used to control spider mites on strawberries. Few specific guidelines are available on release rates and timing.

**Chemical Control**. If a pest population reaches a threshold level despite preventive measures and other types of controls, chemicals may be the last resort as a rescue treatment. Even chemicals are not a foolproof way of controlling pests. If the pest is too far along in its growth cycle or has built up a resistance to a pesticide, use of a chemical may do more harm than good. A full range of topics related to safe and effective use of pesticides is covered in Chapter 5 of this handbook.

## Monitoring Pests and Making Control Decisions

**Action thresholds.** Many crops can tolerate a certain amount of pest damage. Some pests cause economic damage only when they occur in large numbers (for example, spider mites and aphids), while others are considered serious even at very low levels (for example, strawberry clipper and plum curculio). A rescue treatment is not needed until the pest population reaches a critical density usually referred to as a threshold or an action threshold. A threshold is the density of pests that signals the need for control if economic damage is to be avoided. Thresholds for different pests may vary greatly and may be expressed as a number of pests per leaf or per plant, or as a percentage of leaves infested.

One goal in the development of IPM programs is to have an appropriate action threshold for each pest. For example, spider mite control on strawberries is suggested if the percentage of mite-infested leaflets is 25% or greater in a random sample of 60 leaflets. Grape berry moth control is suggested on grapes if the average percentage of infested clusters is 5% or greater in a sample of 100 clusters from the interior of a vineyard and a sample of 100 clusters from the edge of a vineyard. Tarnished plant bug control in brambles is suggested if there is at least 0.5 plant bug per cluster in a sample of 50 clustors. Precise thresholds have not yet been determined for many pests of small fruit crops in the Midwest.

**Monitoring overview.** One basic principle of pest management is that you do not take action against a pest unless you are certain the pest is present and is a threat to your crop. Growers who practice IPM as part of their fruit production operation need to know how to monitor pests, because pest control decisions are based on knowledge of which pests are present in their plantings, how many of each are present, and when they are present, as well as how many are economically tolerable.

Two common types of pest monitoring methods are *scouting* and *trapping.* Scouting and trapping each have their merits. Scouting may be somewhat time consuming but can provide accurate information on the presence of the pest in its damaging life stage. Trapping is easily done, but because it is often done to monitor the adult stage of pests that cause damage in the larval stage, the results may not be directly applicable to making a control decision for the larval form. Both methods should be used, where appropriate, to provide information on which pest control decisions can be based. Another monitoring method that is more predictive of when pests are likely to appear is based on *weather monitoring*. Development of several fungal diseases can be predicted by monitoring temperature, leaf wetness, and rainfall. Activity of some insects can be predicted by monitoring temperatures and calculating degree-days.

**Scouting.** Scouting means walking through the planting and looking for pests or symptoms of their presence. The purpose of scouting is to evaluate the effectiveness of preventive measures and the possible need for a rescue treatment. Scouting is done by examining a representative sample of each crop to determine the average infestation or infection level. Infestation may be expressed as presence or absence of pests on each sample, or as the number of pests on each sample, or as the percentage of plant parts damaged. The number of plants or plant parts to examine can vary according to the crop, size of the planting, and time of the year.

For some crops and pests, very *specific* scouting procedures have been developed so that a minimum number of leaves or fruit need to be examined in order to confidently make a decision about the need for applying a control measure. For other crops or pests, specific scouting procedures have not yet been worked out, and a *general* scouting plan can be followed, such as examining 25 whole plants per field. Under a general scouting plan, fruit plantings should be scouted on a regular basis, generally once per week. When examining plants, it is important to look at them closely in order to see small egg masses or small larvae that may be present before damage is evident. In a general scouting plan, all parts of the plant should be examined, even if they are not parts that will be harvested. Pests may be found on the underside of leaves, on top of leaves, on stems, in stems, in buds, on or in developing fruit, or in the crown. A prerequisite to scouting is knowing how to recognize the pests that can attack the crop.

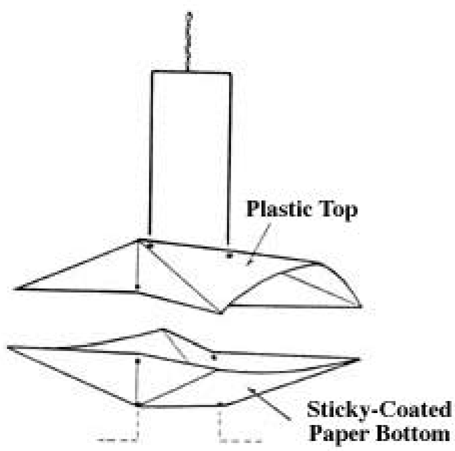
**Insect trapping.** Traps that have the ability to catch insects are useful in some cases as a mechanical control method and in other cases as monitoring tools. Insect traps are a good method of determining if an insect species is present, and they can also give an estimate of the insect's concentration and distribution. Insects can be attracted to traps by visual appearance or by odor. *Visual* traps use light, color and/or shape to attract certain insects. *Odor* traps attract certain insects by using scents associated with food or mates. Another form of trap more often used in gardens than on commercial farms are *shelter* traps, such as shingles or boards placed on the ground to attract pests such as slugs that can then be collected and killed mechanically.

*Food attractant traps.* Traps based on the scent of a food source are now commercially available for rose chafer and Japanese beetle. Although these are most often used as mechanical control devices, they can also be used for monitoring purposes. A well-known bag trap for Japanese beetles uses a food attractant scent to lure both male and female beetles into the trap. This trap is so effective at attracting beetles that it can actually increase the number of beetles in the vicinity of the trap. Despite the sometimes bad reputation the Japanese beetle trap has earned because of its super-attractiveness, the trap still can be effectively used if it is placed at some distance away from the fruit planting to be protected.

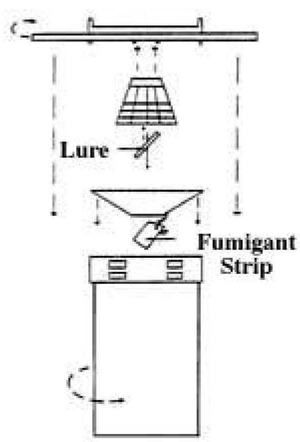
*Colored sticky traps.* The adult form of blueberry maggot is a true fruit fly that is attracted to yellow and to the scent of ammonium. Traps commercially available for monitoring blueberry maggot flies are yellow cardboard or plastic cards coated with a sticky material, which come with an ammonium bait included in the sticky material. The bait is effective for about one week. Small capsules of ammonium bait can also be purchased separately to prolong the attractive life of a trap. Another example is white sticky traps that are sold for monitoring the tarnished plant bug. An alternative to sticky traps is colored bowls filled with soapy water.

*Pheromone traps.* The most common type of trap used for monitoring certain pests in recent years is the pheromone trap. Pheromones are natural scents produced by insects for purposes such as attracting mates. The main advantage of pheromones is that they are specific to individual pest species; for example, the pheromone for grape berry moth attracts only grape berry moth and not the redbanded leafroller or other related moths. Man-made imitations of pheromones are commercially available as lures that can be placed in traps. Most commercial pheromones are imitations of secretions from unfertilized adult female insects, which are used to attract male insects of the same species. Most commercial pheromones are used to monitor various species of moths. Some of the fruit pests that can be monitored with pheromone traps are the grape berry moth, red-banded leafroller, grape root borer, Sparganothis fruitworm, variegated cutworm, and black cutworm.

Traps used with pheromone lures come in a variety of styles and materials; one of the most common types is called a *wing trap*. A wing trap is made of plastic or cardboard top and a sticky cardboard bottom held together by a wire hanger; the pheromone lure can be placed in the middle of the sticky bottom or glued to the trap top. Another style is a *bucket trap* such as a Unitrap or Multi-Pher trap. Bucket traps have a funnel entry system for keeping the pest from escaping, and do not require a sticky coating; the lure is placed near the top of the funnel. The traps can be hung from a vine or be mounted on fence posts. In either sticky wing traps or bucket traps, the pheromone lures need to be replaced periodically, usually every four weeks or as recommended by the manufacturer. Although it is convenient to buy traps ready-made, homemade traps can also be used, with materials such as cardboard milk cartons as a base and Tanglefoot as an adhesive; Tanglefoot is a sticky material available at many garden supply shops.




Wing Style Trap




Bucket Style Trap

While it is the larval stage that often causes the damage, traps catch many pests when they are in the moth (adult) stage of their life cycle because only adult males are attracted by the odor of the pheromone. The moths lay eggs that develop into larvae that feed on crops. To complete their life cycle, the larvae pupate, then change to moths that in turn lay more eggs thus producing more larvae. By knowing when the moth stage of a pest is present, using traps, the grower can be on the lookout for damaging larvae that are likely to follow. The appearance of the first moth can also be used as a starting point for calculating the number of degree days before the emergence of the larvae, if such information is available for a specific pest. This information can help the grower determine the best time to spray for insect control. Some of the insects that follow this pattern of development in apples are the codling moth and San Jose scale; initial catches of either of these in their respective traps determine the timing and/or need of insecticide treatments against these pests. Similar management guidelines may be developed in the future for pests of small fruit crops.

**Insect pheromone trapping guidelines:**

- Use a minimum of two traps for each pest species in representative locations.
- Examine traps at least twice per week.
- Count and record the number of captured insects in each trap. Remove the captured insects during each visit with a wire or twig, wipe them on a rag or paper towel, and dispose of them away from the field.
- Record trap catches on each date in an IPM scouting log. It can help to keep a running graph of the information.
- Sticky panels (the bottom half of wing traps), should be changed regularly to maintain trap effectiveness; replace the panel each month or when covered with debris. Replace the complete trap if drooping or broken.
- Change pheromone lures (baits) every 4 weeks or according to the manufacturer's directions. DO NOT dispose of used pheromone lures in the fruit planting; these would compete with traps and cause lower trap catch numbers. It is useful to establish a pattern when changing lures, such as the first week of every month.
- Store replacement lures in a freezer or refrigerator. It is best to purchase only a one-year supply at a time, but lures can be stored from one season to the next in the freezer. On each package, write the date the lures were purchased and placed in the freezer so that you can use the oldest ones first.
- If you are trapping for more than one species, change gloves or wash your hands when handling pheromones for different species of insects to prevent cross contamination. Minute traces of one pheromone on another can render the second repellent completely ineffective to it's target pest.
- If you are trapping for more than one species, be sure to label each trap with the target pest name and be sure to place the correct pheromone lure into the correct trap.

**Weather monitoring.** The optimum weather conditions for development of some diseases can be monitored to determine the optimal time to control the disease with pesticides. Temperature, leaf wetness, rainfall, and other weather factors can be measured either manually or by a computer. Weather data obtained then can be plugged into equations or computer programs for disease development to determine management actions. An example is management of powdery mildew on grapes, for which a computer forecasting program is available.

**Insect development & degree days.** While scouting and trapping can give information about which pests are present at a given time, another monitoring tool of a more *predictive* nature is temperature-based development models. Temperature plays a major role in determining the rate at which insects develop. Each insect has a temperature range at which it is the most comfortable. Below that temperature range they will not develop, and above that temperature range development will slow drastically or stop. Each insect also has an optimum temperature at which it will develop at its fastest rate. By using this relationship, you can make predictions on the rate of development of insects. By being able to predict when an insect will appear, you can estimate when your crop is most likely to be damaged and when to intervene to prevent damage from occurring.

A method of estimating development time is called the degree day method. The *degree day* method can be used to predict when insects will reach a particular stage of their life cycle, if you know three things: the threshold temperature, the average daily temperature, and a thermal constant. Each insect species has a *threshold* temperature. Below this temperature no development of the insect occurs. The threshold temperature is 50 degrees F for many insect species or 43 degrees F for other species. A degree day is the number of degrees above the *threshold* temperature over a one day (24-hour) period. For example, if the threshold temperature of an insect is 50 degrees F and the average temperature for the day is 70 degrees F, then 20 degree days would have accumulated on this day (70 - 50 = 20).

The accumulation of degree days can be used to predict when insects will hatch, pupate and emerge as adults. By using accumulated degree days, a farmer can estimate when a pest should appear in his crop, then scout for the pest and determine if treatment is needed. However, for degree days to be used to make these predictions, researchers must have determined the number of degree days necessary for the event to occur. That is called the *thermal constant*. The *thermal constant*, just like the *threshold* temperature, will be different for different insects and for different events in the life cycle.

The easiest way to calculate degree days for a date is to subtract the threshold temperature from the average daily temperature. The average daily temperature can be determined by simply averaging the high temperature and low temperature for the date [(maximum temp + minimum temp)/2]. For example, if the high temperature for the day was 90 degrees F and the low was 60 degrees F, then the average temperature for the day would be [(90 + 60)/2 = 150/2 = 75]. If the threshold temperature for an insect were 50 degrees F, the degree days accumulated on this day would be 25 because 75 - 50 = 25.

Temperature extremes add variables to this simple method of calculating degree days. To overcome these and to more accurately predict when insects will be present, follow the following rules.

1. If the maximum temperature for a 24-hour period is not greater than the threshold temperature, no degree days are accumulated. For example:

   maximum daytime temperature = 45 degrees F
   threshold temperature = 50 degrees F

2. If the high temperature for the day is greater than the threshold temperature but the low temperature for the day is less than the threshold temperature, then when

calculating the average temperature for the day the threshold temperature is used as the low temperature for that day. For example:

> maximum daytime temperature = 65 degrees F
> low daytime temperature = 45 degrees F
> threshold temperature = 50 degrees F

The threshold temperature of 50 degrees F would be used as the low day-time temperature when calculating the average daily temperature.

3. If the high temperature for the day is greater than the optimum temperature, the temperature at which the insect will develop at the fastest rate, then you use the optimum temperature as the high temperature for the day when calculating the average temperature for the day. For example:

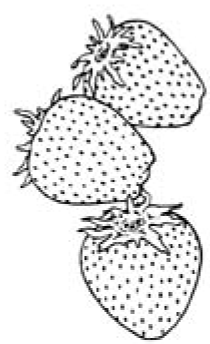
> maximum daytime temperature = 98 degrees F
> optimum temperature = 95 degrees F

The optimum temperature of 95 degrees F would be used as the high temperature for the day when calculating the average temperature for that day.

# Midwest Small Fruit Pest Management Handbook

**Bulletin 861**

---



# Chapter 1

# Strawberries

## General

Strawberries are attacked by a variety of pests. There are many cultural practices that can help in managing these pests. The single most important factor in controlling pathogens is the maintenance of vigorously growing plants. Weeds compete with strawberries for essential water and nutrients. Weeds also promote pest injury by acting as alternate 'homes' for pathogens and insects, by inhibiting spray penetration, and by maintaining a high humidity in the canopy.

Good soil and air drainage are essential. Roots quickly rot in waterlogged soils, and fruit rots are more prevalent when the soil surface does not dry quickly. Well-drained loams are the most suitable soil types for good root penetration. Sites where cold air can drain away to lower levels will decrease the possibility of frost damage to the plants and fruits. A southern, sloping site is the ideal location, providing quick-drying soil and earlier maturing berries.

For good root penetration, aeration, and drainage, organic materials should be added to the soil. Disc farm manures and/or green manure crops (cover crops) thoroughly into the soil before planting. (Poultry manure is least desirable, as it tends to promote too much vegetative growth and soft berries; both conditions encourage disease.) Have the soil pH determined at your Extension office and apply the necessary lime to adjust the pH in the range of 5.8 to 6.5 (See Table 6.1). The calcium level should be above 1,000 pounds per acre. Some soils, that are low in magnesium, may benefit from the use of dolomitic (Hi-Mag) lime or magnesium sulfate (Epsom salts).

In new plantings, a soil test should be taken to determine the rate and type of fertilizer that should be applied. Fertilizer, such as phosphorus and potassium, should be applied before planting in a broad band and incorporated.

Minor elements, boron and zinc, can be blended or mixed with phosphorus and/or potassium and incorporated into the soil. Correcting the elements in the soil by applying the recommended amounts as described by a soil test is the most efficient means of providing optimal nutrition to the planting. In most cases, only annual applications of nitrogen may be necessary for strawberries which are managed for three or four harvest seasons.

Nitrogen should be applied at the broadcast rate of 25 to 40 pounds of actual nitrogen (N) within seven days after transplanting. Apply lower rates to silt loam soils with organic matter of two to four percent and higher amounts to sandy loam soils with low organic matter. In mid-August to early September, broadcast 25 to 40 pounds of actual nitrogen to aid flower bud formation in the transplanting year. Use similar amounts at renovation and in mid-August during the bearing years. Reduce the nitrogen to one half or less when 1) leaf test results are excessive, 2) applying as a side dress, or 3) applying nitrogen in sprinkler or microirrigation systems.

Heavy nitrogen fertilizer applications should be avoided in the spring on established beds; too much nitrogen will promote abundant vegetative growth that encourages disease by inhibiting good air circulation needed to dry plant surfaces. The longer moisture films remain on fruit and leaves from irrigation, rain, dew or high humidity, the greater the chance of fungal spores germinating and disease outbreaks occurring. Berries also may become soft as a result of too much nitrogen and can reduce yields and storage life. Light applications of fertilizer may be made in spring (8-12 lbs of actual N per acre) to promote early plant growth and fruit development on sandy soils. One or two foliar sprays of nitrogen may be more beneficial than soil applied fertilizer.

Leaf tissue analysis is a good way to determine nutrient levels actually in the plant. Sometimes the nutrients in the soil are not available to the plant due to pH, organic matter content, or some other reason. Leaf tissue analysis tells you what elements the plant is getting and what the plant is lacking. The samples are taken after renovation from the first fully expanded new leaves. At least 50 complete leaves per planting should be collected, rinsed, and allowed to dry completely before processing. Contact your regional or state fruit specialists for the exact procedure, processing instructions, and fees. Standards are available for comparison to determine if your results indicate the need for corrective measures .

Strawberries are a cool weather crop, producing most of their growth in the spring and fall. Growth is greatly slowed during the hot, dry summer months, resulting in a shallow root system. During the growing season (April, May, August, September and October), applying 1 1/2 in. of water every 7 to 10 days will aid in growth and fruit bud development. During fruiting, adequate moisture (1/2 to 3/4 in. of water every 2 to 3 days) will maintain fruit size and production.

Irrigation also can eliminate losses due to freezing temperatures during the early bloom periods. If sprinklers are turned on before the temperature at ground level drops to 32 degrees F and continued until air temperature is above freezing and all ice has melted off the plants, the blossoms will be protected. Remember, the first blossoms to open will bear the largest berries. The sensitive, actively-growing tissue in the crown needs to be protected from freezing injury that would make it more susceptible to pathogen attack. When temperatures drop too low or wind speed increases, the irrigation system may not be able to give maximum protection.

---

# Chapter 1 Strawberries

---

## Integrated Management of Strawberry Diseases

The objective of an integrated disease management program is to provide a commercially acceptable level of disease control on a consistent (year-to-year) basis with minimal fungicide use. This is accomplished by developing a program that *integrates* all available control methods into one program. An effective disease management program for strawberries must emphasize the integrated use of specific cultural practices, knowledge of the pathogen and disease biology, disease resistant cultivars and timely applications of fungicides, when needed. In order to reduce the use of fungicides to an absolute minimum, the use of disease resistance cultivars and various cultural practices must be strongly emphasized.

| Table 1. 3. Strawberry disease control strategies. (All possible control strategies must be employed if strawberry diseases are to be controlled.) Key: ++=most important controls; +=helpful controls; - =no controls | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Disease control considerations** | **Verticillium wilt** | **Red stele** | **Black root rot** | **Nematodes** | **Viruses** | **Fruit rot** | **Leaf spots** | **Powdery mildew** |
| 1. Good drainage | - | ++ | ++ | - | - | ++ | + | - |
| 2. No shade | - | + | - | - | - | ++ | ++ | - |
| 3. No infested runoff | + | ++ | + | + | - | | - | |
| 4. Rotation | ++a | ++a | ++a | ++a | - | - | + | - |
| 5. Fumigation for fungi | ++b | ?b | +?b | - | - | - | + | - |
| 6. Fumigation for nematodes | - | - | - | ++c | - | - | - | - |
| 7. Resistant varieties | ++d | ++c | - | - | - | 'Earliglow' | ++f | 'Surecrop' |
| 8. Disease-free plants | ++ | ++ | ++ | + | ++ | - | + | + |
| 9. Adequate plant & row spacing | - | - | - | - | - | ++ | ++ | + |
| 10. Cultivation from infested soil | + | ++ | + | + | - | - | - | - |
| 11. Mulch for winter injury/fruit rot | - | ++ | - | - | | Leather Rot(++) | - | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 12. Avoid frosted blossoms | - | - | - | - | - | + | - | - |
| 13. Fungicide sprays | - | + | - | - | - | ++g | ++g | ++g |
| 14. Fruit storage conditions | - | - | - | - | - | ++ | - | - |
| 15. Renovation | - | - | ++ | - | - | - | + | + |
| 16. Weed Control | + | - | - | | | ++ | ++ | + |
| a Rotations: Verticillium wilt, black root rot, nematodes are 3 to 5 yrs; red stele is very long. | | | | | | | | |
| b Fumigants for fungi: Red stele is limited; Verticillium wilt & black root rot are effective. Refer to Fumigation Appendix Table A-7, page A-7. | | | | | | | | |
| c Fumigants for nematodes: Refer to Fumigation Appendix Table A-7, page A-7. | | | | | | | | |
| d Resistant to Verticillium wilt: 'Earliglow', 'Sunrise', 'Catskill', Guardian', Redchief', 'Surecrop', 'Delite'. | | | | | | | | |
| e Resistant to some strains of red stele: 'Earliglow', 'Redglow', 'Sunrise', 'Guardian', 'Midway', 'Redchief', 'Surecrop', 'Delite', 'Sparkle'. | | | | | | | | |
| f Resistant to leaf spot: 'Guardian', 'Midland', 'Redchief', 'Surecrop'. Resistant to leaf scorchî 'Catskill', 'Guardian', 'Midland', 'Redchief', 'Sunrise', 'Surecrop'. | | | | | | | | |
| g Fungicide sprays: refer to spray schedule. | | | | | | | | |
| Courtesy of Pennsylvania State University, Small Fruit Production and Pest Management Guide. | | | | | | | | |
| Used by permission. | | | | | | | | |

**Identifying and Understanding the Major Strawberry Diseases**

It is important for growers to be able to recognize the major strawberry diseases. Proper disease identification is critical to making the correct disease management decisions. In addition, growers should develop a basic understanding of pathogen biology and disease cycles for the major strawberry diseases. The more you know about the disease, the better equipped you will be to make sound and effective management decisions. The following literature contains color photographs of disease symptoms on strawberries, as well as information on pathogen biology and disease development:

**Compendium of Strawberry Diseases--**Published by the American Phytopathological Society, 3340 Pilot Knob Rd., St. Paul, Minnesota 55121. Phone: 612-454-7250 (1-800-328-7560). This is the most comprehensive book on strawberry diseases available. All commercial growers should have a copy. The following information gives a description of symptoms, causal organisms, and control of the most common strawberry diseases in the midwest.

# Chapter 1 Strawberries

## Foliar Diseases

There are three major leaf diseases of strawberries in the Midwest. They are leaf spot, leaf scorch, and leaf blight (Figure 1). All three diseases can occur singly or together on the same plant or even on the same leaf. All three are caused by fungi. Under favorable environmental conditions, these three diseases can cause serious reductions in strawberry yields. They damage the strawberry plant by causing premature leaf death, reduction in fruit quality, a general weakening of the plant, and (in some situations) plant death. In order to maximize strawberry production, these leaf diseases must be recognized and controlled.

Leaf spot and leaf scorch usually appear first in early to mid-spring. Leaf blight is more common during the summer and early fall.

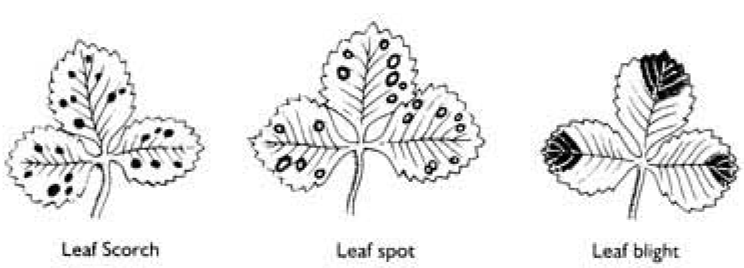



Figure 1. Typical symptoms of leaf scorch, leaf spot and leaf blight on strawberry leaves.

### Leaf Spot

#### Symptoms

Leaf Spot is caused by the fungus *Mycosphaerella fragariae*. The leaf spot fungus can infect leaves, fruit, petioles, runners, fruit stalks, and berry caps or calyxes. The most obvious symptoms of the disease are small, round spots. These spots develop on the upper surface of the leaf and at first are dark purple to reddish-purple. They range in size from 1/8 to 1/4 inch across. With time, the centers of the spots become tan or gray and eventually almost white; while their margins remain dark purple. Later in the season, tan or bluish areas form on the underleaf surface. Symptoms on other plant parts, except fruit, are almost identical to those on the upper leaf surface. On fruits, superficial black spots may form during moist weather. The spots form on ripe berries and around groups of seeds. They are about 1/4 inch in diameter and usually there are only one or two spots per fruit. However, some fruits may be more severely infected.

#### Disease Development

This fungus can produce two types of spores that infect newly-emerging leaves in spring. First, older infected leaves that remain alive during winter may give rise to conidia (spores) that are spread to new foliage by splashing water or by handling infected plants. Another type of spore (ascospore) is produced in speck-sized black perithecia, which form at the edges of the leaf spots during Autumn. In the spring, these ascospores are forcibly ejected from perithecia and are carried by wind or water to new leaf tissue.

Infection by both types of spores occurs through the underleaf surface. Temperatures between 65 and 75 degrees F are optimum for infection and disease development. Infections may occur throughout the growing season, except during hot, dry weather. Young, expanding leaves are the most susceptible to infection.

### Leaf Scorch

#### Symptoms

Leaf scorch is caused by the fungus, *Diplocarpon earliana*. The leaf scorch fungus can infect leaves, petioles, runners, fruit stalks and caps of strawberry plants. Leaf scorch symptoms are very similar to the early stages of leaf spot. Round to angular or irregular dark-purple spots up to 1/4 inch in diameter are scattered over the upper leaf surface. As spots enlarge, they resemble small drops of tar. This tar-like appearance is caused by the formation of large numbers of minute, black, fungal fruiting bodies (acervuli). The centers of the spots remain dark purple. This distinguishes the disease from leaf spot where the center turns white. If many infections occur on the same leaf, the entire leaf becomes reddish or light purple. Severely infected leaves dry up and appear scorched. Similar, but elongated, spots may appear on other affected plant parts. Lesions may girdle fruit stalks causing flowers and young fruit to die. Infections on green berries are rare, appearing as red-to-brown discolorations or a flecking on the fruit surface. The leaf scorch fungus can infect strawberry leaves at all stages of development.

#### Disease Development

The fungus overwinters on infected leaves that survive the winter. In the spring, conidia are produced on both leaf surfaces in speck-sized, black acervuli. The fungus also produces ascospores in the early spring within disk-shaped apothecia (fungal fruiting structures) that appear as black dots in old lesions on the lower surface of diseased leaves that died during winter. In the presence of moisture, ascospores germinate within 24 hours and infect the plant through the lower leaf surface. After symptom development, conidia are produced on the leaf spots in large numbers throughout the growing season. Therefore, repeated infections occur whenever weather conditions are favorable. Conidia are spread mainly by splashing water.

## Leaf Blight

#### Symptoms

Leaf blight is caused by the fungus, Phomopsis obscurans. Leaf blight is found most commonly on plants after harvest. The disease is distinctively different from both leaf spot and leaf scorch. The enlarging leaf spots of this disease are round to elliptical or angular and a quarter of an inch to an inch across. Spots are initially reddish-purple. Later, they develop a darker brown or reddish-brown center surrounded by a light-brown area with a purple border. Similar spots may sometimes develop on the fruit caps. Usually, only one to six lesions develop on a leaflet. Often the infected area becomes V-shaped with the widest part of the "V" at the leaf margin. New lesions appear throughout the summer and fall if weather conditions are favorable. Older leaves become blighted and may die in large numbers. This disease is usually more destructive on slow growing or weak plants. The same fungus can cause an enlarging, soft, pale-pink rot at the stem end of the fruit.

#### Disease Development

This fungus produces spores (conidia) in speck-sized, black pycnidia (fungal fruiting bodies) embedded in the centers of older leaf lesions. Conidia ooze out of pycnidia during damp weather when temperatures are high. Conidia are splashed to new leaf tissue where they germinate in the presence of free water to initiate new infections on leaves and fruit. The fungus overwinters on either infected leaves that survive the winter or in dead tissue on old infected leaves.

## Powdery Mildew

Powdery mildew is caused by the fungus *Sphaerotheca macularis*. Generally the disease is not a serious problem in the Midwest; however, under the proper environmental conditions and on highly susceptible varieties, the disease can become serious.

#### Symptoms

Foliage symptoms usually are the most obvious. An upward curling of leaf edges usually is the first symptom seen. Dry, purplish or brownish patches develop on the lower surface of infected leaves and reddish discoloration may develop on the upper surface. Patches of white, powdery fungus mycelium may appear on the undersides of leaves as the disease progresses.

#### Disease Development

The fungus that causes strawberry powdery mildew infects only wild and cultivated strawberries. This pathogen can not survive in the absence of living host tissue. It apparently overwinters in infected leaves. Spores are carried by wind to infect new growth in the spring. Development and spread of powdery mildew is favored by moderate to high humidity and temperatures of about 60 to 80 degrees F (15 to 27 degrees C). Unlike most other fungi that cause plant disease, powdery mildew does not require free water for spores to germinate and infect.

### Angular Leaf Spot (Bacterial Blight)

Angular leaf spot or bacterial blight of strawberries is caused by the bacterium *Xanthomonas fragariae*. In the Midwest, it is the only reported strawberry disease that is caused by a bacterium. The disease was first reported in Minnesota in 1960, and has since been found in other regions of the United States. It appears to be spreading rapidly to many strawberry-growing areas of the world with the importation of planting material. Although the disease has not been a major problem in the Midwest, it can become serious and does represent a potential threat to production.

#### Symptoms

Typical symptoms of angular leaf spot appear initially as minute, water-soaked lesions on the lower leaf surface. These lesions enlarge to become angular spots, usually delineated by small veins. An important distinguishing characteristic of this disease is that lesions are translucent when viewed with transmitted light, but dark green when viewed with reflected light.

Under moist conditions, lesions often have a viscous bacterial exudate on the lower leaf surface. When it dries, the exudate forms a whitish, scaly film. This exudate or film is an additional characteristic that is useful in the identification of angular leaf spot.

Lesions may coalesce to cover large portions of the leaf. Eventually, lesions become visible on the upper leaf surface as irregular, reddish-brown spots, which are necrotic and opaque to transmitted light. A chlorotic halo may surround the lesion. At this stage, symptoms may be difficult to distinguish from those of common leaf spot and leaf scorch.

Heavily infected leaves may die, especially if major veins are infected. Occasionally, under natural conditions, infection follows the major veins, resulting in veinal water-soaking that may or may not spread to the interveinal regions.

Infection by *X. fragariae* may become systemic. The pathogen can infect all plant parts except fruits and roots and, in some cases, even the fruits have been infected, apparently only in the tissue adjacent to an infected calyx (fruit cap). Calyx infection can be serious. Infected tissues turn black resulting in unattractive fruit.

#### Disease Development

Inoculum for the primary infection of new growth in the spring comes from infected dead leaves where the pathogen overwintered. *X. fragariae* may survive for extended periods in dry leaves or in infected leaves buried in the soil. Spread is primarily from infected leaf debris or infected crowns.

Bacteria that exude from lesions under high-moisture conditions may provide secondary inoculum. Bacteria may be disseminated to uninfected plants or leaves by splashing water, such as rain or overhead irrigation. *X. fragariae* gains entrance into host tissue either passively through wounds or actively as motile cells that swim into natural plant openings by means of drops of dew, gutation fluid, rain, or irrigation water.

Very little is known about the epidemiology of angular leaf spot. Development of the disease is favored by moderate to cool daytime temperatures around 68 degrees F (20 degrees C), low nighttime temperature (near or just below freezing) and high relative humidity. Long periods of precipitation, sprinkler irrigation to protect plants from freezing, or heavy dews in the spring also favor the disease. Young leaf tissue or leaves on healthy, vigorous plants are more likely to become infected than those on diseased or environmentally stressed plants.

---

# Chapter 1 Strawberries

---

## Strawberry Root Diseases

### Red Stele

Red Stele is caused by the soil-borne fungus *Phytophthora fragariae*. Many commercial strawberry cultivars are susceptible to the red stele fungus. This root rot disease has become a serious problem facing strawberry production in the northern two-thirds of the United States. The disease is most destructive in heavy clay soils that are saturated with water during cool weather. Once it becomes established in the field, the red stele fungus can survive in soil up to 13 years.

Normally, the disease is prevalent only in the lower or poorly drained areas of the planting; however, it may become fairly well distributed over the entire field, especially during a cool, wet spring. The red stele fungus may become active at 40 degrees F. However, the optimum temperature for growth and disease development is between 55-60 degrees F. Under favorable conditions of high soil moisture and cool temperature, plants will show typical disease symptoms within 10 days after infection.

**Symptoms**

When plants start wilting and dying in the more poorly-drained portions of the strawberry field, the cause is very likely red stele disease. Infected plants are stunted, lose their shiny green luster, and produce few runners. Younger leaves often have a metallic bluish-green cast. Older leaves turn prematurely yellow or red. With the first hot, dry weather of early summer, diseased plants wilt rapidly and die. Diseased plants have very few new roots compared to healthy plants that have thick, bushy white roots with many secondary feeder roots. Infected strawberry roots usually appear gray, while the new roots of a healthy plant are yellowish-white.

The best way to identify the disease is to carefully dig up a wilted plant and peel off the outside portion of several roots. The inside or central portion of the root is known as the stele. If the stele is pink to brick red or brownish red, the plant has the red stele disease. The stele of normal plants is yellowish-white. The red color may show only near the dead tip of the root or it may extend the length of the root. The red stele is best seen in the spring up to the time of fruiting. No other disease of strawberry produces this symptom.

**Disease Development**

The red stele fungus is introduced into new planting sites mainly through the distribution of infected plants. The fungus can be spread within a field or area by anything that carries or moves infested soil (implements, shoes, water, etc.). Once in the field, spores (oospores) of the fungus produce large numbers of smaller spores (zoospores). Zoospores are motile and swim about when soil moisture is high. Zoospores invade the tips of young fleshy roots. Once in the roots, the fungus grows and destroys the water and food conducting tissues resulting in wilting and plant death (Figure 2). As soil temperatures rise, the fungus forms large numbers of oospores in the stele of infected plants. These oospores survive periods of hot, dry and freezing weather for several years in the soil.

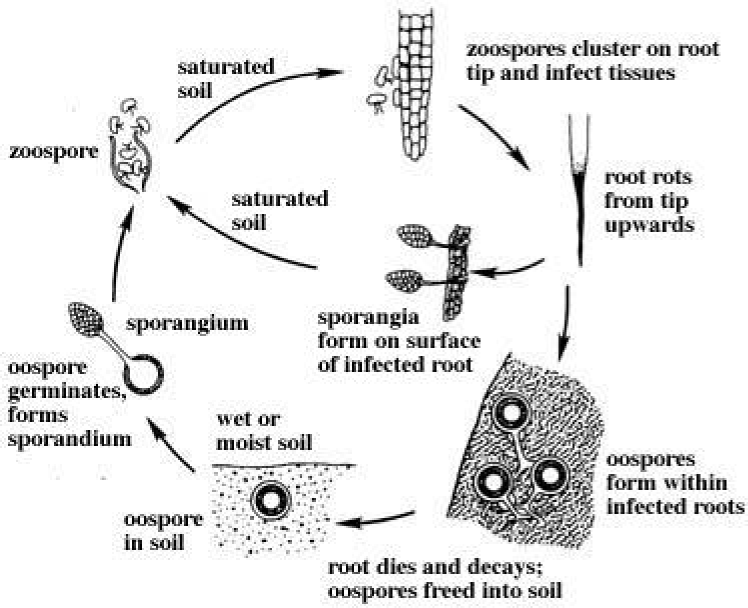



Figure 2. Disease cycle of Red Stele Rot on strawberry. We wish to thank the New York State Agricultural Experiment Station for use of this figure. Figure taken from the Small Fruit IPM Disease Identification Sheet No. 2.

## Verticillium Wilt

Verticillium wilt, caused by the soil-borne fungus Verticillium albo-atrum, can be a major factor limiting production. When a plant is severely infected, the probability of it surviving to produce a crop is greatly reduced. The Verticillium fungus can infect nearly 300 different host plants, including many fruits, vegetables, trees, shrubs, flowers as well as numerous weeds and some field crops. Once it becomes established in the field or garden, it may remain alive for 25 years or longer.

Cool, overcast weather interspersed with warm, bright days is most favorable for development of Verticillium wilt. Optimal conditions for infection and disease development occur when soil temperatures are from 70 to 75 degrees F.

Many soils in the Midwest contain the Verticillium wilt fungus. The fungus can be introduced into uninfested soil on seeds, tools, farm machinery and from the soil and roots of transplants.

#### Symptoms

The first symptoms of Verticillium wilt in new strawberry plantings often appear about the time runners begin to form. In older plantings, symptoms usually appear just before picking time. Symptoms on above-ground plant parts may differ with the susceptibility of the cultivar affected. In addition, above-ground symptoms are difficult to differentiate from those caused by other root infecting fungi. Isolation from diseased tissue and culturing the fungus in the laboratory are necessary for positive disease identification.

On infected strawberry plants, the outer and older leaves drop, wilt, turn dry and become reddish-yellow or dark brown at the margins and between veins. Few new leaves develop and those that do tend to be stunted and may wilt and curl up along the midvein. Severely infected plants may appear stunted and flattened with small yellowish leaves. Brownish-to-bluish black streaks or blotches may appear on the runners or petioles. New roots that grow from the crown are often dwarfed with blackened tips. Brownish streaks may occur within the decaying crown and roots. If the disease is serious, large numbers of plants may wilt and die rapidly. When the disease is not so serious, an occasional plant or several plants scattered over the entire planting may wilt and die.

#### Disease Development

The fungus overwinters in soil or plant debris as dormant mycelium or black speck-sized bodies (microsclerotia). These microsclerotia can remain viable in the soil for many years. Under favorable environmental conditions, they germinate and produce thread-like fungal structures (hyphae). Hyphae can penetrate root hairs directly or through breaks or wounds in the rootlets. Once inside the root, the fungus invades and destroys the water-conducting tissue. Destruction of water-conducting tissue results in reduced water uptake by the plant; thus, plants wilt and wither. As fungal colonies get older, they produce microsclerotia in infected host tissue and the disease cycle is completed.

### Black Root Rot

Black root rot is the general name for several root disorders which produce similar symptoms. The disorders are not clearly understood and are generally referred to as a root rot complex. Although the exact cause of the black root rot is not known, one or more of the following is thought to be responsible: soil fungi (such as *Rhizoctonia* and *Fusarium*); nematodes; winter injury; fertilizer burn; soil compaction; herbicide damage; drought; and excess salt, water or improper soil pH. Black root rot has been found in every strawberry-growing area of the United States. Injured plants may be scattered throughout the planting or localized in one or more areas. A considerable incidence of black root rot has been observed in recent years throughout the Midwest.

To recognize black root rot symptoms, it is necessary to know what a normal root looks like. Newly developed main roots of a normal strawberry plant are pliable and almost white. After several months of growth, they generally become woody and are dark brown to black on the surface. When this dark surface is scraped away, a yellowish-white living core can be seen. Small feeder roots that branch out from the main roots should be white as long as they are active.

Roots affected by black root rot have one or more of the following symptoms: 1) the root system is much smaller than normal; 2) the main roots are spotted with dark patches or zones; 3) the feeder roots are lacking or are spotted with dark patches or zones; 4) all or part of the main root is dead. A cross-section of the dead root shows it blackened throughout. Plants with black root rot are less vigorous than normal plants and produce fewer runner plants. Severely affected plants usually die.

# Chapter 1 Strawberries

## Strawberry Fruit Rots

### Botrytis Fruit Rot (Gray Mold)

One of the most serious and common fruit rot diseases of strawberry is gray mold. Gray mold is caused by the fungus *Botrytis cinerea*. Under favorable environmental conditions for disease development, serious losses can occur. The gray mold fungus can infect petals, flower stalks (pedicels), fruit caps, and fruit. During wet springs no other disease causes a greater threat to flowers and fruit. The disease is most severe during prolonged rainy and cloudy periods during bloom and harvest. Abundant gray-brown, fluffy, fungal growth on infected tissue is responsible for the disease's name "gray mold."

#### Symptoms

Young blossoms are very susceptible to infection. One to several blossoms in a cluster may show blasting (browning and drying) that may spread down the pedicel. Fruit infections usually appear as soft, light brown, rapidly enlarging areas on the fruit. If it remains on the plant, the berry usually dries up, "mummifies," and becomes covered with a gray, dusty powder. Fruit infection is most severe in well-protected, shaded areas of the plant where the humidity is higher and air movement is reduced. Berries resting on soil or touching another decayed berry or a dead leaf in dense foliage are most commonly affected. The disease may develop on young (green) fruits, but symptoms are more common as they mature. Often, the disease is not detected until berry picking time. During harvest, the handling of infected fruit will spread the fungus to healthy ones. After picking, mature fruits are extremely susceptible to gray mold, especially if bruised or wounded. Under favorable conditions for disease development, healthy berries may become a rotted mass within 48 hours after picking.

#### Disease Development

The fungus is capable of infecting a great number of different plants. It overwinters as minute, black, fungal bodies (sclerotia) and/or mycelium in plant debris, such as dead strawberry leaves in the row. In early spring, these fungal bodies produce large numbers of microscopic spores (conidia), which are spread by wind throughout the planting. They are deposited on blossoms and other plant parts where they germinate in a film of moisture. Infection occurs within a few hours (Figure 3).

Disease development is favored by wet conditions accompanied by temperatures between 41 degrees F and 86 degrees F. Conditions that keep flowers and fruit wet, such as rain, dew, or sprinkler irrigation encourage Botrytis rot.

Strawberries are susceptible to *Botrytis* during bloom and again as fruits ripen. During the blossom blight phase of the disease, the fungus colonizes senescing flower parts, turning the blossoms brown. The fungus usually enters the fruit through flower parts, where it remains inactive (latent) within the tissues of infected green fruits. As the fruit matures, the fungus becomes active and rots the fruit. Thus, while infection actually occurs during bloom, symptoms are usually not observed until harvest. This is important to remember when one considers control. Temperatures between 70 and 80 degrees F and moisture on the foliage from rain, dew, fog, or irrigation are ideal conditions for disease development.

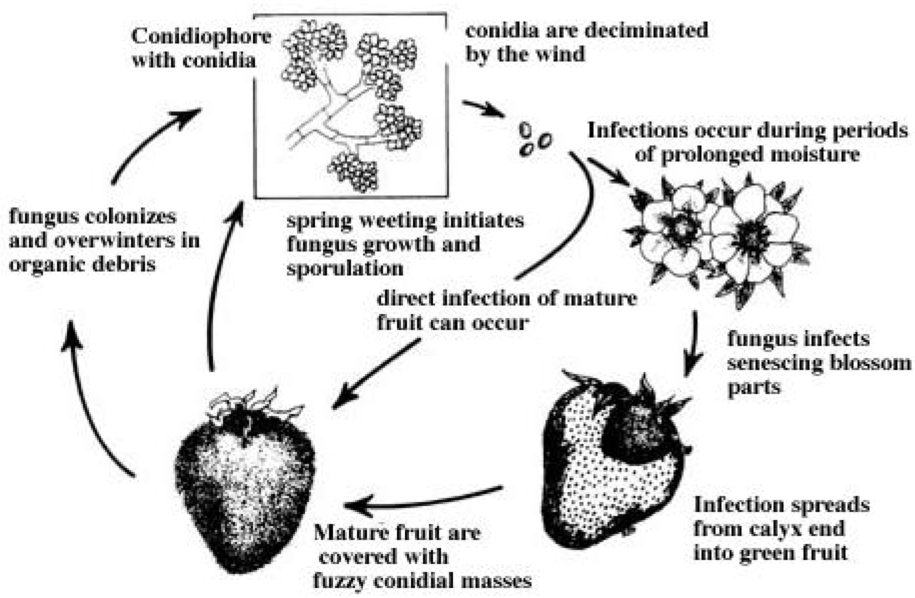



Figure 3. Disease cycle of Grey Mold on Strawberry. We wish to thank the New York State Agricultural Experiment Station for use of this figure. Figure taken from the Small Fruit IPM Disease Identification Sheet No. 1.

## Leather Rot

Leather rot is caused by the soil-borne fungus *Phytophthora cactorum*. Leather rot has been reported in many regions throughout the United States. In many areas, it is considered a minor disease of little economic importance. However, excessive rainfall during May, June, and July can lead to severe fruit losses and quality reduction. In 1981, many commercial growers in the Midwest lost up to 50 percent of their crop to leather rot. The leather rot fungus primarily attacks the fruit, but may also infect blossoms.

#### Symptoms

Leather rot can infect berries at any stage of development. When the disease is serious, infection of green fruit is common. On green berries, diseased areas may be dark brown or natural green outlined by a brown margin. As the rot spreads, the entire berry becomes brown, maintains a rough texture, and is leathery in appearance. The disease is more difficult to detect on ripe fruit. On fully mature berries, symptoms may range from little color change to discoloration that is brown to dark purple. Generally, infected mature fruit is dull in color and is not shiny or glossy. Infected ripe fruit are usually softer to the touch than healthy fruit. When diseased berries are cut across, a marked darkening of the water-conducting system to each seed can be observed. In later stages of decay, mature fruits also become tough and leathery. Occasionally, a white moldy growth can be observed on the surface of infected fruit. In time, infected fruit dry up to form stiff, shriveled mummies.

Berries that are affected by leather rot have a distinctive and very unpleasant odor and taste. Even healthy tissue on a slightly rotted berry is bitter. This presents a special problem to growers in pick-your-own operations. An infected mature berry with little color change may appear normal and be picked and processed with healthy berries. Consumers have complained of bitter tasting jam or jelly made with berries from fields where leather rot was a problem. Leather rot is most commonly observed in poorly-drained areas where there is or has been free-standing water or on berries in direct contact with the soil.

**Disease Development**

The fungus survives the winter as thick-walled resting spores, called oospores that form within infected fruit as they mummify (Figure 4). These oospores can remain viable in soil for long periods of time. In the spring, oospores germinate in the presence of free water and produce a second type of spore called a sporangium. A third type of spore called zoospore is produced inside the sporangium. Up to 50 zoospores may be produced inside one sporangium. The zoospores have flagella and can swim in a film of water. In the presence of free water on the fruit surface, the zoospores germinate, forming a germ tube, and infect the fruit. In later stages of infection, sporangia are produced on the surface of infected fruit under moist conditions.

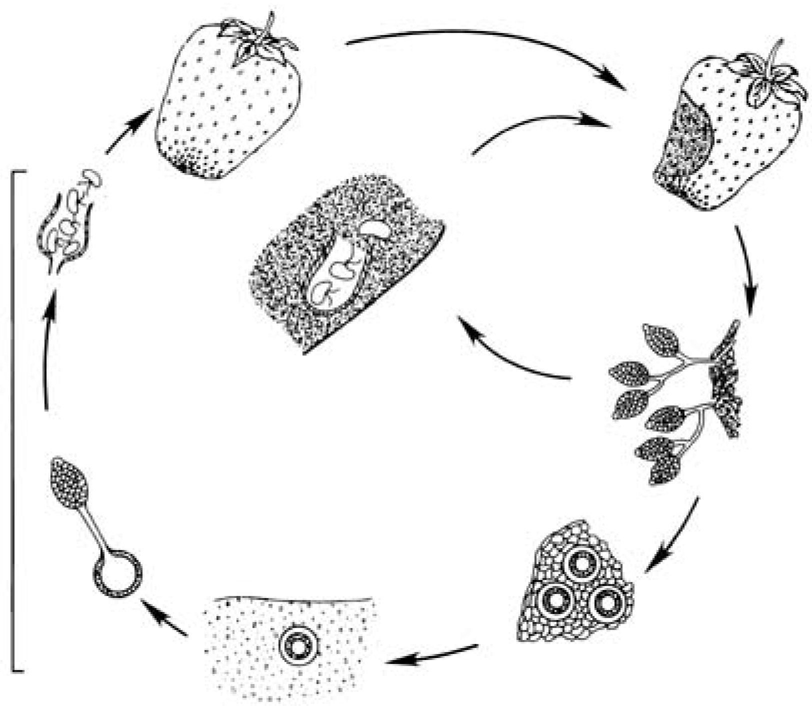


Figure 4. Disease cycle of Gray Mold on strawberry. We wish to thank the New York State Agricultural Experiment Station for use of this figure. Figure taken from the Small Fruit IPM Disease Identification Sheet No. 1.

The disease is spread by splashing or wind-blown water from rain or overhead irrigation. Sporangia and/or zoospores are carried in water from the surface of the infected fruit to healthy fruit where new infections occur. Under the proper environmental conditions, the disease can spread very quickly. A wet period (free water on fruit surface) of two hours is sufficient for infection. The optimum temperatures for infection are between 62 and 77 degrees F. As the length of the wet period increases, the temperature range at which infection can occur becomes much broader. As infected fruit dry up and mummify, they fall to the ground and lie at or slightly below the soil surface. Oospores formed within the mummified fruit enables the fungus to survive the winter and cause new infections the following year, thus, completing the disease cycle.

## Strawberry Anthracnose

Anthracnose is a disease that can affect foliage, runners, crowns and fruit. Various forms of anthracnose can be caused by several fungi. In the Midwest, the most common form of the disease is fruit rot, caused by the fungus *Colletotrichum acutatum*. Although the disease is not very common, if it becomes established in the planting, serious losses can occur.

#### Symptoms

Affected stems are sometimes girdled by lesions, causing individual leaves or entire daughter plants to wilt. Under warm, humid conditions, salmon-colored masses of spores may form on anthracnose lesions.

When crown tissue is infected and becomes decayed, the entire plant may wilt and die. When infected crowns are sliced open, internal tissue is firm and reddish brown. Crown tissue may be uniformly discolored or streaked with brown.

On fruit, symptoms first appear as whitish, water soaked lesions up to 3 mm in diameter which turn brown and enlarge within 2 to 3 days to involve most of the fruit. Lesions are covered with salmon-colored spore masses. Infected fruit eventually dry down to form hard, black, shriveled mummies. Fruit can be infected at any stage of development.

#### Disease Development

The disease is probably introduced into new plantings on infected plants. Spore production, spore germination, and infection of strawberry fruits are favored by warm, humid weather and by rain. Spores require free water on the plant surface in order to germinate and infect. Anthracnose fruit rot is considered to be a warm-weather disease with an optimum temperature for disease development near 80 degrees F. Thus, the disease is generally a problem in the Midwest when abnormally high temperatures and rainfall occur during fruit set and harvest. Spores are dispersed primarily by water splash.

Once the disease is established in the field, the fungus can overwinter on infected plant debris, primarily old-infected, mummified fruit.

### Plant Parasitic Nematodes

Plant parasitic nematodes are microscopic round worms and are common in soils throughout the Midwest. Lesion and root-knot nematodes are probably the most destructive kinds in midwestern plantings. These organisms restrict root growth by feeding directly on roots. This makes plants less efficient at taking up water and minerals from the soil. Nematodes can also cause strawberry roots to be more susceptible to root-rotting fungi. Strawberry plantings in nematode infested soils are not long-lived. Production will decline rapidly after one or two seasons. Nematode damage is most common and most severe in replant situations, because preceding crops increase nematode numbers and high populations of these parasites may be present when the young plants are set. Under these conditions, strawberries never develop strong root systems.

#### Symptoms

Strawberry plants infested with nematodes are stunted and show symptoms of mineral deficiencies and water stress, particularly as the berries form. Because nematodes are unevenly distributed in the field, damaged plants tend to occur in patches. Heavily infested plantings decline rapidly.

Root-knot nematodes cause the formation of knots or galls on fine roots. Heavy galling may cause abundant adventitious root formation and lead to a "whiskery root" condition. Other types do not form such distinct root symptoms. Infested roots are not well developed. Lateral roots may be few. Roots attacked by lesion nematodes are dark in color.

#### Causal Organisms

The lesion nematode (*Pratylenchus penetrans*) and the northern root-knot nematode (*Meloidogyne hapla*) are common in the Midwest. The dagger nematode (*Xiphinema americanum*) is frequently found. The dagger nematode is the vector of tomato ring-spot virus, which it can acquire from common weed hosts, such as dandelion. Ring nematodes (*Criconemella* spp.) and lance nematodes (*Hoplolaimus* spp.) are also found in soils in the Midwest. Their effect on strawberries is not known.

## Use of Disease Resistant Varieties

In the integrated disease management program, the use of cultivars with disease resistance must be emphasized. Many commercial cultivars have good resistance and/or tolerance to ***Leaf Spot, Leaf Scorch, Red Stele, Verticillium Wilt and Powdery Mildew***. The more disease resistance within the program, the better. Table 1.1 lists ratings for disease resistance in several of the more commonly grown cultivars. This type of information is available from a number of sources. Most nurseries should be able to provide information on disease resistance for the cultivars they sell.

**Table 1.1. Disease Resistance of Strawberry Cultivars Commonly Grown in the Midwest**

| Cultivar Junebearing | Red Stele | Verticillium Wilt | Leaf Spot | Leaf Scorch | Powdery Mildew |
|---|---|---|---|---|---|
| Allstar | VR[1] | R | R | R | R |
| Annapolis | S | I | S | S | -- |
| Blomidon | -- | -- | -- | -- | -- |
| Canoga | I | I | R | R | -- |
| Cardinal | S | S | R | R | R |
| Catskill | S | VR | S | R | R |
| Cavendish | R | I | -- | -- | S |
| Delite | R2 | R | R | S-R | S |
| Delmarvel* | R | R | S-R | S-R | T |
| Earliglow | R2 | T-R | S-R | R | I |
| Guardian | R2 | T-R | S-R | R | S-R |

| | | | | | |
|---|---|---|---|---|---|
| Honeoye | S | S | R | R | -- |
| Jewel | S | S | R | R | -- |
| Kent | -- | -- | -- | -- | -- |
| Lateglow[3] | R | R | T | T | T |
| Latestar[3] | R | R | S-R | S-R | T |
| Lester | R | R | R | R | R |
| Midway | R[2] | S-I | S | S | I |
| Noreaster | R | R | S-R | S-R | T |
| Primetime | R | R | T | T | T |
| Raritan | S | S | S | S | I |
| Redchief | R2 | R | S-R | R | S-R |
| Scott | R | I-R | S-R | R | R |
| Seneca | S | S | -- | -- | -- |
| Sparkle | S-R | S | S | S-I | R |
| Surecrop | R[2] | VR | S-R | S-R | -- |
| Veestar | S | T | T | T | -- |
| **Everbearing** | | | | | |
| Tribute | VR | T-R | T | T | R |
| Tristar | R | R | T | T | R |
| 1 VS=very susceptible; S=susceptible; I=intermediate; T=tolerant; R=resistant; VR=very resistant; --=unknown. Resistant characteristics of the cultivar usually preclude the need for other controls. | | | | | |
| 2 Resistant to several races of the red stele fungus. | | | | | |
| 3 Susceptible to leaf blight. | | | | | |
| * Delmarvel has resistance to Anthracnose foliage and fruit rot. | | | | | |

---

# Chapter 1 Strawberries

---

### Cultural Practices For Disease Control

The use of any practice that provides an environment within the planting that is less conducive to disease development and spread should be used. The following practices should be carefully considered and implemented in the disease management program.

## Use Disease-Free Planting Stock

Always start the planting with healthy, virus- indexed plants obtained from a reputable nursery. Remember that disease-free plants are not necessarily disease resistant: cultivar selection determines disease resistance.

## Site Selection

Soil Drainage (Extremely ***Important***)-Select a planting site with good water drainage. Avoid low, poorly-drained wet areas. Good water drainage (both surface and internal drainage) is especially important for control of Leather Rot and Red Stele. Both of these diseases require free water (saturated soil) in order to develop. If there are low areas in the field that have a tendency to remain wet, this is the first place that red stele will develop. Under Midwestern growing conditions, any time there is standing water in the field, plants are subject to leather rot infection. Any site in which water tends to remain standing is, at best, only marginally suited for strawberry production and should be avoided. Any practice, such as tiling, ditching, or planting on ridges or raised beds, that aids in removing excessive water from the root zone will be beneficial to the disease management program.

### Previous Cropping History

Select a site that does not have a previous history of problems with Verticillium wilt in any crop or old strawberry land that does not have a history of red stele or black root rot. To minimize the risk of black root rot, it is not advisable to replant strawberries immediately after removing an old strawberry planting. In general, it is also not a good practice (due primarily to *Verticillium*) to plant strawberries immediately after solanaceous or other *Verticillium*-susceptible crops. These include tomatoes, potatoes, peppers, eggplant, melons, okra, mint, brambles, chrysanthemums, roses or related crops. If possible, select sites that have not been planted to any of these crops for at least 3 to 5 years. There should be no herbicide residual in the soil from previous crops.

### Site Exposure

A site with good air circulation that is fully exposed to direct sunlight should be selected. Avoid shaded areas. Good air movement and sunlight exposure are important to aid in drying fruit and foliage after a rain or irrigation. Any practice that promotes faster drying of fruit or foliage will aid in the control of many different diseases.

### Crop Rotation and Soil Fumigation

*First Planting of Strawberry*--If the land has no recent (5 years or more) history of strawberry production or Verticillium diseases in other crops, soil fumigation should not be required for the purposes of disease control.

*Replanting Strawberries--Crop Rotation and Soil Fumigation.* If strawberries are to be replanted in the same field, either crop rotation must be used or the field should be fumigated. With rotation, the site should be plowed, worked down and planted to a crop that is not susceptible to *Verticillium* Wilt for a minimum of 2 years. Many soil-borne pathogens form specialized survival structures and are capable of surviving for several years in soil, even when strawberries are not present. The longer the site can be rotated away from strawberries prior to replanting, the better.

Soil fumigation (if done properly) will greatly aid in the control of soil-borne diseases and is recommended in most commercial disease control programs where strawberries are continually replanted. For instance, in the annual production systems of California and Florida, strawberry fields are replanted annually following fumigation.

The combination of crop rotation plus soil fumigation is a sound approach that is used by many successful growers. However, for growers wishing to minimize chemical inputs, crop rotation alone often provides acceptable control for most soil borne diseases, if the rotation is sufficiently long.

Neither soil fumigation nor crop rotation will reliably provide adequate control of red stele. With red stele, disease resistant varieties and improved soil drainage must be emphasized. Cultivars with resistance to red stele and verticillium wilt should always be used.

**Fertility**

Fertility should be based on soil and foliar analysis. Soil should be analyzed and nutrient levels adjusted before planting. The use of excess fertilizer, especially nitrogen, should be avoided. Sufficient fertility is essential to produce a crop, but excess nitrogen results in dense foliage that increases drying time in the planting (stays wet longer) and also results in softer berries that are more susceptible to fruit rots. Avoid the application of nitrogen in the spring prior to harvest on medium to heavy soils (See Recommendations for Strawberries).

**Weed Control**

Good weed control is essential to successful strawberry production. From the disease control standpoint, weeds in the planting prevent air circulation and result in fruit and foliage staying wet for longer periods. Gray mold, in particular, is a much more serious problem in plantings with poor weed control versus plantings with good weed control.

In addition, weeds will reduce production through direct competition for light, nutrients, and moisture with strawberry plants and will make the planting less attractive to pick-your-own customers, especially if you have thistles!

**Mulch**

Research and grower experience has shown that a good layer of straw mulch is very beneficial for controlling fruit rots, especially leather rot. Bare soil between the rows should be avoided and a good layer of straw mulch is highly recommended. The mulch keeps berries from contacting the soil where the leather rot fungus overwinters. In addition, it also aids in preventing infested soil from splashing onto the berries. Recent research has shown that plastic mulch (a layer of plastic) under the plants and/or between the rows increases splash dispersal of the pathogens that cause anthracnose and leather rot. Especially where fruit rots have been a problem, the use of plastic mulch is not recommended.

**Sanitation**

Any practice that removes old leaves and other plant debris from the planting is beneficial in reducing the amount of Botrytis inoculum. Leaf removal at renovation is highly recommended.

**Irrigation Practices**

The application of supplemental water should be timed so that the foliage and fruit will dry as rapidly as possible. If diseases, such as gray mold, leather rot or bacterial blight, become established in the planting, overhead irrigation should be minimized.

**Control Movement of People and Machinery**

Movement of people (pickers) and machinery from a field or area that is infested to a clean or uninfested field should be avoided. Diseases of primary concern are anthracnose, leather rot and angular leaf spot (bacterial blight). Diseases such as these are usually spread over relatively short distances by splash dispersal (rain or irrigation). Movement from one field to another field through the air (wind blown spores) is generally not a problem with these diseases. However, pickers moving from a field where the disease is present to a noninfested field can transport fungal spores or bacteria very efficiently on shoes, hands, and clothing. If people or machinery are used in fields where these diseases are a problem, they should complete work in noninfested fields before moving to infested fields.

In addition, any machinery that moves soil from one field to another can introduce soil-borne diseases, such as red stele, Verticillium wilt, leather rot, and nematodes, from infested into noninfested fields.

**Harvesting Procedures**

a) Pick fruit ***frequently*** and early in the day before the heat of the afternoon (preferably as soon as plants are dry). Picking berries as soon as they are ripe is critical. Overripe berries will cause nothing but problems during and after harvest.

b) Handle berries with care during harvest to avoid bruising. Bruised and damaged berries are extremely susceptible to rot.

c) Train pickers to recognize and avoid berries that have disease symptoms of gray mold and leather rot. If at all possible, have pickers put these berries in a separate container and remove them from the field.

**Post Harvest Handling**

a) Always handle fruit with care during movement from the field to market to avoid any form of damage.

b) Get the berries out of the sun as soon as possible.

c) Refrigerate berries immediately to 32 to 35 degrees F in order to slow the development of gray mold (Botrytis) and other fruit rots.

d) Market the berries as fast as possible. Encourage your customers to handle, refrigerate, and consume or process the fruit immediately. Remember that even under the best conditions, strawberries are ***very perishable***.

---

# Chapter 1 Strawberries

---

## Fungicides for Strawberry Disease Control

Most fungicides used on strawberries are directed at the control of fruit rots and foliar diseases (Table 1.2). By using resistant varieties to control foliar diseases, the use of fungicides can be directed primarily toward controlling fruit rots. The two fruit rots that are most prevalent in the Midwest are Botrytis fruit rot (gray mold) and leather rot.

### Leather Rot

Most fungicides currently available for use on strawberries are generally ineffective for controlling leather rot. Although captan and thiram are beneficial in suppressing leather rot, they will not provide adequate control if an epidemic develops. Furthermore, the use of these fungicides is severely restricted or prohibited during harvest due to re-entry restrictions or preharvest intervals. Ridomil is registered for use on strawberries for control of red stele and leather rot. Ridomil is very effective for control of leather rot and may be applied in the spring after the ground thaws and before first growth. This early application is recommended primarily for control of red stele, but may be beneficial in providing some control of leather rot. A second application is recommended specifically for leather rot and can be made during the growing season at fruit set. Aliette 80% WDG is also registered for use on strawberries and should provide good control of both red stele and leather rot. It can be applied from the initiation of bloom through harvest on a 7-14 day schedule and has no preharvest restriction. Although these fungicides are very effective against leather rot, the emphasis for controlling leather rot should be placed on the use of cultural practices, such as using a good layer of mulch and preventing standing water in the planting (good drainage). In many plantings throughout the Midwest and in drier growing seasons, leather rot is generally not a problem.

**Botrytis Fruit Rot (Gray Mold)**

There are several fungicides that have excellent activity against *Botrytis*. Benlate and Topsin-M have been registered for many years and are highly effective in areas where *Botrytis* has not developed a resistance to them. Ronilan and Rovral are relatively new fungicides that have excellent activity against *Botrytis*.

There are two major problems involved with using these fungicides (Ronilan, Rovral, Benlate or Topsin-M) for fruit rot control: 1) None of them have any activity against leather rot. 2) All of them are at risk with respect to the development of resistant strains of *Botrytis*. Because of differences in fungicide chemistry and previous frequency of use, the threat of resistance developing may be somewhat greater for Benlate and Topsin-M than it is for Ronilan or Rovral. For these reasons, the use of minimal numbers of fungicide applications, alternation of fungicides, and fungicide combinations should be encouraged in the disease management program. The benefits of these fungicide use strategies (at least in theory) are: 1) wider spectrum of disease control, and 2) reducing or delaying the development of fungicide-resistant strains of the fungus.

Fungicide application timing is important for gray mold management. Sprays applied during bloom are much more effective than sprays applied after fruit set and during harvest. Bloom sprays also leave less residue on harvested berries.

**Anthracnose Fruit Rot**

Anthracnose fruit rot is not a common problem in many areas, but its occurrence is increasing across the Midwest. Once anthracnose fruit rot is established in a planting, it is difficult to control with fungicides. Benlate was an effective fungicide for controlling anthracnose when the disease became a problem in production fields in the southern U.S. However, due to its continued use, Benlate is no longer effective for anthracnose control, but Captan is providing adequate control of anthracnose fruit rot in these areas. At present, the combination of Benlate or Topsin-M plus Captan, or Captan alone should be the fungicides of choice for anthracnose control in the Midwest.

**Table 1.2. Efficacy of fungicides for strawberry disease management**

| Fungicide[d] | Gray mold | Leather rot | Leaf spot | Powdery mildew | Anthracnose | Preharvest Interval |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| **Alone** | | | | | | |
| Benlate[a] | +++ | 0 | +++ | +++ | ++ | 0 |
| Topsin[a] | +++ | 0 | +++ | +++ | ++ | 1 |
| Captan[b] | ++ | + | ++ | 0 | ++ | 0 |
| Thiram[c] | ++ | + | ++ | 0 | + | 0[b] |
| Ronilan[a] | +++ | 0 | 0 | 0 | 0 | 0 |
| Rovral[a] | +++ | 0 | 0 | 0 | 0 | 0 |
| Ridomil | 0 | +++ | 0 | 0 | 0 | 0[d] |
| Aliette | 0 | +++ | 0 | 0 | 0 | 0 |
| Sulfur | 0 | 0 | 0 | +++ | 0 | 0 |
| **In Combination** | | | | | | |
| Benlate (Topsin) + thiram | +++ | + | +++ | +++ | ++ | -- |
| Benlate (Topsin) + captan | +++ | + | +++ | +++ | +++ | -- |
| Ronilan+thiram | +++ | + | ++ | 0 | + | -- |
| Ronilan+captan | +++ | + | ++ | 0 | ++ | -- |
| Rovral + captan | +++ | + | ++ | 0 | ++ | -- |
| Rovral + thiram | +++ | + | ++ | 0 | + | -- |
| Efficacy rating system: +++ = highly effective; ++ = moderately effective; + = slightly effective; 0 = not effective. | | | | | | |
| a Always apply Benlate, Topsin, Rovral or Ronilan in combination with an unrelated fungicide such as captan or thiram, or in an alternating program where either Benlate and Topsin are alternated with Ronilan or Rovral. Rovral and Ronilan or Benlate and Topsin should not be used in an alternating program with each other. | | | | | | |
| b Although the preharvest interval for captan is 0 days, protective clothing must be worn for 24 hours after application when entering the planting or harvesting fruit. | | | | | | |
| c If thiram is applied within 3 days of harvest, residues must be removed by washing the fruit. | | | | | | |
| d See label for harvest restrictions. | | | | | | |

---

# Chapter 1 Strawberries

---

## Leaf Diseases

**(Leaf Spot, Leaf Scorch, Leaf Blight)**

The emphasis for controlling leaf diseases should be placed on the use of resistant cultivars whenever possible (Table 1.1). If resistance is not available, highly susceptible cultivars should be avoided. There are several fungicides that are registered for control of strawberry leaf diseases (Table 1.2). Benlate, Topsin-M, Captan, Thiram, and Syllit (previously marketed as Cyprex) are registered for use on strawberries. The label states that Benlate and Topsin-M cannot be applied before early bloom; thus, applications made very early in the season (as new growth starts) should use Syllit, Captan or Thiram. If leaf diseases are a serious problem, post-harvest or post-renovation applications of these fungicides may be required.

**Powdery Mildew**

Benlate and Topsin-M are labeled for use on strawberries and were very effective against mildew when they were first introduced; however, due to the development of fungicide resistance, these fungicides generally do not provide adequate control in many production areas across the country. In areas where the fungicides have not been used to control powdery mildew, they still might provide effective control. In areas where Benlate and Topsin-M are not effective, sulfur is the only alternative fungicide for powdery mildew control on strawberries. The use of cultivars with resistance to powdery mildew should be emphasized, and the use of highly susceptible cultivars must be avoided.

**Red Stele in Established Plantings**

Ridomil is registered for control of red stele. The emphasis for control should be placed on the use of resistant cultivars and good soil drainage. However, if red stele develops in an established planting, the use of Ridomil may help reduce losses. Ridomil should be applied in sufficient water to move the fungicide into the root zone of the plants. The label states "Make one application at time of transplanting or in the spring after the ground thaws before first growth. Make another application in the fall after harvest."

Aliette WDG is also registered for red stele control. It is registered as a pre-plant dip and a foliar spray.

***The pre-plant dip*** label reads as follows:
Use 2.5 lbs per 100 gallons "Apply as a pre-plant dip to strawberry roots and crowns for 15-30 minutes. Plant within 24 hours after dipping."

***The foliar application*** label reads as follows:
"In the spring begin foliar applications when the plants start active growth. If disease conditions persist or re-occur, make additional applications on a 30 to 60 day interval. The use rate is 2.5 to 5 lbs per acre.

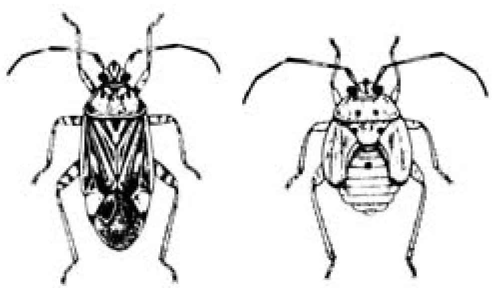
# Chapter 1 Strawberries

## Strawberry Pests and Their Management

### Fruit- or Flower-Feeding Pests of Strawberries

#### Tarnished Plant Bug

**(*Lygus lineolaris*; order Heteroptera, family Miridae)**



Tranished Plant Bug, Adult - Nymph

**Damage:** Slightly to severely uneven berry growth and deformed berries with hollow seeds can result from tarnished plant bug feeding on flower buds and developing fruit. Ripening berries that remain small, with a concentration of seeds at the tip, may be called button berries, cat-faced berries, or nubbins. Injured berries can be woody and unmarketable. Later-maturing varieties are more seriously affected by this pest than early varieties.

**Appearance:** Adult tarnished plant bugs are about 1/4 inch long, coppery brown with yellow and dark brown markings, and somewhat shiny in appearance. A yellow-tipped triangular plate is present in the middle of their backs. The immature stages, or nymphs, are smaller and green. Nymphs are plain green when young but marked with black spots when older. Both nymphs and adults have a beak used for sucking plant juices.

**Life Cycle and Habits:** Adults overwinter in vegetation or stubble that provides protection from extreme cold. In the spring, they are attracted to flower buds and shoot tips of many plants, including strawberry, peach, and apple. They lay eggs in plant tissues of crops and weeds. Eggs hatch in about one week and the nymph stages last about three weeks. Tarnished plant bugs suck sap from developing seeds during and after bloom, or from the receptacle of developing fruit. Their feeding kills surrounding cells and leads to distorted seedy berries. Several generations of this insect develop each year, and adults and nymphs are present on many different plants from April or May until a heavy frost in the fall.

**Cultural Control:** Strawberry varieties that are least susceptible to plant bug injury are Honeoye, Sparkle, Canoga, Catskill, and Veestar, according to work in New England. Controlling weeds in and around strawberry fields reduces in-field overwintering and removes sources of early-season flowers that attract adult tarnished plant bugs to fields. However, *weeds in and near strawberry fields should not be mowed when strawberry buds are swelling and flowers are beginning to open*, because tarnished plant bugs will move from weed hosts to strawberries at a time when the crop is especially vulnerable to damage. If mowing must be done during this period, it is better to mow after applying insecticide than to mow before applying insecticide.

**Mechanical Control:** Row covers put on in the fall to exclude plant bugs in the spring has been shown in New England to reduce, but not eliminate, plant bug injury.

**Monitoring and Thresholds:** Guidelines for monitoring tarnished plant bug infestations and determining whether or not to use an insecticide vary depending on whether adults or nymphs commonly cause damage in a particular region.

Where *adults* that migrate into fields appear to cause more damage than subsequent nymphs, as happens during most seasons in Illinois, producers are advised to monitor the bug population by *sweep net sampling* as buds begin to form. Control is suggested if the population is found to be above the threshold of two tarnished plant bug adults per ten sweeps.

Where damage tends to be caused by *nymphs* that are present when buds are forming, particularly for later varieties or day-neutral varieties, then *shake sampling* is more useful than sweep net sampling. At each of five sites per field, shake ten flower clusters over a white pan or paper to dislodge the nymphs, then count them. Calculate the average number per flower cluster. If counts exceed 0.25 nymph per flower cluster, or more than 10% of the flower clusters are infested (regardless of count), then application of an insecticide is warranted.

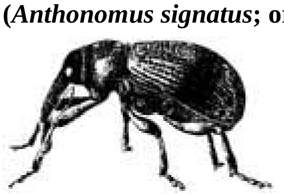
White sticky traps are commercially available for monitoring tarnished plant bug adults, but recent evaluations of these traps in Iowa has shown them to be unreliable for detecting plant bug infestations in strawberries.

*Control by Insecticides:* Control of tarnished plant bugs may be justified if the field has suffered substantial damage from tarnished plant bugs in previous years or where the threshold (as described above) is exceeded. Insecticide (Table 1.4) should be applied soon after blossom buds first become visible and again if reinfestation occurs just before bloom. Do not spray insecticide during bloom to protect bees and other insect pollinators.

| Table 1.4. Effectiveness of pesticides used for the control of strawberry insects and mites | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Chemical** | **Aphids** | **Clip-per** | **Cycla-men mite** | **Leaf-hop-pers** | **Leaf-rol-lers** | **Root Wee-vils** | **Root-worms** | **Slugs** | **Sap Beet-les** | **Spi-der Mites** | **Spittle-bug** | **Tarn-ished Plant Bug** | **White Grubs** | **Pre-harvest Interval (Days)** |
| Agri-Mek (abamectin) | - | - | - | - | - | - | - | - | - | +++ | - | - | - | 3 |
| Brigade (bifenthrin) | - | ++ | - | - | - | - | - | - | ++ | ++ | +++ | +++ | - | 0 |
| Danitol (fenpropathrin) | - | - | - | - | - | - | - | - | - | ++ | +++ | +++ | - | 2 |
| Diazinon | +++ | - | - | ++ | ++ | + | - | - | ++ | - | ++ | + | ++ | 5 |
| Dibrom (naled) | - | - | - | - | - | - | - | - | ++ | - | - | - | - | 1 |
| Guthion (azinphosmethyl) | - | ++ | - | - | +++ | - | - | - | ++ | - | ++ | ++ | - | 5 |
| Kelthane (dicofol) | - | - | ++ | - | - | - | - | - | - | +++ | - | - | - | 2 |
| Lorsban (chlorpyrifos) | - | +++ | - | - | - | - | - | - | - | - | - | - | - | [b] |
| Lannate (methomyl) | - | - | ++ | - | - | - | - | - | - | ++ | - | - | | 3[a] |
| Malathion | - | - | - | - | - | - | - | - | + | - | - | ++ | - | 3 |
| Metaldehyde | - | - | - | - | - | - | - | ++ | - | - | - | - | - | [a] |
| Methoxychlor | - | ++ | - | - | - | - | + | - | - | - | ++ | - | - | 14 |
| Sevin (carbaryl) | - | - | - | ++ | + | - | - | - | - | - | ++ | - | - | 1 |
| Thiodan (endosulfan) | +++ | - | +++ | - | - | - | - | - | - | - | +++ | +++ | - | 4[a] |
| Vendex (fenbutatinoxide) | - | - | - | - | - | - | - | - | - | +++ | - | - | - | 1 |
| +++=Highly effective; ++ = moderately effective; + = slightly effective; - = not effective | | | | | | | | | | | | | | |
| a See label restrictions | | | | | | | | | | | | | | |
| Do not apply after fruit begins to form | | | | | | | | | | | | | | |

**Strawberry Bud Weevil or Strawberry Clipper**

**(*Anthonomus signatus*; order Coleoptera, family Curculionidae)**



Strawberry Clipper, Adult

**Damage:** Nearly mature blossom buds are injured by adult clippers that puncture buds with their snouts, deposit eggs inside buds, then girdle the buds and clip the stem below the buds. Clipped buds hang down or fall to the ground. Injured buds that survive to flowering may have small holes in the petals.

**Appearance:** The strawberry clipper adult is a dark, reddish-brown weevil about 1/10 inch long; its head is prolonged to form a slender, curved snout about one-third as long as the body. The larva is white and 1/16 inch long.

**Life Cycle and Habits:** Adult clippers overwinter in fencerows and woodlots near strawberry plantings. Once temperatures reach 60 degrees F, they move to plants with developing fruit buds. A small portion of a population may remain in the strawberry field over the winter. Strawberry flowering coincides with the the time that clippers move out of their overwintering sites, so strawberries are ideal host plants for this insect. Redbud trees are another early host. Adult clippers first feed on immature pollen by puncturing nearly mature blossom buds with their snouts. Each female then deposits a single egg inside the bud and girdles the bud, which prevents it from opening and exposing the developing larva. The female then clips the stem. Eggs hatch in about one week. Larvae feed within the damaged bud for three to four weeks; a new generation of adults emerges in late June and July. These weevils feed on the pollen of various flowers for a short time, but seek shelter in midsummer in preparation for overwintering. There is one generation per year.

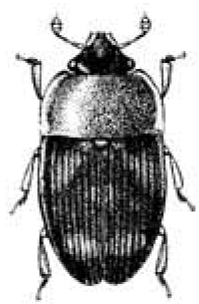
**Cultural Control:** Because the strawberry clipper does not disperse over long distances, locating strawberry plantings away from woodlots and hedgerows that harbor this insect through the winter can reduce the number of adults that move into strawberries in the spring. Because early varieties are usually damaged more than later ones, planting two or three rows of an early variety as a trap crop around the perimeter of each field has been suggested as a way to reduce overall damage or to concentrate the adults for control by use of an insecticide only in the trap crop.

**Monitoring and Thresholds:** Early detection of clipper activity is important. Sample for strawberry clipper adults and damage as soon as temperatures are above 65 degrees F and flower trusses are visible in crowns. In each of five places within each planting, examine a 1-foot by 2-foot length of row. Sampling should be most intensive along field edges near woods or hedge rows. Get down on hands and knees and look closely for clipped buds of unopened flowers, and look for adult weevils in unexpanded flower clusters. An insecticide application is warranted for clipper control if any live weevils are observed, or if the average damage per 1- by 2-foot length of row is greater than 1.3 clipped buds.

**Control by Insecticides:** If control is necessary, insecticide should be applied as soon as damage begins to occur; this usually occurs well before most flowers have begun to open. When damage is observed only in rows along a field border, then insecticide application can be limited to border rows. Plantings with a history of clipper problems may require a second application 7 to 10 days after the first application.

### Strawberry Sap Beetle

**(*Stelidota geminata*; order Coleoptera, family Nitidulidae)**



Strawberry Sap Beetle

**Damage:** Deep cavities in ripe berries are chewed by strawberry sap beetle adults. This injury also can lead to infection of berries by rot organisms. Because over-ripe fruit is especially attractive to sap beetles, damage is often greatest in Pick-Your-Own operations where pickers leave large numbers of ripe and over-ripe berries in the field.

**Appearance:** Adult strawberry sap beetles are about 1/8 inch long, oval-shaped, flat, and mottled brown in color. Larvae are white with a brown head, and up to 1/10 inch long.

**Life Cycle and Habits:** Strawberry sap beetle adults fly into strawberry plantings from wooded areas at about the time berries begin to ripen. They chew on berries, often in groups of several beetles per berry. They may be hard to see because they drop to the ground when disturbed. Females deposit eggs on the injured fruit. Eggs hatch in two to three days. Although larvae feed in berries for about one week, they usually are unnoticed because the fruit has already begun to decompose as a result of damage caused by adults. A parasitic wasp contributes to suppression of this pest by laying eggs in the adult beetles; parasitized beetles lay fewer eggs than healthy beetles.

**Cultural Control:** Strawberry sap beetles are best controlled by timely and complete picking of harvestable berries and the removal of over-ripe and damaged berries.

**Mechanical Control:** Trap buckets of over-ripe fruit can be placed outside field borders as the crop begins to ripen, to intercept immigrating beetles and reduce pest numbers in the crop.

**Control by Insecticides:** Because sap beetle populations usually do not build up until the picking cycle is underway, the use of insecticides is limited by frequent harvests. The required preharvest interval specified on the insecticide label must be obeyed.

### Slugs

***Deroceras (Agriolimax)*** **species (family Limacidae) and** ***Arion*** **species (family Arionidae; Phylum Mollusca, Class Gastropoda)**

Slug

**Damage:** Slugs damage fruit by eating deep ragged holes into the surface of berries, especially under the cap. Slugs leave slime trails on the fruit or leaf surfaces as they move around.

**Appearance:** Soft-bodied and slimy, slugs are worm-like molluscs that range in size from 1.5 to 7 inches long. They may be dark gray, black, yellow-gray, or brown, and may be covered with spots.

**Life Cycle and Habits:** Slugs that damage strawberries in the spring and early summer hatched from eggs deposited in the soil in strawberry plantings the previous fall. Conditions that favor egg-laying in the fall include the continuous presence of straw mulches. Slugs survive best and damage fruit the most in fields with rows close together and thick mulch, and when overcast and rainy weather creates continuously moist conditions in strawberry beds. Slugs feed mainly at night.

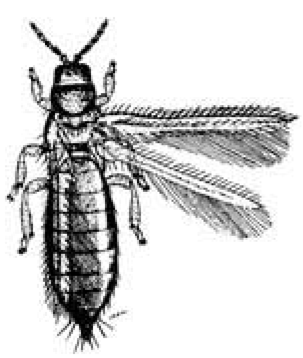
**Cultural Control:** Planting at lower densities, removal of straw mulch after harvest, summer renovation, and delaying fall mulching as long as is practical are effective steps in reducing slug populations. Removal of trash and debris around the field helps to eliminate slug breeding grounds.

**Mechanical Control:** Traps made of wet boards or burlap bags may be set out in the evening; remove and destroy trapped slugs the following morning. Shallow dishes of beer can be used as a bait under the traps. Although trapping can remove many slugs, it may not remove enough to result in significantly less injury to fruit.

**Control by Insecticides:** Slug baits that contain metaldehyde may be used in strawberries only if the baits are applied to the soil or mulch surface and do not contact plants. Baits are most likely to work when used at the full labeled rate. Some growers have tried diatomaceous earth for slug control, but research results are not available to verify the effectiveness of this material.

### Flower Thrips or Eastern Flower Thrips

**(*Frankliniella tritici*; order Thysanoptera, family Thripidae)**



Flower Thrips, Adult

**Damage:** Strawberry fruits can be dull or bronzed, small, and seedy as a result of the flower thrips feeding during bloom and fruit set. Thrips may also cause blemished seeds on achenes, and uneven maturity of fruit. Berries may be marketable if thrips damage is light but unmarketable when damage is severe. In California, a related species called the western flower thrips causes golden brown discoloration of fruit that renders berries unmarketable when populations of thrips are large.

Thrips damage to strawberries was rare until 1994, when problems were reported throughout the midwestern and eastern United States. The strawberry crop failed to develop normally in 1994; berries failed to enlarge or ripen, and remained golden brown and leathery. Some planting had yield reductions of up to 90%. In Illinois, this problem was greatest in the central portion of the state and less severe in the far south and the north. Whether or not the flower thrips caused these dramatic strawberry losses cannot be proved, but many observations now suggest that thrips were to blame. The thrips injury in 1994 probably resulted from an earlier-than-normal immigration of thrips that coincided with strawberry bloom and fruit set in a large portion of the Midwest.

**Appearance:** The flower thrips, which is sometimes called the eastern flower thrips, is a tiny, slender, cigar-shaped insect. Nymphs and adults have the same general shape. Nymphs are wingless, whitish yellow when small, and yellow when fully grown. Adults are yellowish brown, 1/16 inch long, and have narrow wings that are fringed with hairs. While resting, the wings are folded lengthwise over the back.

**Life Cycle and Habits:** The flower thrips is not known to overwinter outdoors in the upper Midwest, but overwintering in greenhouses probably occurs. Populations of flower thrips develop each year as a result of long-distance migrations from southern states on high-level winds associated with weather fronts. Migration of thrips probably occurs simultaneously with migration of the potato leafhopper. Adult flower thrips are attracted to flowers of many different plants. Adults and nymphs feed using rasping-sucking mouthparts to obtain sap. On strawberry fruit, they begin feeding on seeds soon after the buds open. They feed on the tissue between the seeds as the fruit expand. Bronzing results from surface cells being killed. Thrips are often overlooked because they prefer to feed from protected sites, such as under the calyx (cap) and in grooves around seeds, rather than exposed sites. When the population is large, they run out of space in protected sites and thus may be found anywhere on the fruit. They actively run when disturbed. The adults lay eggs in plant tissue. There are two active nymph stages and two inactive pupal-like nymph stages. The life cycle can be completed in several weeks; there can be many generations per year.

**Monitoring and Thresholds:** To determine whether or not thrips control is warranted, strawberry growers should begin sampling for thrips by examining early flower clusters on early varieties, and continue sampling all varieties as they begin to bloom. Tap flowers onto a white or very dark plate or saucer, and look for the slender yellow thrips. As an alternative, flower blossoms can be placed into a zipper-type reclosable plastic bag and shaken to dislodge thrips and allow counting. Although the relationship between eastern flower thrips density and strawberry damage is not well understood, control is probably warranted only if populations exceed 10 thrips per blossom. Once berries are 1/4 inch in diameter, 50 randomly selected fruit should be picked and examined; control is suggested if an average of 0.5 or more thrips per fruit are detected.

Control by Insecticides: **If insecticides are to be used for thrips control, applications must be timed to avoid killing pollinators. Insecticide should be applied prebloom or before 10% of the plants have open blossoms.**

---

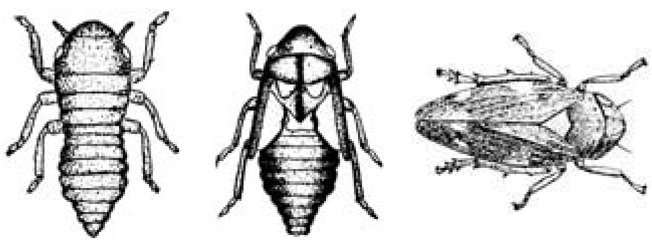
# Chapter 1 Strawberries

---

### Foliage- or Stem-Feeding Pests of Strawberries

**Meadow Spittlebug**

**(*Philaenus spumarius*; order Homoptera, family Cercopidae)**



Meadow Spittlebug

Young Nymph, Older Nymph, Adult

**Damage:** Spittlebugs pierce the plant and suck on sap, which can result in reduced plant vigor, stunting, and decreased yield. Early-season feeding can result in stunted, off-color plants; this damage can appear much like that caused by cyclamen mite. Spittlebugs are not liked by pickers at Pick-Your-Own operations because of the unsightly foam on plants when picking.

**Appearance:** Hidden beneath masses of frothy spittle on stems or leaves are the immature spittlebugs, which are soft-bodied, elongated bugs. Young nymphs are 1/8 inch long and yellow; older nymphs are 1/4 inch long and green. The adults, which are called froghoppers, are brown or gray and 1/4 inch long.

**Life Cycle and Habits:** The meadow spittlebug overwinters as egg masses in the stubble of strawberries and other hosts such as small grains or alfalfa. Eggs hatch at about the time that the earliest strawberry flowers appear. Once nymphs begin feeding, they begin to produce spittle. Spittlebugs feed first at the base of plants, then move up on stems and blossom clusters before and during bloom. They pierce the plant and suck on plant sap.

The nymph stages last for five to eight weeks. Once they reach adulthood, they leave the spittle mass. Female adults lay eggs in September. There is only one generation per year.

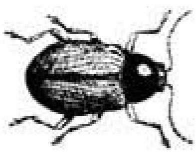
**Threshold:** Complaints most often occur when there is one or more spittle mass per square foot of canopy.

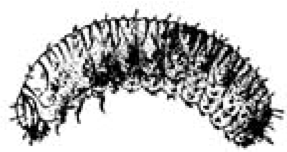
**Cultural Control:** Spittlebugs are most abundant in weedy fields, so weed control can contribute to spittlebug management. Often heavy rains or irrigation can wash froth from plants.

**Control by Insecticides:** Insecticide applications early in the season, such as those targeting the tarnished plant bug, are usually adequate for keeping spittlebugs in check.

### Strawberry Rootworm

**(*Paria fragariae*; order Coleoptera, family Chrysomelidae)**





Strawberry rootworm, adult Strawberry rootworm, larva

**Damage:** Strawberry leaves attacked by strawberry rootworm beetles are riddled with small holes. Some leaf damage occurs in May, but most occurs in August. Heavy infestations can reduce plant growth or kill plants. Although *larvae* of the strawberry rootworm feed on the *roots* of strawberry, *leaf-feeding* by *adult* beetles is more damaging to strawberry production.

**Appearance:** Adult strawberry rootworms are brown to black, shiny, oval-shaped beetles with four blotches on the shell-like wing covers. They are 1/8 inch long. The immatures are grubs that are 1/8 inch long, creamy white, with three pairs of legs.

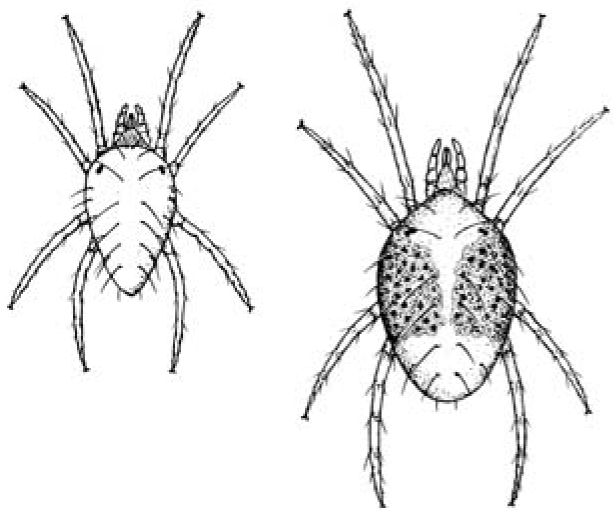
**Life Cycle and Habits:** Adult strawberry rootworms overwinter in mulch and soil crevices, and become active in May and June. Adults feed primarily at night and hide in soil or mulch during the day. They chew small holes in leaves, and females lay eggs on older leaves near the soil surface. Larvae burrow into the ground to feed on strawberry roots from late spring to early summer. New adults begin emerging in mid-summer, and these beetles feed on strawberry foliage through early fall.

**Monitoring:** Scouting for the presence of adult beetles is best done after dark using a flashlight to examine plants. No threshold has been established for this insect, but a population of 10 to 20 beetles per square foot is considered high.

**Control by Insecticides:** As with all the root feeding insects, control of the root feeding stage is very difficult. Therefore, control measures for strawberry rootworm should be directed toward the adult stage. If feeding injury is observed in May or June, an insecticide spray at this time will reduce the number of egg laying females and, therefore, the number of grubs feeding during the summer. When the next generation of adults emerges in July or August, control measures may be needed again. Post-harvest foliar sprays of registered insecticides applied according to label directions provide control of adult strawberry rootworms.

### Two-spotted spider mite

***(Tetranychus urticae*; order Acari, family Tetranychidae)**



Two-Spotted spider mite, male and female

**Damage:** Spider mites feed on plant sap by rasping and sucking on leaf surfaces. This destroys leaf chlorophyll and causes mottling, speckling, or bronzing of foliage. Severely damaged leaves die and drop, which can lead to reduced plant vigor and yield reduction. The undersides of infested leaves can be covered with a fine webbing. Two-spotted spider mites are common pests in Midwestern crops, but infestations in most strawberry fields do not reach densities high enough to require control by pesticides.

**Appearance:** Adult two-spotted spider mites are 1/50-inch long and barely visible to the naked eye. They are yellowish-white with two large dark spots. They have eight legs. Immature forms are usually dark in color.

**Life Cycle and Habits:** Mated adult females overwinter in the cover of vegetation in fields and along roadsides and hedgerows. They begin feeding and laying eggs when temperatures rise in the spring, and many generations develop each season. Adults and immatures feed on the underside of leaves. Although wingless, the adults are highly mobile, as they disperse by "ballooning" in the wind on fine silken threads that they secrete while feeding. Warm, dry weather favors spider mite outbreaks, and problems occur most often in new fields where spider mites are carried in by winds before predatory mites have reached the field or in older plantings where insecticides have eliminated predators.

**Cultural Control:** Annual renovation of strawberry beds reduces the potential for mite outbreaks in the following season, because the destruction of leaf tissue by renovation removes the mites' food and habitat.

**Biological Control:** There is a natural predator called *Neoseiulus (Amblyseius) fallacis* that feeds on two-spotted spider mite. This predator is also a mite that is equally small as two-spotted mites, but is flatter and lacks the two spots on its back; it is teardrop shaped, shiny, and yellowish white. The predatory mites move around on the leaf much more rapidly than the two-spotted mite. It is important to encourage natural enemies of spider mites by reducing the use of pesticides that harm them.

Several companies commercially produce predatory mites, including *N. fallacis*. These predators can be released in strawberry plantings and may provide some control of spider mites, but more research is needed to determine appropriate release rates and timing. See Appendix C for predatory mite suppliers.

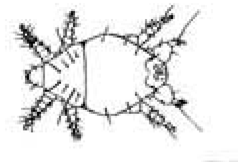
Monitoring and Thresholds: Mite colonies are usually localized in "hot-spots" in the field rather than being evenly distributed throughout the field. Look over the whole field, and choose the first samples in any spots where bronzing is seen on leaves. Collect and examine 60 strawberry leaflets per field. Examine the underside of the leaves for the presence or absence of mites. A magnifier can help. Record the information on a field map so that "hot spots" can be identified and treated. The use of a miticide for control of spider mites is justified if 25% of the leaflets (15 out of 60) are infested by one or more mites. This threshold corresponds to an average infestation of five mites per leaflet during random sampling.

When sampling a field, presence of predatory mites, as well as two-spotted spider mite, should be noted. Where predatory mites such as *N. fallacis* are present, miticide applications usually are unnecessary. A ratio of one predatory mite per ten two-spotted mites is an approximate target for adequate biological control.

Control by Insecticides: Several miticides and combination miticide/insecticides are currently registered for use on strawberries. Most miticides do not kill eggs, so if eggs and motile mites are both present at the time of application, then a second application may be needed five to seven days later to kill motile mites that emerge from eggs.

## Cyclamen mite

**(*Phytonemus pallidus*; order Acari, family Tarsonemidae)**



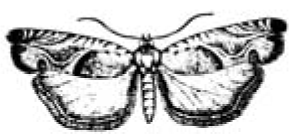
Cyclamen Mite, adult male

Distorted purplish leaves and distorted blossoms and fruits can result from the cyclamen mite feeding on young, unfolding leaves in the crowns of plants and on blossoms. This mite is most common as a pest of greenhouse plants, but it can cause serious losses where infested strawberry plants are transplanted in new fields. It is important to buy nursery stock from a reputable source to avoid bringing in mite-infested plants. The cyclamen mite is tiny; it is only 1/100-inch long, and is not visible without the aid of a magnifying glass. Cyclamen mite varies in color from orange-pink to white or green.

Control of cyclamen mites is best accomplished by planting only transplants that are mite-free, as determined by careful examination as soon as plants arrive from the nursery. This pest is difficult to control by pesticides once it becomes established. If a field infestation is discovered, use a registered pesticide one to two days before bloom and again 10 to 14 days later. Pesticides are not effective at controlling cyclamen mite if application is delayed until mid-summer.

### Strawberry Leafroller

**(*Ancylis comptana fragariae*; order Lepidoptera, family Tortricidae)**



Strawberry leafroller, adult Strawberry leafroller, larva

**Damage:** Strawberry leaflets infested by leafroller are folded and tied together with silken threads. Only the epidermis of each leaf is fed upon, but entire leaflets usually turn brown. Damage by first-generation larvae occurs in late May and June. Damage by second-generation larvae occurs in late July and August.

Other leafroller species that can cause similar damage in strawberries are the variegated leafroller (*Platynota flavedana*), the oblique-banded leafroller (*Choristoneura rosaceana*), and the blueberry leafroller (*Sparganothis sulfureana*).

**Appearance:** Strawberry leafroller larvae change from pale green when young to grayish brown when fully grown. Larvae are approximately 1/2-inch long when fully grown. The adult stage of strawberry leafroller is a reddish brown moth, with distinctive yellow markings on the forewings. The wingspan is approximately 1/2-inch.

**Life Cycle and Habits:** Strawberry leafrollers overwinter as fully grown larvae or pupae in folded leaves or leaf litter. Adult moths emerge in April and May and deposit translucent eggs, usually on the lower surface of strawberry leaves. Eggs hatch in one to two weeks. As larvae feed on leaves, they secrete silken threads to fold and tie leaves around them. They pupate for about one week inside the folded leaves. The strawberry leafroller undergoes two or three generations each year. Moths of the summer generations are often present from July through September. Infestations may develop in spring and early summer, but they may also build up after harvest. Natural enemies of strawberry leafroller include two parasitoid wasp species that often kill a high percentage of larvae, especially during summer generations.

**Threshold:** Low levels of leafroller infestation do not warrant control because they do not cause reductions in plant vigor or yield during the current or subsequent season. The definition of low-level infestation has not been defined, but 10 to 20% of strawberry leaflets, especially after harvest, is a reasonable estimate.

**Mechanical Control:** If an infestation is detected at an early stage, rolled leaves can be removed and destroyed.

**Control with Insecticides:** Where control is necessary, several registered insecticides are effective. Products that contain Bacillus thuringiensis (BT) can provide effective control if spray coverage is good and applications are made when many larvae are young and have not yet webbed leaves together fully. For BT products to work, sprays must reach the leaf surfaces where larvae are feeding.

## Strawberry Aphid

**(*Chaetosiphon fragaefolii*; order Homoptera, family Aphididae)**

Aphids cause damage primarily by transmitting viruses from infected to non-infected plants. When present in great numbers, aphid feeding can result in stunted, malformed plants. Aphids occur on new shoots, undersides of leaves, and on buds while they are still in crowns. There are several species of aphids that infest strawberries; all are small (1/16 inch long), soft-bodied insects. Both wingless and winged forms of aphids can be found. Viruses are best managed by using virus-tolerant varieties, planting certified virus-free plants, and eliminating wild strawberries from the area.

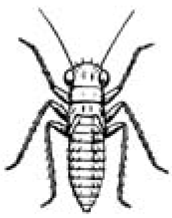
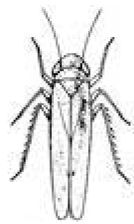
## Strawberry Whitefly

**(*Trialeurodes packardi*; order Homoptera, family Aleyrodidae)**

Strawberry plants infested with whiteflies may show a large number of tiny white adults that move actively when plants are shaken, or they may show a large number of immobile scale-like immatures on the underside of leaves. Both immatures and adults suck on plant sap. They produce honeydew, a sticky substance that drips onto plants and serves as a substrate for growth of black sooty mold. They overwinter as eggs on the underside of leaves.

### Potato Leafhopper

**(*Empoasca fabae*; order Homoptera, family Cicadellidae)**

Potato Leafhopper, nymph Potato Leafhopper, adult

Leafhoppers feed primarily on the underside of strawberry leaves, causing them to yellow between the veins and become curled and distorted. Feeding activity is most serious during the late spring and early summer. Leafhoppers are 1/8 inch long, green, bullet-shaped insects that take flight quickly if disturbed.

The nymphs are light green and do not fly. Nymphs are easily identified by their habit of moving sideways when disturbed. Insecticides should be applied only when large populations of nymphs are noted on the leaves or symptoms become apparent.

---

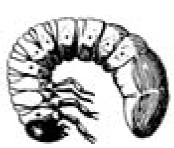
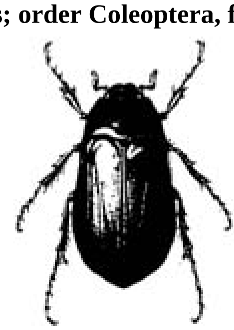
# Chapter 1 Strawberries

---

## Root- or Crown-Feeding Pests of Strawberries

### White Grubs

**(*Phyllophaga* species; order Coleoptera, family Scarabaeidae)**

White Grub, larva White Grub, adult

**Damage:** White grub larvae feed on crop roots. Root injury weakens the plant dramatically and also provides an entry site for root diseases like black root rot. Risk of white grub infestation is highest in new plantings established on newly plowed sod or other grasses. As adults, the beetles feed on leaves in late summer, which results in skeletonized leaves.

**Appearance:** Adults are called May beetles or June beetles. They range in length from 1/2 to 1 inch and vary in color from tan to dark brown, and are shiny. C-shaped larvae are whitish gray with brown heads and three pairs of legs; they are 1/2 to 1 1/2 inches long. White grub species in the genus *Phyllophaga* are known as "perennial" white grubs or "true" white grubs. Other beetle species that have similar grubs are Japanese beetle (*Popilla japonica*), rose chafer (*Macrodactylus subspinous*), and green June beetle (*Cotinis nitida*); these are described in the chapter on brambles.

**Life Cycle and Habits:** Females deposit eggs in soil during late spring or early summer; they especially prefer grass sod near wooded areas for egg-laying. Eggs hatch in two to three weeks. Newly-hatched larvae feed on crop roots throughout the summer, then burrow deep in the soil to overwinter. The following year they again migrate to the root zone to feed. These larger larvae cause much greater damage than they did the year before. After overwintering again well below the soil surface, white grubs pupate early in the following summer, and adults emerge from pupal cells in the spring three years after the cycle began. Adult beetles hide in soil during the day and fly to trees to feed at night.

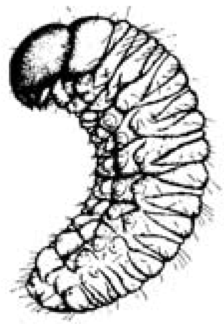
**Cultural Control:** Do not put new strawberry plantings on newly turned ground that was used for sod, pasture, or grass set-aside the previous year. On such sites, plow the field and let it lie fallow or in a rotational cover crop such as sudan grass, or buckwheat, or a salable crop such as pumpkins or squash, for at least one season prior to planting with strawberries. Avoid setting a strawberry field next to large grassy fields that could be a source of these beetles and their larvae.

**Control by Microbial Insecticides:** Milky spore is a bacterial disease that kills grubs; it is commercially available as a product that is incorporated into the ground. Several formulations are on the market. Once this kind of bacteria is established in the soil, grub control is perennial and effective. There has been difficulty in getting the bacteria established in northern soils; milky spore cannot be considered a reliable control measure until this problem is overcome.

**Control by Conventional Insecticides:** An insecticide labelled for grub control can be banded over the row to reduce the amount and cost of insecticide treatment.

### Strawberry Root Weevil

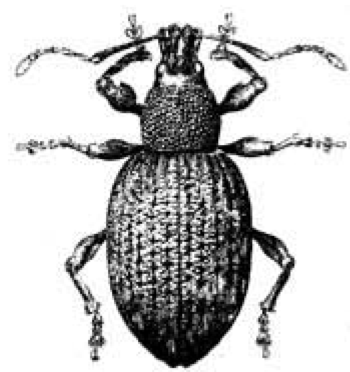
**(*Otiorhynchus ovatus*; order Coleoptera, family Curculionidae).**



Strawberry Root Weevil, larva

Strawberry Roow Weevil, adult

Rough Strawberry Root Weevil



Black Vine Weevil

**Damage:** The larvae of root weevils feed on strawberry roots and crowns, which can weaken, stunt, or kill plants. Root systems weakened by weevils are then more susceptible to winter injury and disease infection. Infested plants can have leaves that turn red, and berries that are undersized. Infestations are generally in patches in the field. Damage is worse when plants are under stress such as during droughty periods. Although the adult weevils chew notches from the edges of leaves, their feeding usually causes no economic losses.

**Appearance:** Adult strawberry root weevils are black or dark brown beetles that are about 1/5-inch long. They have a promiment blunt snout and elbowed antennae on the snout. Their backs are marked by many rows of small pits. Larvae are thick-bodied, white, legless grubs with brown heads; they are usually found in a curved position. Larvae reach about 1/4-inch in length.

Two other species of weevils similar to the strawberry root weevil are the black vine weevil (*Otiorhynchus sulcatus*) and the rough strawberry weevil (*Otiorhynchus rugosostriatus*). These two species are similar in appearance to the strawberry root weevil except that they are larger: 1/4 inch for rough strawberry weevil, and 1/3 inch for black vine weevil. They are also similar to the strawberry root weevil in damage and life cycle.

**Life Cycle and Habits:** The strawberry root weevil overwinters as a full-grown larva, pupa, or adult in soil, or as an adult in plant debris or other protective habitat. Larvae and pupae complete development in the spring, and emerge as adults in May or June; overwintered adults become active in strawberries in May. The adult strawberry root weevil cannot fly. Adults feed on leaves at night. Root weevil adults lay eggs in strawberry fields throughout thesummer, with each female depositing 150 to 200 eggs in the soil. Eggs hatch in about ten days. Larvae burrow through the soil to feed on roots until they mature or until cold temperatures suspend their activity.

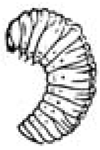
**Cultural Control:** New plantings should be isolated from existing fields and wooded overwintering sites, because flightless adults do not travel far. Infested old plantings should be plowed under to destroy grubs before new beds are plants.

**Monitoring:** Plants should be examined in the spring if patches of poor vigor are noticed. Lift up a section of row with a spade and examine the roots within a 6-inch layer of soil. If grubs are found, control measures should be taken after harvest, when the adults emerge. In mid- and late summer, look every one to two weeks for notch-like feeding damage on leaves.

**Control by Insecticides:** Sprays directed to adults are not usually very effective. In some States, carbofuran (Furadan 4F) use is permitted after harvest under a special local needs (SLN) label, also called a 24(c) label, for control of root weevil larvae. Check with your state's Department of Agriculture to find out if your state has such a SLN label.

### Strawberry Crown Borer

**(*Tyloderma fragariae*; order Coleoptera, family Curculionidae)**



Strawberry Crown Borer, Larva  Strawberrry Crown Borer, Adult

**Damage:** Strawberry plants are weakened, stunted, or killed as one or more larvae bore downward in the crown. Field borders or the portions of fields nearest older, infested plantings are often most heavily damaged. Infestations spread slowly. Leaves of infested plants might turn red. The adult beetles chew many small round holes in leaves in the fall, but this defoliation rarely is economically damaging.

**Appearance:** Adult crown borers are reddish-brown weevils about 1/6-inch long. They have a short thick snout. Their backs are marked with three pairs of dark spots. The larva is a yellowish, legless grub, about 1/5 inch long when fully grown.

**Life Cycle and Habits:** Adults overwinter in plant debris in strawberry fields or in surrounding areas. They become active in the spring at about the same time that strawberries begin to bloom. They feed in crowns, opening holes into which they lay eggs that hatch in about one week. Egg-laying continues through mid June. Eggs hatch into grubs that feed for several weeks in strawberry crowns before pupating in late summer and emerging as adults in the fall. Adults are unable to fly; they feed on strawberry foliage, and then seek shelter in plant debris to pass the winter.

**Cultural Control:** Isolating new fields from existing infestations greatly reduces the likelihood that this insect will cause significant losses, because adult strawberry crown borers cannot fly. Commercial growers should purchase plants that are free of crown borer and establish new fields at least 300 yards from existing fields. To prevent crown borer survival and migration, infested fields should be destroyed and tilled soon after the final picking.

**Control by Insecticides:** Although chemical control is rarely advised, some insecticides applied to control other insects may kill crown borers as well. Prebloom sprays intended to limit damage by tarnished plant bug can kill some crown borer adults, but peak adult activity occurs slightly later. Egg-laying adults are especially active during bloom, a time period when insecticides should not be applied. Insecticide applied between bloom and harvest for the control of leafroller or sap beetle may also kill crown borer adults if they are still active on foliage, but killing adults at this time is unlikely to significantly reduce crown damage. Postharvest sprays may be used to reduce the population of newly emerged adults in late summer before they overwinter, but this practice is seldom warranted.

# Chapter 1 Strawberries

---

## Summary of Strawberry Insect Pest Management Procedures

I. Cultural controls when establishing a new planting

A. site selection:

1. do not put in after sod or grasses to avoid problems with white grubs.
2. avoid putting near woods or fencerows to avoid problems with clipper weevils.
3. do not put near old plantings if root weevils or crown borers were present.

B. variety selection: avoid varieties highly susceptible to tarnished plant bug injury.
C. source of nursery stock: get plants that are free of cyclamen mite.
D. plant density and row spacing: wide plant spacing will contribute to slug management.

II. Cultural controls while maintaining a planting

A. weed control: contributes to tarnished plant bug and spittlebug management.
B. harvest: prompt removal of all ripe and cull berries helps sap beetle management.
C. mulch: remove mulch after harvest and delay mulching in fall to discourage slugs.
D. renovation: helps with slug and mite management.
E. sanitation: remove debris that may shelter pests, in and around fields.

III. Mechanical control options

A. bait buckets during harvest for sap beetles.
B. traps for slugs.
C. row covers to exclude tarnished plant bug.

IV. Scouting for pests

A. pre-bloom (once per week)

1. 1. strawberry clipper: examine plants for clipped buds.
2. two-spotted spider mite and predatory mites: examine leaflets.
3. tarnished plant bug, adults: sweep-net sampling.

B. during bloom (once per week)

4. flower thrips: shake flowers in plastic bag.
5. tarnished plant bug, nymphs: shake flowers over dish.
6. spittlebug: examine plant stems.

C. post-harvest (once every two weeks)

7. two-spotted spider mite and predatory mites: examine leaflets.
8. strawberry rootworm beetles: examine leaflets.
9. miscellaneous pests: leafrollers, leafhoppers, whiteflies, aphids, root weevils.

---

# Chapter 2

# Brambles (Raspberries and Blackberries)

# General

The success of a bramble planting is highly dependent upon its location. The site should have full exposure to sunlight and good air circulation. It should also be somewhat protected, however, from cold winter wind, since brambles are quite susceptible to winter injury. Temperatures below -20 degrees F will injure most fruit buds above the snow line. Colder temperatures, especially if no snow cover is present, can kill canes to the ground or damage roots, causing plants to die in the early summer when not enough water can be taken in to support them.

The soil should be well-drained; brambles simply will not tolerate "wet feet." Wet soils encourage the spread of Phytophthora root rot which will destroy brambles. Brambles should be planted on raised beds that are approximately 8 inches high and 4 feet wide. The soil should have 2 to 4 percent organic matter. Incorporate animal manure or green manures into the soil one to two years before planting. If additional organic matter is necessary apply composted animal manure or composted yard waste to the raised bed and incorporate the material into the upper 2 to 3 inches of soil several months before planting. If there are areas of standing water after a heavy rain or poor internal drainage (percolation) then drain tile is necessary. Place lateral lines 20 to 25 feet apart according to soil conservation district recommendations.

Do not plant brambles where potatoes, tomatoes, or eggplant have recently been grown as these crops carry Verticillium, another root rot fungus which can infect brambles. Avoid planting brambles near any wild brambles. Wild raspberries and blackberries harbor insects and virus diseases which will spread to cultivated plants. If possible, destroy all wild brambles within 600 feet of your planting.

Always obtain raspberry plants from a reputable nursery which certifies their plants to be virus-free. Raspberries are best planted in early spring. Plant your rows at least 8 feet apart, preferably 10 to 12 feet apart to ensure adequate air circulation, as well as room for harvesting and pruning operations.

Take a soil sample one to two years before planting and adjust the pH, phosphorus, potassium, minor elements, and organic matter as recommended. A pH of 6.0 to 6.5, 25 to 40 pounds available phosphorus, 280 to 320 pounds of potassium (K), and 2 to 4 percent organic matter are good to excellent levels of elements. Nitrogen (N) should be the only element required for the first three years if the soil contains adequate nutrients as described. Broadcast 20 to 30 pounds of actual nitrogen per acre one to two weeks after planting using a low nitrogen fertilizer such as calcium nitrate or ammonium sulfate to reduce plant injury. If necessary 10-10-10 can also be used successfully. Use low rates on silt loam or heavy soils and higher rates on light soils. Split applications of one half of the above on light soils 4 to 6 weeks apart can be helpful. Do not apply high rates of granular fertilizer after late June or winter injury can be increased. If vigorous nursery matured tissue cultured plants and compost is incorporated, a low rate of nitrogen should be used. When using injected fertilizers in microirrigation systems, use one half the rates suggested. Stop fertilizer injection in late July but continue to irrigate (water only) until mid-September if dry weather continues. Where rainfall equals or exceeds daily evaporation in August and September, irrigation should end in mid-August. Broadcast 40 to 70 pounds of actual N in the second year and later years based on vigor of the current years' fruiting canes height and diameter. Red raspberries can be seven feet high for optimal production.

Thornless blackberries may require less fertilizer. At planting broadcast 20 lbs/acre of actual nitrogen, 7 to 10 days after planting. Use a low analysis nitrogen fertilizer or 10-10-10 to avoid plant damage. For bearing thornless blackberry plants, broadcast 25 to 40 lbs/acre of actual nitrogen in late April. Use low rates on vigorous plants growing on silt loam soils with high organic matter. Split applications are suggested with 50% in late April and the remainder in mid-May to early June but before bloom.

New recommendations for raspberries, blueberries, and blackberries have suggested rates per 100 linear feet of row (Table 2.1). As the drive row distance decreases the amount of linear feet per acre increases.

Thus, higher amounts of nitrogen may be required for narrow rows. In most raspberry, blueberry, or blackberry plantings, distance between rows can be 14, 12, or 10 feet. If an acre is 215 ft (long) by 200 ft (width), then the following broadcast rates per 100 ft of row apply. If you are banding fertilizer or using microirrigation (fertigation) use 1/2 of these rates.

**Table 2.1. Pounds of nitrogen per 100 linear feet of row[z]**

| **Actual Nitrogen/acre** | **Width between rows** | | |
|---|---|---|---|
| | **14 ft** | **12 ft** | **10 ft** |
| | | | |
| 10 | 0.34 | 0.30 | 0.24 |
| 20 | 0.68 | 0.59 | 0.48 |
| 30 | 1.0 | 0.90 | 0.71 |
| 40 | 1.4 | 1.2 | 0.95 |
| 50 | 1.7 | 1.5 | 1.20 |
| 60 | 2.0 | 1.8 | 1.4 |
| 70 | 2.4 | 2.1 | 1.7 |
| 80 | 2.7 | 2.4 | 1.9 |
| z When using 33% nitrogen multiply amount by 3 to give total amount per year. | | | |
| When using 20% nitrogen multiply amount by 5 to give total amount per year. | | | |

There are 2940, 3360, and 4200 linear feet of rows, respectively if rows are spaced 14, 12, or 10 feet apart. There are 13% and 30% more linear feet in a 12 ft or 10 ft row width, respectively, than a 14 ft width. You may wish to adjust the amount of actual nitrogen by these amounts. All brambles will require less fertilizer with high soil fertility, high organic matter and microirrigation. Injected nutrients from May to mid-June can use one fourth or less actual N and K as $KNO_3$ (potassium nitrate) when a one half rate granular fertilizer is applied in late March. Take leaf and soil samples during July and late August during the production years to monitor your fertilizer programs. When berries are soft or do not ship well or have fungus problems, high nitrogen may be the cause. Review spray programs and fertilizer rates and adjust both to your conditions.

Proper pruning is a crucial part of pest management for raspberries. Remove old, second-year canes in the fall and also thin out weak, spindly, first-year canes. In the early spring, thin out the remaining canes, leaving only those with good height, large cane diameters, and no symptoms of winter injury, insect or disease damage. Everbearing cultivars (e.g., Heritage) may be completely mowed down each year in March as a pruning practice.

Plant rows for red or yellow raspberries should be narrowed to a width of 2 feet or less. When finished, there should be no more than 3 or 4 canes per square foot of row remaining. Canes, which have been cut, should be removed from the planting and destroyed. Pruning in this manner will greatly reduce the incidence of most raspberry cane diseases by increasing air circulation and reducing disease inoculum. Check with your Extension office for local bramble cultivar and cultural recommendations.

**Integrated Management of Bramble Diseases**

An integrated disease management program for controlling raspberry and blackberry diseases integrates the use of all available control methods into one program. The use of fungicides for control of several important diseases can be a major part of the overall disease management program, but the use of various cultural practices is perhaps even more important in obtaining effective disease control. Furthermore, many important bramble diseases cannot be controlled by fungicides, thus their control is almost completely dependent upon the use of cultural practices (Table 2.2). An effective disease management program for brambles must emphasize the integrated use of specific cultural practices, knowledge of the pathogen and disease biology, disease resistant cultivars, and timely applications of fungicides, when needed.

Fungicides can play an important role in the disease management program; however, increasing emphasis is being placed on minimizing the overall use of fungicides, while maximizing their benefits. Thus, the objective of the disease management program is to provide a commercially acceptable level of disease control on a consistent (year-to-year) basis, with minimal fungicide use.

**Table 2.2. Bramble disease control strategies.**

| Disease control considerations | Virusesa | Verticillium wilt | Orange rust | Cane blights [b] | Powdery mildew | Fruit rot |
|---|---|---|---|---|---|---|
| Good air/water drainage | - | - | - | ++ | + | ++ |
| 500+ ft from brambles | ++ | - | - | - | - | - |
| Rotation | +[c] | **[d] | - | + | - | - |
| Fumigation for fungi | - | + | - | - | - | - |
| Fumigation for nematodes | +c | - | - | - | - | - |
| Cultivar tolerance/resistance | ++[e] | ++[f] | ++[g] | - | + | - |
| Avoid adjacent plantings | ++[j] | - | - | - | + | - |
| Eliminate wild brambles | ++ | - | ++ | - | + | - |
| Disease-free stock | ++ | ++ | ++ | ++ | + | - |
| Aphid control (vectors) | ++ | - | - | - | - | - |
| Rogue infected plants | ++ | - | ++ | - | - | - |
| Speed drying (weeds, pruning) | - | - | + | ++ | - | ++ |
| Prune 3 days before rain | - | - | - | ++ | - | - |
| Dispose of pruned canes | - | + | + | ++ | - | - |
| Maintain plant vigor | - | - | - | ++ | - | - |
| Fungicide sprays | - | - | - | ++[h] | ++[i] | ++ |
| Harvest before overripe | - | - | - | - | - | ++ |
| Fruit storage conditions | - | - | - | - | - | ++ |

| |
|---|
| Key: ++ = most important controls; + = helpful controls; - = no effect. |
| a Viruses: Mosaic (rasp.), Leaf Curl (raspberry, with blackberry symptomless), Ringspot (red raspberry), and Streak (purple and black raspberry). |
| b Cane blights: anthracnose, cane blight, spur blight, and Botrytis blight. |
| c Rotation effective for ringspot virus only; 2 years of grass crop (e.g. corn) with excellent weed control before planting red raspberry should eliminate need to fumigate for Xiphinema, a nematode vector. |
| d Rotation for Verticillium wilt: Avoid fields planted to susceptible crops (tomatoes, potatoes, eggplant, peppers, strawberries, raspberries, stone fruit) within the past 5 years. Avoid fields with history of Verticillium wilt unless soil is fumigated. |
| e Virus resistance, tolerance, and immunity: Mosaic-Blackberries are not affected; black and purple raspberries are more severely affected than red raspberries. Of purple and black raspberries, 'New Logan', 'Bristol', and 'Black Hawk' are tolerant; 'Cumberland' is susceptible. Of red raspberries, 'Milton', 'September', 'Canby', and 'Indian Summer' are "resistant" because aphid vectors avoid them. Leaf Curl-Blackberries are symptomless; all raspberries are affected. Tomato Ringspot-Red raspberries are affected. Streak - Black and purple raspberries are affected. |
| f Verticillium tolerance: Most blackberries are resistant; red raspberries are more tolerant than black raspberries. 'Cuthbert' and 'Syracuse' red raspberries appear to be resistant under field conditions. |
| g Orange Rust resistance: Red raspberries are immune. Other brambles are affected. Of blackberries, 'Eldorado', 'Raven', 'Snyder', 'Ebony King', 'Choctaw', 'Commanche', 'Cherokee', and 'Cheyenne' are reported resistant. |
| h Fungicide program for cane blights: The lime-sulfur spray (delayed dormant) is most important for anthracnose and cane blight. |
| i Fungicide program for powdery mildew: Benlate can be used at early bloom, full bloom, and up to 3 more times at 14-day intervals. |
| j Keep blacks and purples away from reds because mosaic virus can spread from reds and is more severe on blacks and purples; Keep all reds away from blackberries because blackberries can be a symptomless carrier of leaf curl virus. |
| k Fungicide program for Botrytis fruit rot (gray mold): Benlate, Ronilan, and Rovral are all registered. See comments under fungicides for bramble disease control, and refer to spray guide. |
| Source: Pennsylvania State University, Small Fruit Production and Pest Management Guide. Used by permission. |

---

**Acknowledgments**

We extend grateful appreciation to the following persons who have contributed their talent to this publication:

**David E. Scardena**
OSU, Editor, Communications and Technology

**Jane Hoffelt/Pageworks**
Graphic Designer

**Shirley M. Funt**
OSU Continuing Education Assistant

**Additional Copies**

Additional copies of this handbook, either soft or hard bound, can be purchased from your land grant university listed in the front. If you live outside of the Midwest region you may write or call Extension Publications 385, Kottman Hall, 2021 Coffey Rd., Columbus, Ohio 43210-1044. 614/292-1607.

**Trade Names**

The use of trade names, suppliers, or other private labels are used for identification. No product endorsement is implied nor is discrimination intended toward similar products or materials not mentioned or listed. Extension and the participating universities make no warranty or guidance of any kind, expressed or implied, concerning the use of these products.

---

# Chapter 2 Brambles (Raspberries and Blackberries)

---

## Integrated Management of Bramble Diseases

An integrated disease management program for controlling raspberry and blackberry diseases integrates the use of all available control methods into one program. The use of fungicides for control of several important diseases can be a major part of the overall disease management program, but the use of various cultural practices is perhaps even more important in obtaining effective disease control. Furthermore, many important bramble diseases cannot be controlled by fungicides, thus their control is almost completely dependent upon the use of cultural practices (Table 2.2). An effective disease management program for brambles must emphasize the integrated use of specific cultural practices, knowledge of the pathogen and disease biology, disease resistant cultivars, and timely applications of fungicides, when needed.

Fungicides can play an important role in the disease management program; however, increasing emphasis is being placed on minimizing the overall use of fungicides, while maximizing their benefits. Thus, the objective of the disease management program is to provide a commercially acceptable level of disease control on a consistent (year-to-year) basis, with minimal fungicide use.

**Table 2.2. Bramble disease control strategies.**

| Disease control considerations | Virusesa | Verticillium wilt | Orange rust | Cane blights [b] | Powdery mildew | Fruit rot |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| Good air/water drainage | - | - | - | ++ | + | ++ |
| 500+ ft from brambles | ++ | - | - | - | - | - |
| Rotation | +[c] | **[d] | - | + | - | - |
| Fumigation for fungi | - | + | - | - | - | - |
| Fumigation for nematodes | +c | - | - | - | - | - |
| Cultivar tolerance/resistance | ++[e] | ++[f] | ++[g] | - | + | - |
| Avoid adjacent plantings | ++[j] | - | - | - | + | - |
| Eliminate wild brambles | ++ | - | ++ | - | + | - |
| Disease-free stock | ++ | ++ | ++ | ++ | + | - |
| Aphid control (vectors) | ++ | - | - | - | - | - |
| Rogue infected plants | ++ | - | ++ | - | - | - |
| Speed drying (weeds, pruning) | - | - | + | ++ | - | ++ |
| Prune 3 days before rain | - | - | - | ++ | - | - |
| Dispose of pruned canes | - | + | + | ++ | - | - |
| Maintain plant vigor | - | - | - | ++ | - | - |
| Fungicide sprays | - | - | - | ++[h] | ++[i] | ++ |
| Harvest before overripe | - | - | - | - | - | ++ |
| Fruit storage conditions | - | - | - | - | - | ++ |
| | | | | | | |

Key: ++ = most important controls; + = helpful controls; - = no effect.

a Viruses: Mosaic (rasp.), Leaf Curl (raspberry, with blackberry symptomless), Ringspot (red raspberry), and Streak (purple and black raspberry).

b Cane blights: anthracnose, cane blight, spur blight, and Botrytis blight.

c Rotation effective for ringspot virus only; 2 years of grass crop (e.g. corn) with excellent weed control before planting red raspberry should eliminate need to fumigate for Xiphinema, a nematode vector.

d Rotation for Verticillium wilt: Avoid fields planted to susceptible crops (tomatoes, potatoes, eggplant, peppers, strawberries, raspberries, stone fruit) within the past 5 years.

| |
|---|
| Avoid fields with history of Verticillium wilt unless soil is fumigated. |
| e Virus resistance, tolerance, and immunity: Mosaic-Blackberries are not affected; black and purple raspberries are more severely affected than red raspberries. Of purple and black raspberries, 'New Logan', 'Bristol', and 'Black Hawk' are tolerant; 'Cumberland' is susceptible. Of red raspberries, 'Milton', 'September', 'Canby', and 'Indian Summer' are "resistant" because aphid vectors avoid them. Leaf Curl-Blackberries are symptomless; all raspberries are affected. Tomato Ringspot-Red raspberries are affected. Streak - Black and purple raspberries are affected. |
| f Verticillium tolerance: Most blackberries are resistant; red raspberries are more tolerant than black raspberries. 'Cuthbert' and 'Syracuse' red raspberries appear to be resistant under field conditions. |
| g Orange Rust resistance: Red raspberries are immune. Other brambles are affected. Of blackberries, 'Eldorado', 'Raven', 'Snyder', 'Ebony King', 'Choctaw', 'Commanche', 'Cherokee', and 'Cheyenne' are reported resistant. |
| h Fungicide program for cane blights: The lime-sulfur spray (delayed dormant) is most important for anthracnose and cane blight. |
| i Fungicide program for powdery mildew: Benlate can be used at early bloom, full bloom, and up to 3 more times at 14-day intervals. |
| j Keep blacks and purples away from reds because mosaic virus can spread from reds and is more severe on blacks and purples; Keep all reds away from blackberries because blackberries can be a symptomless carrier of leaf curl virus. |
| k Fungicide program for Botrytis fruit rot (gray mold): Benlate, Ronilan, and Rovral are all registered. See comments under fungicides for bramble disease control, and refer to spray guide. |
| Source: Pennsylvania State University, Small Fruit Production and Pest Management Guide. Used by permission. |

---

# Chapter 2 Brambles (Raspberries and Blackberries)

---

### Identifying and Understanding the Major Bramble Diseases

It is important for growers to be able to recognize the major bramble diseases. Proper disease identification is critical to making the correct disease management decisions. In addition, growers should develop a basic understanding of pathogen biology and disease cycles for the major bramble diseases. The more you know about the disease, the better equipped you will be to make sound and effective management decisions.

The following literature contains color photographs of disease symptoms on brambles as well as in-depth information on pathogen biology and disease development. These publications also contain excellent color photographs and information about insect pests as well.

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

***Bramble Production Guide***--This is a very comprehensive book covering most phases of bramble production. It can be purchased from: Northeast Regional Agricultural Engineering Service, 152 Riley-Robb Hall, Cooperative Extension, Ithaca, NY 14853. Phone: 607-255-7654.

***Brambles: Production, Management and Marketing***--Bulletin 783 of Ohio State University Extension, can be obtained from Ohio State University Extension Publications Office, 385 Kottman Hall, 2021 Coffey Rd., Columbus, OH 43210-1044. Phone 614-292-1607.

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

---

# Chapter 2 Brambles (Raspberries and Blackberries)

## Cane and Leaf Diseases

### Anthracnose

Anthracnose is caused by the fungus *Elsinoe veneta*. One of the most common and widespread diseases of brambles in the United States, anthracnose can infect red and black raspberries, blackberries, dewberries, and loganberries. The disease is very destructive on black and purple raspberries. On red raspberries, it can be common but is usually not a serious problem. Disease losses can occur from defoliation, general stunting and a decrease in cane vigor, reduction in fruit yield and quality, and cane death.

#### Symptoms

Anthracnose can cause symptoms on canes, leaves, fruit and stems of berry clusters. The most striking symptoms are on canes. A few days after the fungus invades the succulent tissue of young canes, minute purplish spots appear. These spots enlarge in diameter and become oval or lens-shaped. The centers become somewhat sunken and are pale-buff to an ash-gray color. Margins are somewhat raised and purple to purple-brown. If numerous, the lesions may merge and cover large portions of the cane. Diseased tissue extends down into the bark, partly girdling the cane. As the canes dry in late summer and early fall, diseased tissue often cracks. In the following year, fruit produced on severely diseased canes may fail to develop to normal size and may shrivel and dry, especially in a dry growing season.

On leaves, anthracnose appears on the upper surface in early- to midsummer as irregular, yellowish-white spots about 1/16 inch in diameter. The spots gradually enlarge and develop a reddish-purple margin around a light-gray center. The centers of these spots may drop out, producing a "shot hole" effect. This "shot hole" symptom is more common on trailing blackberries and raspberries. On blackberries, leaf spots may merge together producing large grayish dead areas between the veins. Anthracnose does not usually cause much damage to leaves of erect blackberries.

#### Disease Development

The anthracnose fungus overwinters in the bark or within lesions on infected canes (Figure 5). In early spring the fungus produces two types of microscopic spores called conidia and ascospores. Conidia, which are produced in small fungal fruiting structures called acervuli, are the most common form of inoculum. Ascospores are comparatively rare. Production of these spores coincides with the leafing out of brambles in early spring. Spores are rain-splashed, blown, or carried by insects to young, succulent, rapidly growing plant parts that are susceptible to infection. The spores germinate in a film of water and penetrate into the plant tissue. Symptoms appear about a week later. Small pimple-like reproductive bodies are produced within lesions on infected canes and the fungus overwinters there. These bodies produce conidia for new infections the next spring, completing the disease cycle. As canes age and harden, they become much less susceptible.

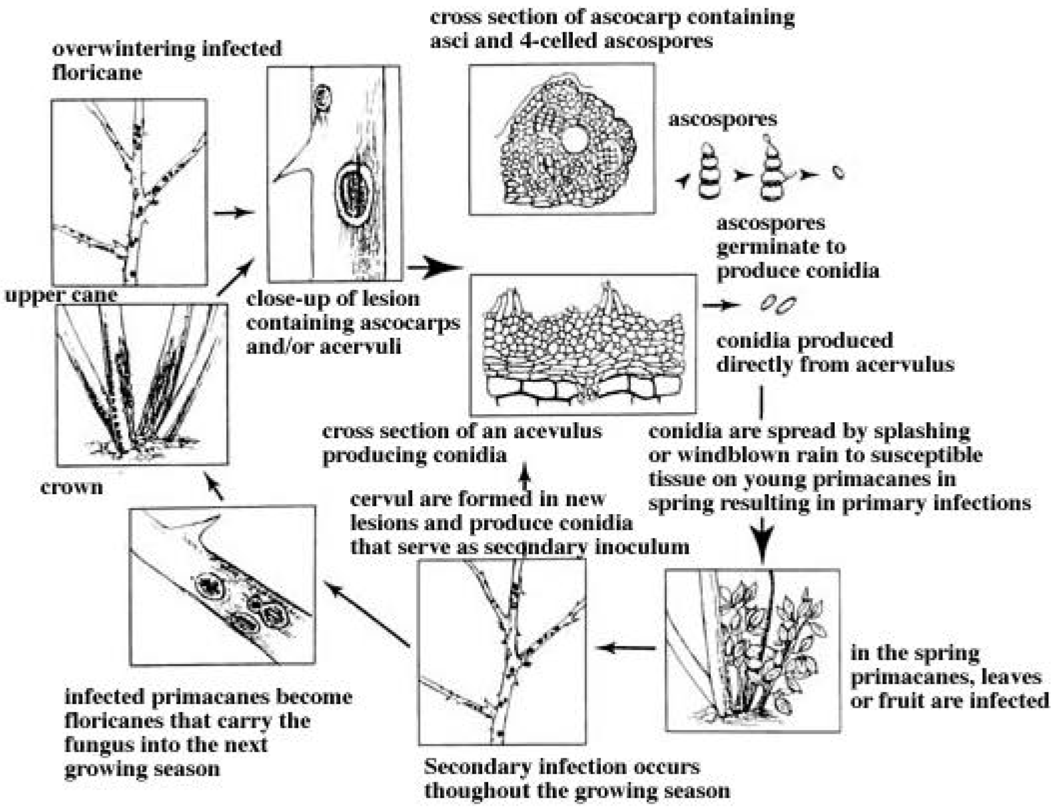



Figure 5. Disease cycle of Raspberry Anthracnose. Taken from the Compendium of Raspberry and Balckberry Diseases and Insects of the American Phytopathological Society. Used with permission.

## Cane Blight

Cane blight is caused by the fungus Leptosphaeria coniothyrium. Cane blight is one of the more damaging diseases of raspberries. The disease is most common on black raspberries, but also occurs on red and purple cultivars. Cane blight occasionally occurs on blackberries and dewberries. Cane blight can result in wilt and death of lateral shoots, a general weakening of the cane, and reduced yield. It is usually most severe during wet seasons.

#### Symptoms

Dark brown to purplish cankers form on new canes near the end of the season where pruning, insect, and other wounds are present. The cankers enlarge and extend down the cane or encircle it, causing lateral shoots to wilt and eventually die. On second-year canes, the side branches may suddenly wilt and die, usually between blossoming and fruit ripening. On close examination, dark brown or purplish cankers can be observed on the main cane or branches below the wilted area. Infected canes commonly become cracked and brittle and break easily. Tiny black specks (pycnidia), which are reproductive bodies of the cane blight fungus, develop in the brown cankered bark. In wet weather, large numbers of microscopic spores (conidia) ooze out of the pycnidia. This ooze gives the bark a dark-gray, smudgy appearance.

#### Disease Development

The pathogen survives over winter on infected or dead canes (Figure 6). The following spring, conidia, formed in the pycnidia, ooze from them during wet periods, and are blown, splashed by rain, and carried by insects to nearby canes. Under moist conditions, the spores germinate and penetrate into the plant through pruning wounds, insect punctures, fruit stem breaks, and other wounds. After entry, the fungus rapidly invades and kills bark and other cane tissues. Pycnidia are formed in older cankers and complete the disease cycle. Dead canes can continue to produce conidia and remain a source of infection for several years.

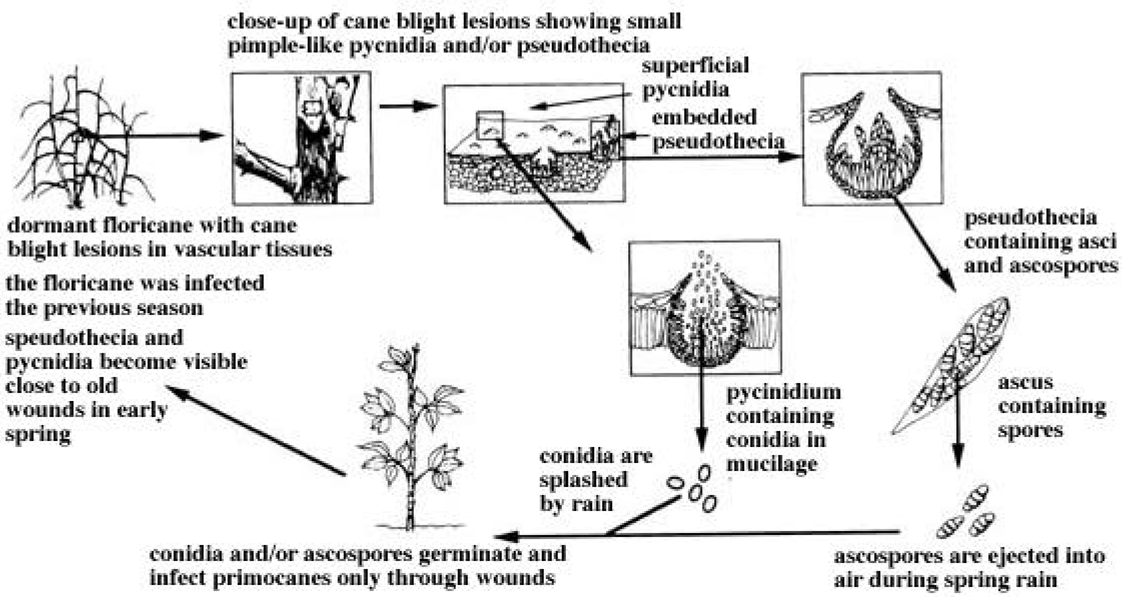



Figure 6. Disease cycle of Raspberry Cane Blight. Taken from the Compendium of Raspberry and Balckberry Diseases and Insects of the American Phytopathological Society. Used with permission.

## Spur Blight of Red Raspberries

Spur blight is caused by the fungus Didymella applanata. Spur blight occurs only on red and purple raspberries. Spur blight has been considered to be a serious disease of red raspberry; however, recent studies in Scotland suggest that spur blight actually does little damage to the cane. The extent of damage caused by spur blight in the United States is not clearly understood.

#### Symptoms

Symptoms first appear on young canes in late spring or early summer. Purple to brown areas (cankers) appear just below the leaf or bud, usually on the lower portion of the stem. These cankers expand, sometimes covering all of the area between two leaves. In late summer or early fall, bark in the cankered cane area splits lengthwise and fungal fruiting bodies, appearing as small black specks, develop in the cankers. They are followed shortly by the formation of many slightly larger, black, erupting spots, another form of fungal fruiting body. Leaflets sometimes become infected and show brown, wedge-shaped diseased areas, with the widest portion of the wedge at the top of the leaf. Infected leaves may fall off, leaving only petioles without leaf blades attached to the cane.

As diseased primocanes become fruiting canes (floricanes) during the next season, the side branches growing from diseased buds are often weak and withered and produce less fruit.

**Disease Development**

The fungus survives the winter in diseased canes (Figure 7). The following spring and summer, during wet and rainy periods, spores are released and carried by splashing rain and wind to nearby new growth. There they germinate and produce new infections, where the fungus will again overwinter.

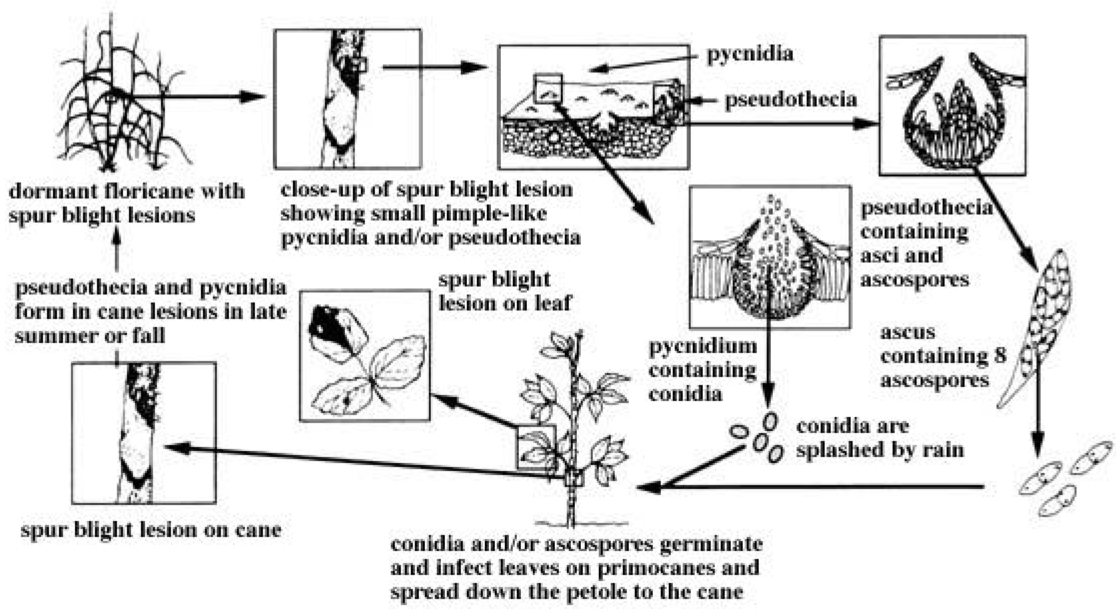



Figure 7. Disease Cycle of Raspberry Spur Blight.Taken from the Compendium of Raspberry and Balckberry Diseases and Insects of the American Phytopathological Society. Used with permission.

## Septoria Leaf and Cane Spot

Septoria leaf and cane spot is caused by the fungus Septoria rubi. The disease is common and can be quite severe in the southern portions of the Midwest on erect and trailing blackberries and black raspberries. Leaves and canes of severely infected plants become badly spotted. The disease can cause premature defoliation which will produce weak plants that are more susceptible to winter injury.

#### Symptoms

On leaves, Septoria leaf spot lesions have a whitish to gray center surrounded by a brown to purple border. The spots are circular and are about 3 or 4æmm in diameter. Tiny black pycnidia (fungal fruiting bodies) form in the center of the spots. The pycnidia are small; therefore, it may be necessary to use a magnifying glass (10X hand lens) to see them. Leaf spots caused by Septoria are similar to those of anthracnose. Spots on canes and petioles are similar to those on leaves but are generally more elongated.

#### Disease Development

The fungus overwinters as mycelium and pycnidia (fungal fruiting bodies) in dead plant debris (leaves and stems) and on infected canes. Pycnidia on infected canes from a nursery can be an effective means for moving the fungus into new fields. In the spring, spores (conidia) are produced inside the pycnidia. They are released in high numbers and carried to young susceptible leaves and canes by splashing or wind-driven rain. The fungus spores germinate in a film of moisture and penetrate the leaf or cane tissue. As leaf and cane spots form and age, new pycnidia form in the centers. These also produce and release spores that can cause secondary infections throughout the growing season. Although the environmental conditions required for infection are not clearly understood, periods of rainfall are highly conducive to disease development. After overwintering in infected canes or debris, the fungus produces spores for new infections the following spring, completing the disease cycle.

## Rosette

Rosette, or double blossom, is caused by the fungus Cercosporella rubi. Rosette is a serious disease of many varieties of erect and trailing blackberries, particularly in the humid southern United States and the southern regions of the Midwest. Rosette also occurs on red and black raspberry, but is seldom serious. Rosette infected blossoms do not form berries and noninfected parts of the same cane may produce poor quality fruit. The disease seriously reduces fruit quality and yield.

#### Symptoms

Symptoms of rosette disease are striking and may completely change the plants' appearance. Buds on new canes of erect and trailing blackberries are infected in early summer. Generally, no symptoms will develop until the following spring, although a few "witches' brooms" may develop during warm spells in late fall. In the spring, numerous leafy sprouts develop from infected buds. These shoots are generally smaller than normal and have pale- green foliage that later turns a bronze color. This proliferation of shoots is referred to as a witches' broom. Several of these witches' brooms may be formed on one cane. Unopened infected flower buds are abnormally large and coarse and frequently somewhat redder. Sepals enlarge and occasionally change into leaves. Flower petals may become green and leaflike. As flower buds open, petals are usually pinkish in color, wrinkled and twisted. Pistils are usually larger and longer than normal and occasionally become abnormally shaped. The fungus produces a whitish spore mass that can cover the surface of the infected pistils and stamens. Berries do not develop from infected blossoms, noninfected parts of the same cane often produce small, poor quality fruit. In some varieties the witches' brooms symptoms may not be apparent; however, the fruit set in infected blossoms is always impaired.

**Disease Development**

Young buds on vegetative canes are infected in early spring (Figure 8). The double blossom fungus grows between the bud scales and surrounds the embryonic tissues within the bud. As secondary buds develop beside an infected bud, they are also invaded. After the bud is colonized by the fungus, very little happens. Infected buds usually remain symptomless until the next spring. A few infected buds are sometimes forced out in an unusually warm late fall. The fungus overwinters in infected buds. During the winter the fungus continues to grow within the bud. Bud proliferation is induced. When infected buds break dormancy in spring, they develop a large number of short, abnormal and off-colored shoots, the witches' broom effect. Infected flower buds usually produce abnormal blossoms upon which the fungus produces its spores. These spores are carried by wind or insects to the newly formed vegetative buds, which are only susceptible to infection in early spring. The fungus infects these buds and overwinters in them to cause new symptoms the next spring, thus completing the disease cycle.

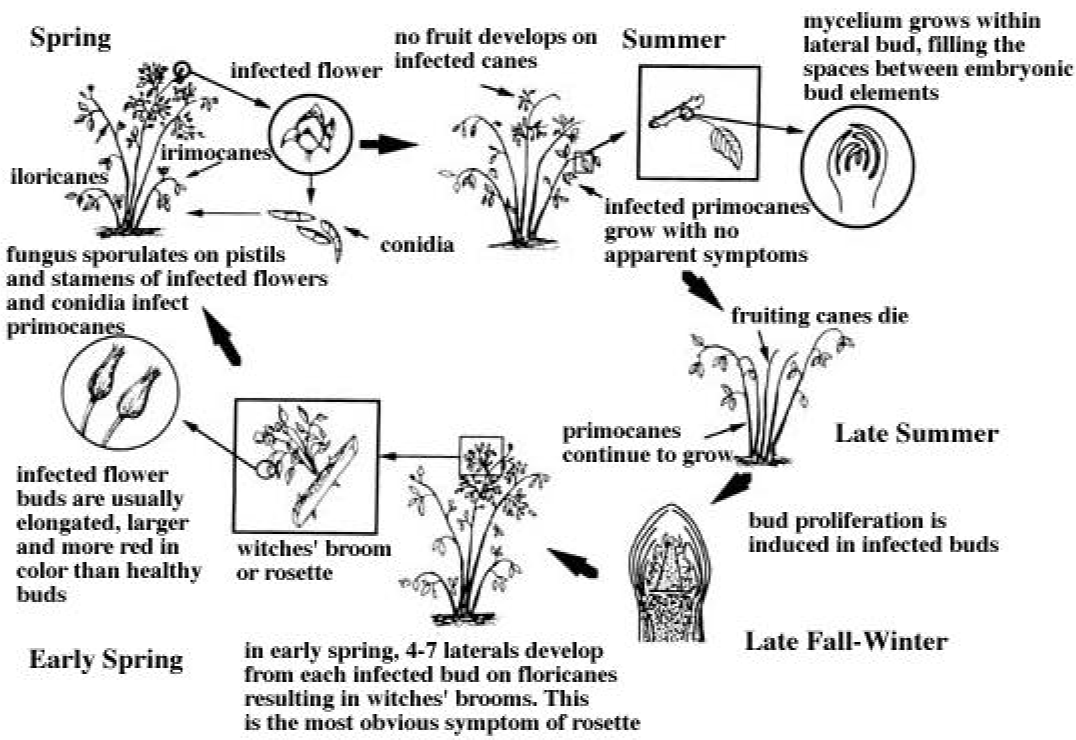



Figure 8. Disease cycle of Rosette or Double Blossom. Taken from the Compendium of Raspberry and Balckberry Diseases and Insects of the American Phytopathological Society. Used with permission.

## Powdery Mildew

Powdery mildew is caused by the fungus *Sphaerotheca macularis*. Powdery mildew affects susceptible cultivars of red, black, and purple raspberries. Blackberries and their hybrids are usually not affected. The disease can be severe (varying from year to year) on highly susceptible cultivars, and these plants may be stunted and less productive. The infection of flower buds reduces fruit quantity. Infected fruit may be lower in quality or unmarketable as a result of the unsightly covering of mycelial growth.

#### Symptoms

Infected leaves develop light green blotches on the upper surface. Generally, the lower surface of the leaf directly beneath these spots becomes covered by white, mycelial growth of the powdery mildew fungus. The leaf spots may appear water-soaked. Infected leaves are often mottled, and if surface growth of the fungus is sparse, they often appear to be infected by a mosaic virus. Infected shoot tips may also become covered with mycelial growth. When severely infected, the shoots become long and spindly (rat-tailed), with dwarfed leaves that are often curled upward at the margins. Infected fruit may also become covered with a white mycelial mat. When the disease is severe, the entire plant may be stunted.

### Disease Development

The fungus overwinters as mycelium in buds on shoot tips in Minnesota, but in California it has been reported to overwinter only as cleistothecia (fungal fruiting structures), producing ascospores as primary inoculum in the spring. Conidia are generally abundantly produced on the surface of infected tissue, and these serve as secondary inoculum for repeated cycles of infection throughout the growing season. They are airborne and probably remain viable for no more than 21 days. The development of this disease, like most other powdery mildew diseases, is favored by warm, dry weather.

## Orange Rust

Orange rust is the most important of several rust diseases that attack brambles. All varieties of black and purple raspberries and most varieties of erect blackberries and trailing blackberries are very susceptible. Orange rust does not infect red raspberries. Orange rust is caused by two fungi that are almost identical, except for a few differences in their life cycles. *Arthuriomyces peckianus* occurs primarily in the northeastern quarter of the United States and is the causal agent for the disease in the Midwest. *Gymnoconia nitens* is a microcyclic (lacks certain spores) stage of *A. peckianus*. *G. nitens* is the more common rust pathogen on erect and trailing blackberries in the Southeast.

Unlike all other fungi that infect brambles, the orange rust fungus grows "systemically" throughout the roots, crown and shoots of an infected plant, and is perennial inside the below-ground plant parts. Once a plant is infected by orange rust, it is infected for life. Orange rust does not normally kill plants, but causes them to be so stunted and weakened that they produce little or no fruit.

### Symptoms

Orange rust-infected plants can be easily identified shortly after new growth appears in the spring. Newly formed shoots are weak and spindly. The new leaves on such canes are stunted or misshapen and pale green to yellowish. This is important to remember when one considers control, because infected plants can be easily identified and removed at this time. Within a few weeks, the lower surface of infected leaves are covered with blister-like pustules that are waxy at first but soon turn powdery and bright orange. This bright orange, rusty appearance is what gives the disease its name. Rusted leaves wither and drop in late spring or early summer. Later in the season, the tips of infected young canes appear to have outgrown the fungus and may appear normal. At this point, infected plants are often difficult to identify. In reality, the plants are systemically infected, and in the following years, infected canes will be bushy and spindly, and will bear little or no fruit.

### Disease Development

In late May to early June, the wind and perhaps rain-splash spreads the bright orange aeciospores from the pustules on infected leaves to healthy susceptible leaves where they infect only localized areas of individual mature leaves (Figure 9). When environmental conditions favorable for infection occur, the spores germinate and penetrate the leaf.

About 21-40 days after infection, small, brownish black telia develop on the underside of infected leaflets. The teliospores borne in these telia germinate to produce a basidium, which in turn produces basidiospores. In blackberries these spores then infect buds on cane tips as they root. They also may infect buds or new shoots being formed at the crowns of healthy plants in the summer. The fungus becomes systemic in these young plants, growing into the crown at the base of the infected shoot, and into newly formed roots. As a result, a few canes from the crown will show rust the following year. The fungus overwinters as systemic, perennial mycelium within the host.

Orange rust is favored by low temperatures and high humidity. Temperatures ranging from 43 degrees to 72 degrees F favor penetration and development of the fungus, but higher temperatures decrease the percentage of spore germination. At 77 degrees F, aeciospores germinate very slowly, and disease development is greatly retarded. Spore germination and plant penetration have not been observed at 86 degreesF. Aeciospores require long periods of leaf wetness before they germinate, penetrate, and infect plants.

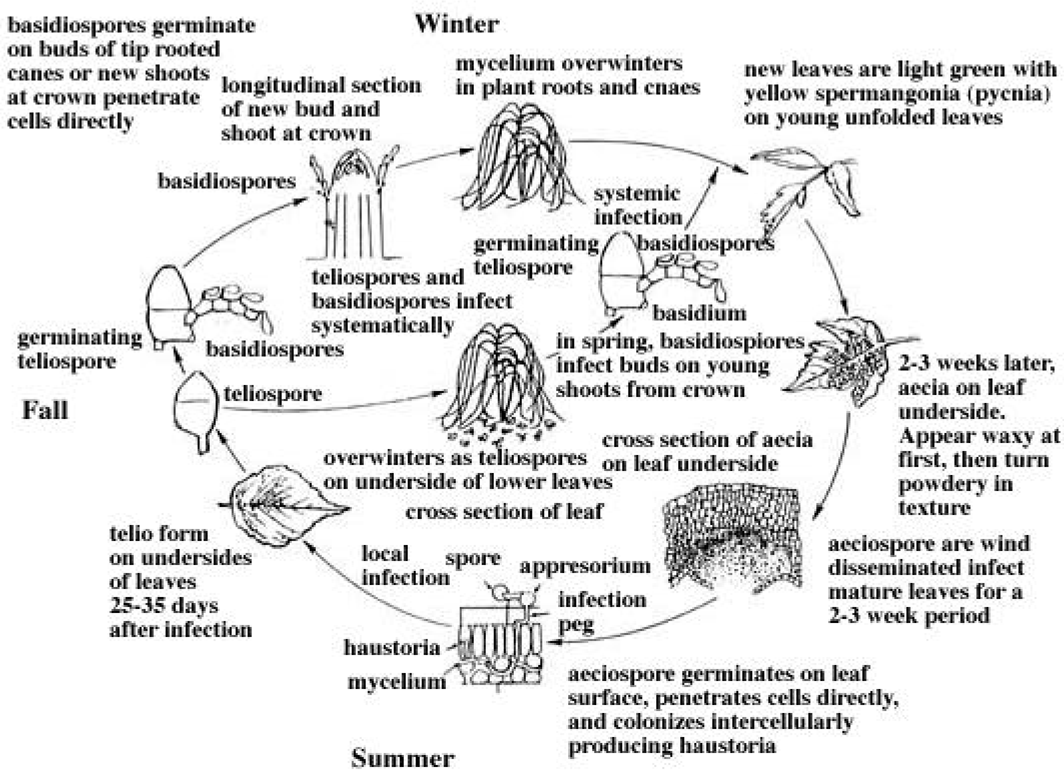



Figure 9. Disease cycle of Orage Rust on Black Raspberry. Taken from the Compendium of Raspberry and Balckberry Diseases and Insects of the American Phytopathological Society. Used with permission.

**Late Leaf Rust**

Late leaf rust, caused by the fungus *Pucciniastrum americanum*, can cause serious damage to susceptible red raspberry cultivars. Economic losses occur from fruit infection and premature defoliation. Because it usually appears late in the season and only occasionally in a severe form, some consider it to be a minor disease. The wild red raspberry, *Rubus strigosus*, in the eastern United States is very susceptible to this rust. A number of cultivars originating from this species also are highly susceptible. While late leaf rust occurs throughout the northern half of the United States and southern Canada, it is more common east of the Mississippi River. In recent years, its occurrence has increased in the northern areas of the Midwest and it has caused significant losses. The rust does not occur on black raspberries or blackberries.

**Symptoms**

On mature leaves, late leaf rust causes small chlorotic or yellow spots to form on the upper leaf surface. These spots may turn brown before leaves die in the fall. Unless the disease is severe, foliar infections can be rather inconspicuous. Small pustules filled with powdery spores (not waxy like orange rust spores) are formed on the undersides of infected leaves. These spore masses may also occur on leaf petioles, canes, and even on the fruit. Infected fruit are worthless, thus yield of marketable fruit is reduced. Badly infected leaves may drop prematurely, and in years when the disease is severe, canes may be defoliated by September.

**Disease Development**

Unlike the orange rust fungus, the late leaf rust fungus is not systemic. The rust fungus produces two types of spores (urediniospores and teliospores) only on raspberries (Figure 10). The alternate host for the rust is white spruce (*Picea canadensis*), on which another type of spore (aeciospore) is produced. The rust apparently does not need the aeciospores stage to survive on raspberries, because the disease is found year after year in regions remote from any spruce trees. It is probable that the fungus overwinters on raspberry canes and, in the following season, produces urediniospores that serve as the source of primary inoculum for new infections.

The small, numerous, light-yellow spots seen on the undersurfaces of the leaves are the uredinial pustules that contain the urediniospores of the fungus. These spores are capable of causing new infections throughout the growing season. Black, one-celled teliospores may be found later in the season intermingled with the uredinial pustules. They are capable of infecting the alternate host (spruce) through the production of yet another type of spore (basidiospore), but probably play little part in the life cycle of the rust on Rubus.

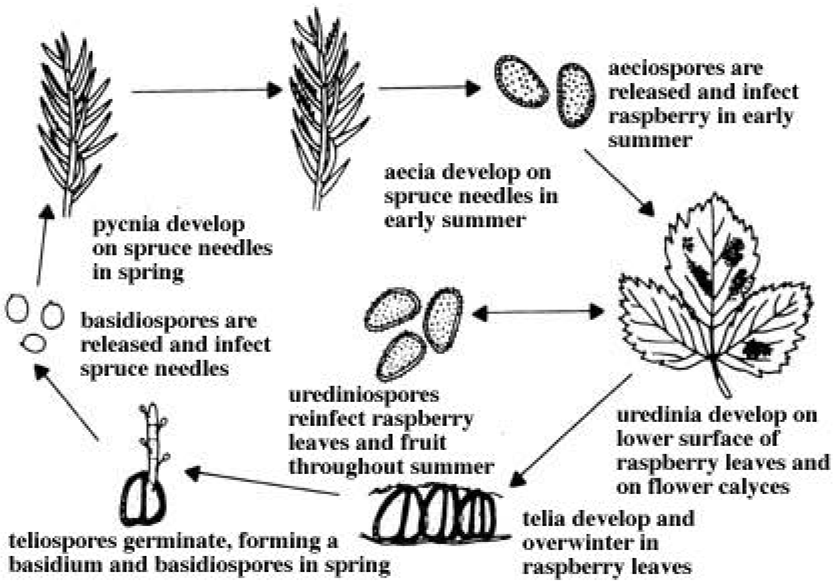



Figure 10. Disease cycle of late feaf rust on red raspberry. Taken from the Compendium of Raspberry and Balckberry Diseases and Insects of the American Phytopathological Society. Used with permission.

## Botrytis Fruit Rot (Gray Mold)

Many fungi are capable of rotting mature or near-mature fruits of raspberries and blackberries under favorable environmental conditions. The most serious and common fruit rot disease worldwide is gray mold. Gray mold is caused by the fungus *Botrytis cinerea*. In wet, warm seasons, probably no other disease causes a greater loss of flowers and fruit. The disease is most severe during prolonged rainy and cloudy periods just before or during harvest.

#### Symptoms

Young blossoms are very susceptible to infection. One to several blossoms in a cluster may show blasting (browning and drying) that may extend down the pedicel. Fruit infections usually appear as soft, light brown, rapidly enlarging areas on the fruit. Infected berries usually become covered with a gray, dusty, or powdery growth of the fungus. This is why the disease is called "Gray Mold." Fruit infections are most severe in the interior areas of the plant canopy, where the humidity is high and air movement is poor. Berries touching another infected berry or a dead leaf in dense foliage are commonly affected. Symptoms may develop on green fruits, but fruits become more susceptible as they mature. Symptoms are generally not detected until harvest. After picking, mature fruits are extremely susceptible to infection, especially if bruised. During picking, the handling of infected fruit will spread the fungus to healthy ones. Under favorable conditions for disease development, healthy berries may become a rotted mass within 48 hours of picking.

#### Disease Development

The gray mold fungus is capable of infecting a great number of different plants. It overwinters as minute, black fungus bodies (sclerotia) on infected plant debris including dead raspberry leaves and canes. In early spring, these fungal bodies produce large numbers of microscopic spores (conidia). Spores are spread by wind where they are deposited on blossoms and fruits. They germinate when moisture is present and infection occurs within a few hours. The fungus usually enters the fruit through flower parts, where it remains inactive (latent) within the tissues of infected green fruits. As the fruit matures, the fungus becomes active and rots the fruit. Thus, while infection actually occurs during bloom, symptoms are usually not observed until harvest. This is important to remember when one considers control. Temperatures between 70 and 80 degrees F and moisture on the foliage from rain, dew, fog, or irrigation are ideal conditions for disease development. The disease can develop at lower temperatures if foliage remains wet for long periods.

Vast numbers of conidia are produced on the surface of infected plant parts, especially fruit. One infected fruit may be covered by millions of spores, which are carried by wind to cause additional infections on flowers and ripe fruit.

---

# Chapter 2 Brambles (Raspberries and Blackberries)

---

## Root Diseases

### Phytophthora Root Rot

Phytophthora root rot is caused by several related species of soilborne fungi belonging to the genus *Phytophthora*. To date, *P. megasperma*, *P. cryptogea*, *P. citriocola*, *P. cactorum*, and at least two additional unidentified Phytophthora species have been implicated in this disease. The disease occurs on red, black, and purple raspberries, although in the northeastern United States it has been documented most commonly on red raspberries. The disease has reported to occur in blackberries in Kentucky. Phytophthora root rot can be an extremely destructive disease on susceptible cultivars where conditions favor its development. Infected plants become weak and stunted and are particularly susceptible to winter injury; seriously infected plants commonly collapse and die.

#### Symptoms

The disease is most commonly associated with heavy soils or portions of the planting that are the slowest to drain (lower ends of rows, dips in the field, etc.). In fact, most declining plants that are considered suffering from "wet feet" may be suffering from Phytophthora root rot. Symptoms include a general lack of vigor and a sparse plant stand. Apparently healthy canes may suddenly decline and collapse during the late spring or summer. In such cases, leaves may initially take on a yellow, red, or orange color or may begin scorching along the edges. As the disease progresses, affected canes wilt and die. Infected plants frequently occur in patches, which may spread along the row if conditions remain favorable for disease development.

Because wilting and collapsing plants may be caused by other factors (winter injury, cane borers, etc.), it is necessary to examine the root system of infected plants to diagnose the disease. Suspect plants should be dug up and the epidermis (outer surface) scraped off the main roots and crown. On healthy plants, the tissue just beneath the epidermis should be white; on plants with Phytophthora root rot, this tissue will be a characteristic brick red (eventually turning dark brown as the tissue decays). Sometimes a distinct line can be seen between infected and healthy tissue, especially on the below-ground portion of the crown.

#### Disease Development

The fungi persist primarily as mycelium in infected roots or as dormant resting spores in the soil. When the soil is moist, reproductive structures (sporangia) are formed upon the infected tissue or by germinating resting spores (oospores) in the soil. Within each of these structures a number of individual spores called zoospores are formed.

These zoospores are expelled into the soil during periods when the soil is saturated with water. The zoospores have "tails" (flagella), which allow them to swim through the water-filled soil pores to reach new plant parts. Upon reaching a plant root or crown, the zoospores become attached and begin the infective process. As water remains standing and oxygen is depleted from the root zone, the plant is progressively less capable of resisting the fungus's attempts at invasion, and infection becomes more likely and severe. Each new infection site is a potential source of additional resting spores and zoospores, allowing for epidemic disease development in sites which are subjected to repeated periods of standing water. Although the optimum season for infection is not known for certain, it is likely that spring and fall are particularly favorable periods. However, it is assumed that infection can occur throughout the growing season if soil moisture conditions are favorable.

### Verticillium Wilt

Verticillium wilt is caused by the soilborne fungus *Verticillium dahalie* and is one of the most serious diseases of raspberries. This disease reduces raspberry yields by wilting, stunting, and eventually killing the fruiting cane or the entire plant. The disease is usually more severe in black and purple than in red raspberries. Blackberries are also susceptible to the disease, but seldom suffer severe losses.

Verticillium wilt is usually a cool-weather disease and is most severe in poorly drained soils and following cold, wet springs. The appearance of symptoms on new canes frequently coincides with water stress caused during hot, dry, midsummer weather.

#### Symptoms

Symptoms usually appear on black raspberries in June to early July, and on red raspberries about a month later. The lower leaves of diseased plants may at first appear to have a dull green cast as compared to the bright green of normal leaves. Starting at the base of the cane and progressing upward, leaves wilt, turn yellow, and drop. Eventually, the cane may be completely defoliated except for a few leaves at the top. Black raspberry and blackberry canes may exhibit a blue or purple streak from the soil line extending up the cane to varying heights. This streak is often not present or is difficult to detect on red raspberries. In the spring following infection, many of the diseased canes are dead. Others are poorly developed and have shriveled buds. The new leaves are usually yellow and stunted. Infected canes may die before fruit matures, resulting in withered, small, and tasteless berries.

#### Disease Development

*Verticillium* is a common soilborne fungus. It causes disease on more than 160 different kinds of plants, including strawberries, eggplant, tomatoes, potatoes, stone fruits and peppers. The fungus overwinters in the soil and plant debris as dormant mycelium or black, speck-sized bodies called microsclerotia. The fungus can survive in the soil for many years. When conditions are favorable, microsclerotia germinate and produce threadlike fungal filaments (hyphae). These hyphae can penetrate the root directly, but invasion is aided by breaks or wounds in the roots. Once inside the root, the fungus grows into the water-conducting tissue (xylem). The destruction of water-conducting tissue prevents the movement of water from the roots to the rest of the plant. Thus, the plant eventually wilts and dies.

### Bacterial Crown Gall and Cane Gall

Crown gall is caused by the bacterium *Agrobacterium tumefaciens*. Cane gall is caused by a very similar bacterium, *Agrobacterium rubi*. Crown gall is a widespread disease of all brambles. Cane gall affects black and purple raspberries more frequently than red raspberries or blackberries. These diseases are particularly serious in nursery fields where freedom from the disease is essential. The bacteria induce galls or tumors on the roots, crowns, or canes of infected plants. Galls interfere with water and nutrient flow in the plants. Seriously infected plants may become weakened, stunted, and unproductive.

#### Symptoms

Young galls (tumorlike swellings) are rough, spongy, and wart-like. Galls can be formed each season and vary in size from a pinhead to several inches in diameter. They develop near the soil line or underground in the spring. Cane galls occur almost exclusively on fruiting canes and usually appear in late spring or early summer. Both crown and cane galls become hard, brown to black, woody knots as they age. Some disintegrate with time and others may remain for the life of the plant. The tops of infected plants may show no symptoms, but plants with numerous galls may be stunted; produce dry, poorly-developed berries; break easily and fall over; or show various deficiency symptoms due to impaired uptake and transport of nutrients and water.

#### Disease Development

Crown gall bacteria enter the plant only through natural openings or wounds in the epidermis or bark of the plant. The bacteria survive in infested soil for years and can invade the roots and crowns of susceptible plants through natural growth cracks, tissue damaged by winter injury, or damage caused by soil insects. Man-made wounds that occur during pruning and cultivation are important points of entry. After the bacteria enter plant tissues, an incubation period of 11 to 28 days, or more if the host is dormant, may be required before the bacteria induce cell proliferation, enlargement, and disorganized growth, resulting in the production of galls. Bacteria, abundant in the outer portions of galls, are continually sloughed off into the soil. The bacteria overwinter in soil and in diseased galls. The following spring, these bacteria are spread by splashing rain, water, cultivation (any practice that moves soil), pruning tools and insect feeding. When they contact wounded tissue of a susceptible host, they enter and induce gall formation, completing the disease cycle.

---

# Chapter 2 Brambles (Raspberries and Blackberries)

---

## Virus Diseases of Raspberries

Red and black raspberries are susceptible to numerous viruses. Raspberries probably suffer greater infection and more serious damage from viruses than any other fruit crop in the United States. Virus infection in raspberries can reduce fruit yields 70 percent or more. There are four main virus-induced diseases of raspberries: mosaic, leaf curl, streak, and tomato ringspot.

Other disorders of raspberries can cause symptoms similar to viruses. Late-spring frosts, mineral deficiencies (such as iron and nitrogen), powdery mildew, pesticide injury, and feeding by leafhoppers, aphids and mites can all cause symptoms similar to those caused by various viruses. Positive identification of a bramble virus or virus complex cannot be based on foliar symptoms alone. Greenhouse and laboratory tests using specific scientific techniques are required for positive identification of viruses.

## Mosaic

This disease is caused by a virus complex (more than one virus involved). Viruses of the mosaic complex (Rubus yellow net, black raspberry necrosis, raspberry leaf mottle and raspberry leaf spot virus) cause the greatest reduction in growth, vigor, fruit yield, and quality of any of the bramble viruses. No raspberry plants are immune, but black and purple cultivars are damaged more severely than red cultivars. The symptoms of mosaic vary considerably, depending upon the cultivar grown, which virus or viruses of the complex are involved, and time of year. Symptoms are most evident on new canes during cooler weather of spring and fall. Symptoms may disappear in the summer when temperatures are high. This is an important point to remember when considering control of virus diseases. Even though symptoms may disappear temporarily, plants remain infected for life. Infected canes are usually short and less vigorous than healthy canes. Leaves are mottled with yellowish or light green spots on a darker green background. On more susceptible cultivars, leaves become puckered with large, dark-green blisters surrounded by yellowish or yellowish-green tissue. Leaves that develop in hot weather may be symptomless or show only faint mosaic pattern with yellow flecks in the normal green color. Leaves formed in late summer show a fine, yellowish, speckled mottling.

Mosaic-infected plants are often progressively more stunted each year. In addition to leaf symptoms, the fruit yield is reduced and may be dry, seedy (often crumbly), and lack flavor. On black and purple raspberries, the tops of newly-infected canes often curl downward, turn black, and die.

The raspberry mosaic virus complex is spread almost exclusively by one species of insect, the large raspberry aphid (Amophorophora agathonica). The aphid is widespread and feeds on the undersides of leaves near the tip of the canes. The aphids become contaminated with the viruses and can spread the viruses to healthy plants up to a quarter of a mile or more away. The mosaic virus can also be spread by commercial propagation from infected plants and movement of the diseased nursery plants.

## Leaf Curl

Leaf curl is less common than the mosaic complex, but it is considerably more destructive. Infected plants are worthless and should be destroyed immediately. The yield of infected raspberries can be reduced up to 70 percent. Infected black raspberry plants may degenerate and die after two or three years.

Leaf curl symptoms are easily recognized. Leaves on infected plants are uniformly small, dark green, crinkled, and tightly curled downward and inward. When diseased shoots first appear, they are pale yellowish-green, but they soon turn dark green, become stiff and brittle, and usually do not branch. Each year the plant loses more vigor and is progressively more dwarfed. Fruiting laterals are shorter and more upright than normal ones. Berries on infected plants may ripen prematurely and are small, dry, seedy, and crumbly.

The raspberry leaf curl virus, the causal agent of raspberry leaf curl disease, is spread exclusively by the small raspberry aphid (*Aphis rubicola*). Heavy populations of this aphid can cause severe inrolling of leaves even in the absence of the leaf curl virus. Winged forms of the aphid can transmit the virus to healthy raspberries from nearby infected brambles. Windborne aphids may spread the disease several miles.

#### Raspberry Streak

Raspberry streak, caused by tobacco streak virus, is generally a minor, but widespread disease. It is presently limited to northern Ohio, western Pennsylvania, and western New York. Streak affects only black raspberries.

The most obvious symptom of the disease is numerous purplish streaks that appear on the lower parts of infected canes. Usually, the streaks are less than an inch long. Terminal leaves on infected canes are often hooked or recurved, twisted or rolled, and darker green than normal. Leaves on the lower positions of the cane may show yellowing along veins and mottling. Fruits on infected canes are smaller than normal, dull, seedy, and crumbly and lack flavor. The individual drupelets often ripen unevenly, giving the fruit a blotched appearance.

#### Tomato Ringspot Virus

This virus disease occurs only in red raspberries and is widespread in the major red raspberry-producing areas of the Pacific Coast and northeastern United States. Infected plants may appear normal, but they are usually somewhat less vigorous than healthy plants. The most obvious symptom of the disease is the production of small, crumbly berries that fall apart when touched. The crumbly berry is caused by the failure of some of the tiny fruitlets (druplets), which make up the fruit, to develop.

The tomato ringspot virus can affect many other species of woody and herbaceous plants. This virus is transmitted through the soil by the dagger nematode (*Xiphinema americanum*).

---

# Chapter 2 Brambles (Raspberries and Blackberries)

---

## Control of Virus Diseases

Always start new plantings with the highest-quality plants available. Use only certified, disease-free, virus-indexed stock. Avoid obtaining uninspected plants from friends or neighbors. Select a planting site that is sunny and fertile and has good air and water drainage. Destroy all wild and neglected raspberries and other brambles located within 600 to 1,000 feet of your planting site. Five hundred feet is the minimum.

Do not plant black or purple raspberries near red raspberries, even though the red raspberries appear to be healthy. Red raspberries may have latent infections. This means that they can be infected, but do not show symptoms. Even though infected plants are symptomless, the virus can still be transmitted from them to healthy plants. If black and red raspberries are planted together, separate them as far apart as possible. If possible, plant black raspberries upwind from reds. The reason for this is the aphids that transmit viruses are generally blown or carried by wind rather than by active flight. Therefore, you do not want aphids to be blown from your red raspberries to your more susceptible black raspberries.

Go through the raspberry planting at least twice a year and remove all plants showing any virus symptoms. This should be done once about mid-June and again in August or September. Before removing infected plants, kill all aphids on them by spraying infected plants with an insecticide a day or two before removal. Dig out the diseased plants, including roots, and dispose of them away from the planting site. In established plantings, where more than 5 to 10 percent of the plants show visible virus symptoms, removal of infected plants probably will not pay. In this case, maintain the planting until fruit yield becomes unprofitable, then destroy it. It is unwise to establish new plantings next to old, infected ones. Maintain strict aphid control at all times, especially in late spring and early summer when aphid populations are highest.

If the virus is transmitted by nematodes, the nematodes must be controlled in order to control the disease. Have the soil tested for plant parasitic nematodes before planting. Samples should be taken in July of the year preceding planting. Spring samples, taken when soils are cold, are not accurate and do not give the grower sufficient time to apply a preplant nematicide. Information on collecting soil samples and submitting them for analysis is available from your Extension service.

---

# Chapter 2 Brambles (Raspberries and Blackberries)

---

### Use of Disease-Resistant Cultivars

In a disease management program where emphasis is placed on reducing overall fungicide use, it is essential to identify any available disease resistance cultivars and use them. Unfortunately, good resistance to most of the major diseases is not available in most commercially grown raspberry and blackberry cultivars in the Midwest. Thus, the disease management program must rely mainly on the use of cultural practices and efficient fungicide use. Whereas resistant cultivars are not generally available for most diseases, cultivars do vary greatly in their level of susceptibility to certain diseases. If good resistance is not available, those cultivars that are highly susceptible to important diseases should be avoided.

### Notes on disease resistance.

#### Phytophthora Root Rot

*Phytophthora* root rot is most serious on red raspberries and some of the hybrids. The black raspberry varieties 'Cumberland' and 'Munger' are reported to be susceptible. The cultivars 'Bristol,' 'Dundee' and 'Jewel' appear to be moderately to highly resistant. Among red raspberry cultivars, none are immune to the disease, but cultivars do differ greatly in their level of susceptibility. Among varieties grown in the Midwest and Northeast, 'Titan' and 'Hilton' are extremely susceptible, with 'Festival,' 'Heritage,' 'Reveille,' and 'Taylor' moderately to highly susceptible. 'Newburgh' is somewhat resistant, and 'Latham,' 'Boyne,' 'Killarney,' and 'Nordic' are considered to be fairly resistant.

#### Verticillium Wilt

Red raspberries are more tolerant than black raspberries. 'Cuthbert' and 'Syracuse' appear to be resistant under field conditions. Black raspberries are highly susceptible. Blackberries are susceptible, but the disease is seldom a serious problem.

#### Orange Rust

Red raspberries are immune. Other brambles are susceptible. Of blackberries, 'Eldorado,' 'Raven,' 'Snyder,' and 'Ebony King' are reported to be resistant. The Arkansas erect types (Arkansas Indian series) are reported to be resistant to orange rust.

# Chapter 2 Brambles (Raspberries and Blackberries)

---

## Virus Diseases

**Mosaic Virus**

Blackberries are not susceptible. Black and purple raspberries are more severely affected than red raspberries. Of the purple or black raspberries, 'New Logan,' 'Bristol,' and 'Black Hawk' are tolerant and 'Cumberland' is susceptible. The red raspberries 'Milton,' 'September,' 'Canby,' and 'Indian Summer' are resistant because the aphid vectors of the virus avoid them.

**Leaf Curl Virus**

Blackberries are symptomless. All raspberries are susceptible.

**Tomato Ringspot Virus**

Red raspberries and blackberries are susceptible.

**Raspberry Streak**

Black and purple raspberries are susceptible.

---

# Chapter 2 Brambles (Raspberries and Blackberries)

---

## Cultural Practices for Disease Control

The use of any practice that reduces or eliminates pathogen populations or creates an environment within the planting that is less conducive to disease development must be used. It is important to remember that many diseases, such as viruses and orange rust, cannot be controlled with fungicides at the present time. Thus, cultural practices are the major means for their control. When fungicides are used, certain cultural practices, such as maintaining narrow row width or cane thinning to open the plant canopy, will greatly increase the efficacy of the fungicide program by allowing better spray penetration and promoting faster drying of susceptible plant parts. The following practices should be carefully considered and implemented whenever possible in the disease management program.

**Use Virus-Indexed Planting Stock**

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

**Site Selection**

Proper site selection is critical to developing a successful disease management program. Establishing a planting on a site that is conducive to disease development is a critical error. Such plantings may be doomed to failure, regardless of the amount of pesticide a grower uses. The following considerations should play a major role in the disease management program.

**Soil drainage** --Soil drainage (both surface and internal drainage) is an ***extremely important*** consideration when selecting a planting site. Planting brambles on poorly or even marginally drained sites is a poor management decision. For example, poorly drained soils that are frequently saturated with water are highly conducive to the development of *Phytophthora* root rot, ***especially in red raspberries***. Even in the absence of plant disease, wet soils are not conducive to good plant growth and productivity.

Any practice such as tiling, ditching, or planting on ridges that aids in removing excessive water from the root zone will increase the efficacy of the disease management program. Once the planting is established, it is difficult, if not impossible to improve soil drainage.

**Site Exposure (Air Circulation and Sunlight Exposure)**--Avoid sites that do not have full exposure to sunlight, such as shaded areas near woods or buildings. In addition, sites with poor air circulation that tend to accumulate still, damp air should be avoided. Planting rows in the direction of the prevailing winds will help promote good air circulation and rapid plant drying.

The primary reason for the above considerations is to **promote faster drying of canes, foliage, and fruit.** Most plant pathogenic fungi and bacteria require water on plant surfaces in order to penetrate and infect the plant. Any practice that reduces wetness duration (speeds drying time) of susceptible plant parts is beneficial to the disease management program.

**Previous Cropping History**--Avoid establishing plantings on sites that have a previous history of problems with *Verticillium* wilt, either in previous plantings of brambles or other susceptible crops. In general, it is not a good practice to plant brambles immediately after solanaceous or other Verticillium-susceptible crops, such as tomatoes, potatoes, peppers, eggplant, melons, strawberries and other related crops. Certain common weeds, such as black nightshade, redroot pigweed, lamb's-quarters, and horsenettle will also support growth of the *Verticillium* fungus, and fields with a high population of these weeds should also be avoided. This is particularly important if *Verticillium* wilt is known to have been a problem on the site in the past. The fungus that causes *Verticillium* wilt can survive in soil for very long periods of time (at least 14 years in California). If a site is known to have had a problem with Verticillium wilt within the last 5 to 10 years it should probably not be used for establishing plantings of *Verticillium*-susceptible bramble cultivars unless the soil is fumigated before planting.

Most brambles are susceptible to *Verticillium* wilt and when the disease becomes established within the planting, it can be devastating. Good resistance to *Verticillium* wilt in the cultivars currently grown in the Midwest is not available. In general, black raspberries are significantly more susceptible than red raspberries, and (in general) blackberries are the least susceptible.

If the site has a previous history of *Phytophthora* root rot, either in previous bramble plantings or other perennial fruit crops, it should probably be avoided. *Phytophthora* spp. (like *Verticillium*) can also survive in soil for extended periods of time. It is important to remember that *Phytophthora* root rot is usually associated with poorly drained (wet) sites and improving soil drainage is one of the principal means of control.

If nematodes have been a problem in previous crops or they are suspected to be a problem on the site, a soil analysis to determine the presence of harmful nematodes should be conducted. Nematodes are most likely to be a problem on the lighter (sandy) soils. Nematode sampling kits and instructions on taking samples can be obtained through your Extension office. Infested sites may be treated with an approved nematicide before planting if sampling indicates a need to do so.

**Proximity (closeness) to established bramble plantings and wild bramble plants**--Ideally, a new planting should be isolated as far as possible from old established plantings or wild bramble plants that serve as reservoirs for diseases and other pests. The benefits of using virus-indexed plants to establish a new field are greatly reduced if the fence row around the planting or a woods directly adjacent to the planting contains wild, virus-infected or orange rust-infected plants. The same is true if a new planting is established next to an old planting that has disease problems.

Currently no information is available on exactly how far away from an established planting or weeded area is "far enough." The distance of 600 to 1000 feet is used commonly in Extension literature; similarly, the New York State virus certification program requires that nurseries in the program use a minimum distance of 1,000 ft. It is probably safe to say "the farther the better."

**Crop Rotation and Soil Fumigation (Replanting Brambles)**

When replanting brambles on the same site, the practices of crop rotation and/or soil fumigation must be considered. Due to the build up and persistence of soilborne plant pathogens, replanting brambles on the same site is not recommended without the use of crop rotation and/or soil fumigation.

**Crop rotation**--At present, data describing how long a rotation is required before replanting brambles on the same site is not available. In fact, this requirement is probably different for every different planting site. Once again, the safest recommendation is probably "the longer, the better," particularly if the site has a history of soilborne diseases.

All soilborne diseases, however, are not the same. For instance, Verticillium wilt generally becomes a problem only after populations of the Verticillium fungus slowly build up to high levels. Thus, if no brambles or other susceptible crops are grown for a suitable period (probably at least 5 years), the fungus population declines and brambles can be reintroduced and grown for a number of years before the population builds back up to damaging levels. This same principle is true for many harmful nematodes, but it is not true for Phytophthora root rot. The *Phytophthora* fungi reproduce very rapidly under proper environmental conditions, so even a low population can rebuild to damaging levels within one or two seasons.

**Soil fumigation**--If done properly, soil fumigation can aid greatly in control of certain soil- borne diseases. It is important to remember that soil fumigants usually reduce the populations of disease-causing fungi and nematodes, but seldom eliminate them. Therefore, diseases that respond well to crop rotation (Verticillium wilt, nematodes) also usually respond to fumigation. In contrast, fumigation is unlikely to provide control of Phytophthora root rot for more than 1 or 2 years, for the same reason that rotation is ineffective. From a disease control standpoint, fumigation might be thought of as a "fast" form of crop rotation with best results obtained when the fumigant is applied after a short (1 or 2 years) rotation has already been implemented to reduce pathogen populations. Where soil fumigation is practiced, care should be taken not to reintroduce disease-causing organisms on infested soil from other parts of the farm.

Neither soil fumigation nor crop rotation will eliminate all problems associated with soilborne diseases. These techniques should always be integrated with other control measures, such as the choice of resistant or partially-resistant cultivars, improvements in drainage, etc. Where other control measures cannot be used (for instance, the site cannot be adequately drained), it is not advisable to replant brambles.

### Avoid Excessive Fertilization

Fertility should be based on soil and foliar analysis. The use of excessive fertilizer, especially nitrogen, should be avoided. Sufficient fertility is essential for producing a crop, but excessive nitrogen can result in dense foliage that increases drying time in the plant canopy, i.e., it stays wet longer (See Recommendations for Brambles).

### Control Weeds In and Around the Planting

Good weed control within and between the rows is essential. From a disease-control standpoint, weeds in the planting prevent air circulation and result in fruit and foliage staying wet for longer periods. For this reason, most diseases caused by fungi are generally more serious in plantings with poor weed control than in those with good weed control. Furthermore, some disease-causing organisms (Verticillium wilt fungus, crumbly berry virus) can build up on certain broadleaf weeds in the planting. Any practice that opens up the canopy in order to increase air circulation and reduce drying time of fruit, foliage and young canes is generally beneficial to disease control. Controlling wild brambles (which are weeds) near the planting is also important because they can serve as a reservoir for several important diseases and insect pests.

## Sanitation

## (Removal of Overwintering Inoculum)

The fungi that cause anthracnose, cane blight, spur blight, Botrytis fruit rot, cane and leaf rust and several other important diseases overwinter within the planting on canes infected during the previous year. Pruning out all **old fruited** canes and any diseased new canes (primocanes) immediately after harvest and removing them from the planting breaks the disease cycle and greatly reduces the inoculum. All infected pruning waste should be removed from the field and destroyed. If you are attempting to minimize fungicide use, good sanitation (removing old fruited canes) is critical. If old fruited canes cannot be removed before winter, they should **definitely** be removed before new growth starts in the spring.

For fall bearing raspberries, such as Heritage, all canes are cut off each year. Removing all cut canes from the planting will aid the disease management program. If it is impossible to remove pruned canes from the field, they should be chopped in place as quickly as possible with a flail mower to speed decomposition before new canes emerge.

### Plant population and canopy management

Any practice that alters the density of the plant canopy and increases air circulation and exposure to sunlight is generally beneficial to disease control. Optimizing between-row and within-row spacings and maintaining interplant spacings through judicious cane thinning throughout the life of the planting is desirable. Ideally, rows for red raspberries should not be over 2 feet wide and should contain about 3 or 4 canes per square foot. Control of plant vigor, particularly through avoidance of high levels of nitrogenous fertilizers and careful use of cane vigor control techniques, can greatly aid in improving the canopy density. Specialized trellis designs for various *Rubus* spp. can further improve air circulation and increase exposure to sunlight, as well as increase harvest efficiency. Trickle irrigation, as opposed to overhead sprinkler irrigation, greatly reduces the wetting of foliage and fruit and the risk of splash dispersal of several important fungal pathogens.

Removing young fruiting shoots (before they exceed 4 inches in length) from the lower portions of canes (approximately the lower 20 inches) will remove fruit that might become soiled. This practice also removes shoots that disproportionately contribute to shading and poor air circulation in the canopy.

For information on methods for cane vigor control, trellis designs and optimum spacing requirements, the following book is very useful: **Bramble Production Guide**, edited by Marvin Pritts and David Handley. It can be purchased from: Northeast Regional Agricultural Engineering Service, 152 Riley-Robb Hall, Cooperative Extension, Ithaca, NY 14853. Phone: 607-255-7654.

### Inspect the Planting Frequently and Rogue Out (Remove) Diseased Plants

Plants showing symptoms of virus diseases, rosette, or orange rust must be removed and destroyed immediately, including the roots, whenever they are found. These plants may bear fruit, but it will be of poor quality. The longer these plants remain, the greater the chances that other plants will become infected. Viruses and the orange rust fungus are systemic and can move to adjacent plants via root grafts. Because of this possibility, use a flag to mark the locations where diseased plants are removed so the adjacent plants can be checked frequently for new symptoms.

For **orange rust**, not a problem on red raspberries, it is particularly important to inspect the planting early in the growing season. The planting should also be inspected on a routine basis (at least once a week) from the time growth starts in the spring through harvest. New leaves of early spring growth on orange rust infected plants are chlorotic (yellowish), shoots are bunched and spindly. They are easy to identify in the spring. It is important that infected plants be identified and removed prior to the development of the "orange rust" pustules on the leaves. If these pustules are allowed to develop, they will produce large numbers of aeciospores which will spread the disease. If infected plants are not removed early in the spring, they become more difficult to identify later in the growing season.

Early spring is also a good time to inspect for virus diseases. Symptom expression of many viruses is more obvious during cool growing conditions. The higher temperatures of mid-to late summer often mask virus symptoms making infected plants difficult, if not impossible, to detect.

### Adjust Production Practices to Prevent Plant Injury and Infection

Any practice that minimizes unnecessary physical damage to the plant is beneficial to the disease management program. Many plant pathogens take advantage of wounds in order to penetrate and infect the plant. Cane blight and bacterial crown gall are two important pathogens of brambles that enter the plant almost exclusively through wounds. The use of sharp pruning tools will help minimize damage to canes during pruning operations. Prune only when necessary (avoid cosmetic pruning of primocanes) and avoid pruning during periods when plants are wet or immediately before wet weather is forecast. Most plant pathogens require water on the surface of plant tissues before they can penetrate the plant. Providing proper cane support through trellising or otherwise tying the canes will aid greatly in avoiding abrasions from sharp spines and wind whipping of plants during windy conditions. Proper spacing between rows and the use of the proper size equipment will also prevent plant damage.

**Proper Harvest, Handling and Storage of Fruit**

Proper harvesting and storage methods are critical components of the disease management program. It is of little value to produce high-quality fruit in the field if it is bruised or crushed during harvest or permitted to rot during storage. Raspberry and blackberry fruit are **very perishable**. Even under the "best conditions" these tender fruits are extremely susceptible to physical damage and post harvest rots. The following practices need to be considered well in advance of initiating the harvest. The proper implementation of these practices will aid greatly in providing your customers with the best quality fruit possible.

a) Handle all fruit carefully throughout all phases of harvest, transport and sale. Bruised or crushed (leaky) fruit are much more susceptible to fungal infection and rot than firm, intact fruit.

b) Harvest all fruits as soon as they are ripe. During periods of warm weather, harvest may require picking intervals as short as 36 to 48 hours. Pick early in the day before the heat of the afternoon. Overripe fruit in the planting will attract a number of insect pests and provide a source for inoculum buildup of fruit rotting fungi.

c) It is highly desirable to combine harvesting and packing into one operation. This prevents unnecessary handling and additional physical injuries.

d) If possible, train pickers to remove damaged or diseased berries from the field. Some growers have programs where they pay the picker as much, or more, for damaged berries picked into separate containers, then for healthy berries. This is a good sanitation practice that reduces inoculum levels of fruit rotting-fungi in the field. Providing hand washing facilities in the field so pickers can periodically clean their hands, should be helpful in reducing the movement of fungus spores that are encountered by touching rotten (diseased) berries.

e) Pick into shallow containers. Ideally, fruit should be no more than 3 to 4 berries deep; this greatly reduces bruising and crushing the fruit, which results in juice leakage that encourages the development of fungal fruit rots.

f) Refrigerate fruit immediately after harvest. Fruit should be cooled as close to 32 degrees F as possible within a few hours after harvest. This temperature should be maintained throughout storage and, if possible, throughout shipment and sale. If you do not have refrigeration, fruit should be placed in the coolest place possible. Never allow the fruit to sit in the sun.

g) Avoid condensation of water on fruit after it is removed from cold storage. This is best accomplished by enclosing it in a waterproof over-wrap before it leaves the refrigerated area. The over-wrap should be kept in place until the fruit temperature has risen past the dew point.

h) **Sell the fruit immediately** ("move it or lose it"). Many berries produced in the Midwest are sold to pick-your-own customers or directly at farm markets, and are not refrigerated prior to sale. Customers should be encouraged ("educated") to handle, refrigerate, and consume or process the fruit immediately in order to assure the highest quality possible. We must remember that even under the best conditions, raspberry and blackberry fruits are **very perishable**.

---

# Chapter 2 Brambles (Raspberries and Blackberries)

---

### Fungicides for Bramble Disease Control

Fungicides can play an important role in the bramble disease management program. However, in order to obtain maximum benefits with minimal use, fungicides must be integrated with the use of the previously described cultural practices and resistant or less susceptible varieties. It must be remembered that several important bramble diseases cannot be controlled with fungicides. These include Verticillium wilt, several rust diseases, and all of the virus diseases. On the other hand, fungicides can be a very effective component in control programs for Botrytis fruit rot (gray mold), powdery mildew, Septoria leaf spot, raspberry leaf spot, anthracnose, cane blight, and Phytophthora root rot.

Although fungicides are an important disease management tool, it should be noted that **very few** fungicides are currently labeled for use on brambles in the United States. The lack of currently registered fungicides combined with the fact that several important diseases cannot be controlled with fungicides makes the diligent use of cultural practices within the disease management program **extremely important**. The following comments are intended to provide some general information about the currently registered fungicides. It is always the growers' responsibility to read and follow all label instructions. In today's modern agriculture, regulations and recommendations can change rapidly; therefore, the following information could change before you read it.

**Benlate 50WP**

Benlate is labeled for control of Botrytis fruit rot and powdery mildew. Although not mentioned on the label, Benlate should also provide some level of control for anthracnose, cane blight, Septoria leaf spot and raspberry leaf spot. Benlate is about the only "broad spectrum" fungicide currently labeled on brambles that can be applied during the growing season. The label states that it can be applied at 3/4 lb per acre at early bloom (5 to 10%) and at full bloom. Three additional applications at 14-day intervals can be made as needed. Do not apply Benlate within 3 days of harvest. Thus, a maximum of 5 applications of Benlate can be made on brambles per season. However, a major problem with the use of Benlate is the development of fungicide resistance. Many fungi have developed resistance to Benlate after repeated exposure, including those that cause gray mold (Botrytis fruit rot) and powdery mildew. To maintain its useful life, Benlate should be used no more than necessary (ideally, no more than once or twice a year). Resistance does not "go away" after Benlate use is discontinued; that is, once the fungicide quits working in a particular planting, it's lost to that planting for good.

**Captan 50WP and 80WP**

In 1994, Ohio received a special local need (24-C) label for the use of Captan on brambles. This registration is good for Ohio only. For information about the use of Captan on brambles in Ohio, contact Mike Ellis (330-263-3849). We are trying to obtain federal registration for Captan on brambles. By the time you read these recommendation, Captan may be available for use in your state. Contact your local Extension office for up-to-date information on the status of Captan.

**Liquid Lime Sulfur**

Lime sulfur is recommended for use on brambles as a delayed-dormant application in early spring (when buds show 1/4 inch green). It is used at the rate of 5-10 gal per 100 gal of water or 10-20 gal per acre. If applied at this rate later in the season it can cause severe damage to leaves and young canes. Lime sulfur is recommended for control of the cane infecting fungi (anthracnose, cane blight and spur blight). The delayed dormant application in spring is intended to eliminate or reduce the overwintering inoculum for these diseases on canes. Where cane diseases are a problem, this spray is very important. When good sanitation is used, (old fruited and infected canes are removed from the field), the need for this spray may not be necessary.

**Sulfur**

Sulfur is registered for control of powdery mildew. It is available as a wettable powder or in flowable formulations. Sulfur has little or no activity against the other bramble diseases caused by fungi. Because powdery mildew is generally not a serious problem in the Midwest, sulfur is generally of little importance within the bramble disease management program.

**Ronilan 50WP & 4F and Rovral 50WP & 4F**

These fungicides are closely related and both have excellent activity against Botrytis fruit rot (gray mold), but have little or no activity against the other fungal pathogens on brambles. Like Benlate, both fungicides are at risk for resistance development by the fungus that causes gray mold fruit rot. If the fungus develops resistance to either Rovral or Ronilan, it is automatically resistant to the other. Therefore, these materials should not be used more often than necessary; the less they're used, the longer they'll last. Ideally, we should limit their use to no more than 2 or 3 applications per season.

### Ronilan

The label states that it is for use on **raspberries**. No other brambles are mentioned on the label; therefore, it should only be used on raspberries and will provide excellent control of Botrytis fruit rot (gray mold). The label states that the first Ronilan application should be made no later than 10% primary bloom. Timing of subsequent applications varies from 7 to 14 days based on weather conditions and resultant disease pressure. Ronilan can be applied at rates ranging from 1 to 2 lbs product per acre. As with all fungicides, rate and spray intervals should be determined by disease pressure (wet weather and amount of fungus inoculum available). Ronilan may not be applied within **9 days** of harvest.

### Rovral

Of the fungicides used for Botrytis control, Rovral is currently the only one labeled for raspberries that can be applied up to and including the day of harvest (0 day PHI). It should provide excellent control of Botrytis fruit rot (gray mold). In addition, the label states it can be used on "caneberries;" therefore, it can be used on all brambles. Rovral may be applied to caneberries at the rate of 1 to 2 pounds per acre. Apply Rovral first at early bloom (5-10% bloom) and make a repeat application again at full bloom. Up to 3 subsequent applications can be applied at 14-day intervals or as required. The final application can be made up to and including the day of harvest. It is our intention to provide a program that will allow growers to use a **minimum** number of fungicide applications. In general, use of Rovral and Ronilan can be minimized by (1) cultural practices that improve air circulation in the planting (very important for Botrytis control); (2) prompt harvest of ripe fruit and removal of overripe or rotten fruit from the planting (also very important for Botrytis control); and (3) focusing sprays during bloom (and immediately before harvest, if necessary), just before long rainy or foggy periods.

### Ridomil

Ridomil is labeled for control of Phytophthora root and crown rot on raspberries. It has no activity against the other bramble diseases caused by fungi in the Midwest. It is available in a liquid or granular formulation. Although Ridomil is very effective for control of Phytophthora root rot, it needs to be emphasized that cultural practices (primarily good soil drainage) are the primary means for controlling this disease. In other words, Ridomil is most effective when used in combination with these cultural practices and/or the avoidance of highly susceptible cultivars (Titan, Ruby, Hilton). It is often ineffective if used in very wet sites, particularly on the above cultivars.

---

# Chapter 2 Brambles (Raspberries and Blackberries)

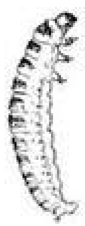
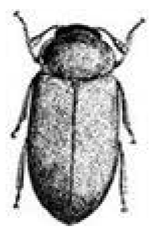
---

## Bramble Pests and Their Management

### Fruit- or Flower-Feeding Pests of Brambles

#### Raspberry Fruitworm

**(*Byturus unicolor*; order Coleoptera, family Byturidae)**

Raspberry Fruitworm, Larva Raspberry Fruitwrom, Adult

**Damage:** The grubs feed in the fruit receptacle or carpels and may end up as contaminants in the harvested berries. The adults chew holes in unfolding leaves and in flower buds. Damaged leaves look skeletonized or tattered, while damaged flower buds result in distorted berries, reduced fruit set, or premature fruit drop. Many flowers and fruit can be destroyed by this insect. Early fruit is more at risk of attack than late fruit.

**Appearance:** Raspberry fruitworm adults are beetles that are small, yellowish brown, about 1/8 inch long, with clubbed antennae. When viewed through a magnifier, dense hairs can be seen on their backs. The immature or larval forms, called grubs, are yellowish white with a light brown section on top of each segment, and a light brown head. Grubs are about 1/4 inch long when fully grown.

**Life Cycle and Habits:** Raspberry fruitworms overwinter as pupae in soil around brambles. The adults emerge at about the time raspberry leaves are unfolding, in late April to early May. The adults first feed along the midrib of folded leaves, then move to developing flower buds, then to flowers where they feed on pistils and stamens. Females usually deposit eggs on swollen but unopened flower buds; they sometimes lay eggs on developing fruit. Eggs hatch in a few days. Larvae tunnel into the flower receptacle to feed, then into the center of developing fruits. Larvae feed for about 30 days. When infested fruit is picked, larvae often remain attached to the inner surface of the druplets. Those that remain on receptacles after harvest will drop to the ground to pupate and overwinter.

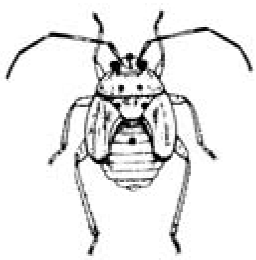
**Cultural Control:** Cultivation of plant rows in late summer or early fall kills some larvae and pupae in the soil. There is some evidence that this insect is more of a problem in weedy plantings; good weed control thus may prevent fruitworm infestation. Because fruitworm larvae drop to the ground in early July, fall-fruiting brambles escape injury. Long ago, effective control resulted when poultry were allowed in the planting after harvest to feed on fruitworm larvae or pupae in the soil.

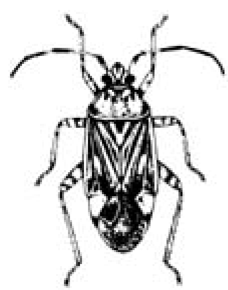
**Monitoring:** Raspberry fruitworm infestations can be detected by examining foliage for long holes that give leaves a tattered appearance; this symptom indicates the potential for infestation of fruit by larvae. Flower buds can be examined for small holes. The adults tend to be most active and noticeable on plants in the early evening hours.

**Control by Insecticides:** Raspberry fruitworm can be controlled by insecticide applied in the early pre-bloom stage (as blossom buds first appear) and again at the late prebloom stage (just before flowers begin to open).

### Tarnished Plant Bug

**(*Lygus lineolaris*; order Heteroptera, family Miridae)**





Tarnished Plant Bug, Nymph Tarnished Plant Bug, Adult

**Damage:** Malformed berries or failed druplets result from tarnished plant bugs sucking juices from developing fruits. Whitening of the damaged druplet results from plant bug feeding on mature fruit. Injured fruit tend to crumble easily and are generally unmarketable. Other plant bug species and stink bugs can cause similar damage.

**Appearance:** Adults of tarnished plant bug are about 1/4 inch long, somewhat flattened, and generally brassy in appearance. They are coppery brown with a yellow-tipped triangular area on their backs. The immature stages, or nymphs, are smaller and bright green. Nymphs resemble aphids but are much more active than aphids.

**Life Cycle and Habits:** Tarnished plant bug overwinters as adults in vegetation that provides protection from extreme cold. In the spring, they are attracted to flower buds and shoot tips of many plants, including apple, peach, and strawberry. Several generations of this insect develop each year, and adults and nymphs are present on many different plants from April or May until a heavy frost in the fall. Adults of early and midsummer generations move onto blossoms and fruits of brambles as fruit begins to form. Both adults and nymphs use piercing/sucking mouthparts to feed on the developing flowers and fruit.

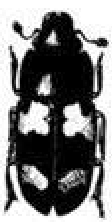
**Cultural Control:** Controlling weeds in and around brambles helps to reduce populations of the tarnished plant bug. However, weeds and nearby forage crops such as alfalfa should not be mowed when brambles are flowering and setting fruit, because mowing encourages the movement of tarnished plant bugs from these plants to blackberries and raspberries.

**Monitoring and Thresholds:** To monitor the tarnished plant bug population in brambles, sample 50 plants in mid-morning by tapping one flower or fruit cluster per plant over a small saucer or tray to dislodge tarnished plant bugs. Control is suggested if counts exceed a threshold of 0.5 plant bugs per cluster, especially in blackberries.

**Control by Insecticides:** If needed, sprays are most effective in reducing damage if applied just before flowers begin to open, and again when fruits begin to color.

### Picnic Beetles

**(*Glischrochilus* species; order Coleoptera, family Nitidulidae)**



Picnic Beetle

**Damage:** Picnic beetles bore into ripe and overripe fruit to feed and lay eggs. Their feeding makes fruit unmarketable, and the beetles themselves become contaminants in harvested fruits. They also introduce fruit-rotting fungi to berries. Late-maturing raspberries are more vulnerable to picnic beetle damage than early berries because beetle populations are greatest in late summer and early fall.

**Appearance:** The picnic beetle is about 1/5 inch long, black, with four yellow-orange spots on its back. It has knobbed antennae. Other related sap beetles are smaller and brown. The immature form of the picnic beetle is a larva that is white with a brown head; it reaches 1/4 to 3/8 inch long.

**Life Cycle and Habits:** The picnic beetles overwinter as adults in many types of plant cover near the soil surface. Once temperatures reach 60 to 65 degreesF in the spring, they become active and feed on fungi, pollen, or sap from many kinds of plants. They lay eggs in old corn ears or other decaying matter. Larvae develop in decomposing plant material, then pupate in the soil. New adults emerge in midsummer. There is one generation per year.

**Cultural Control:** Sanitation is the key to preventing sap beetle infestation. Keep berries off the ground, and practice frequent, complete picking. Remove overripe and damaged berries, and bury culled berries.

**Mechanical Control:** Use bait buckets filled with overripe fruit; place the buckets outside the fruit planting to trap picnic beetles.

**Control by Insecticides:** Because picnic beetles are attracted to overripe fruit, infestations usually build up after harvests are underway, and the use of insecticides is precluded by a combination of frequent picking and required preharvest intervals.

### Scarab Beetles

**(order Coleoptera, family Scarabaeidae):**

### Japanese Beetle

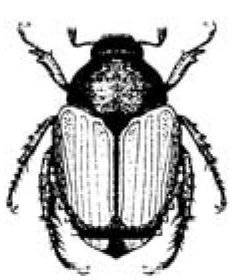
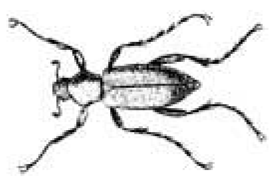
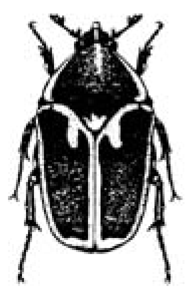
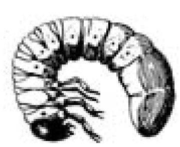
**(*Popillia japonica*)**

### Rose Chafer

**(*Macrodactylus subspinosus*)**

### Green June Beetle

**(*Cotinis nitida*)**

Japanese Beetle Rose Chafer Green June Beetle Larva

**Damage:** Leaves are skeletonized during mid- to late-summer by Japanese beetles; leaves may also be fed upon in early summer by rose chafers. Ripe berries are destroyed by Japanese beetles and green June beetles. Flower buds are destroyed by rose chafers. Japanese beetle is most troublesome in the first two to three years after a planting is established. Rose chafer is most common in areas with light sandy soil. Green June beetles are most numerous in plantings near sites where manure or compost has been spread.

**Appearance:** The Japanese beetle is about 1/2 inch long and copper-colored, with metallic green markings and tufts of white hairs on the abdomen. The rose chafer is light brown, 1/2 inch long, and long legged. The green June beetle is 1 inch long, metallic green on top and brown on the sides. Larvae of all are soft white grubs with six legs and a brown head, usually found in a curled position.

**Life Cycle and Habits:** There is one generation per year of all three of these beetle species. Larvae, or grubs of these scarab beetles develop in pastures, lawns, and other types of turf, where they live in the soil and feed on roots of grasses. The adults move to raspberry and blackberries to feed on flowers, leaves, and fruit. *Rose chafers* emerge in May and June; they feed most commonly on the white flowers and foliage of brambles, sometimes destroying flower buds and greatly reducing fruit production. *Japanese beetles* begin emerging in June and July; they feed on foliage but prefer ripe berries, especially those that are exposed to full sunlight. *Green June beetles* also emerge in July and they also feed on ripe fruit. Green June beetles are common where manure or compost has been spread, because such soils attract egg-laying females and serve as ideal sites for larval development.

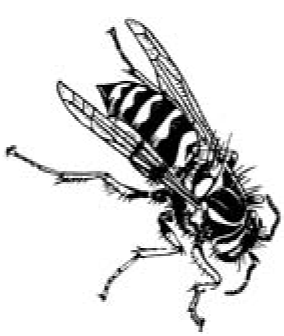
**Cultural Control:** Clean harvesting, which prevents an accumulation of overripe fruit, helps to prevent beetles from being attracted to plantings. Plowing or cultivation can destroy pupae in the soil.

**Mechanical Control:** For Japanese beetle and rose chafers, traps are available that use a sex attractant and/or feeding attractant to capture the beetles in a can or plastic bag, but such traps may not provide adequate control. Place traps *near* the planting, but not in the planting, because plants close to a trap may suffer increased localized damage from beetles that are attracted to the trap but not caught by it.

**Control by Insecticides:** Where immigrations of these beetles occur, insecticide application currently offers the only effective means of control. Preharvest restrictions must be obeyed.

### Yellowjackets

**(*Paravespula species,* Vespa species, and Vespula species; order Hymenoptera, family Vespidae)**



Yellowjacket

**Damage:** Yellowjackets feed on ripe and injured fruit. Their ability to sting and their aggressive behavior make them an annoyance and danger to pickers.

**Appearance:** There are several species of this group of wasps found in the North Central United States. Yellowjackets are yellow and black wasps that are about 1/2 to one inch long. Whitejackets and bald-faced hornets are close relatives that are black and white. Both are aggressive and nasty stingers.

**Life Cycle and Habits:** Depending on the species, the yellowjacket builds its nest underground or in old logs, or builds a large paper nest in trees or houses. The workers scavenge food such as caterpillars or other insects, pieces of flesh from dead animals, or ripe or injured fruit. Food is taken back to the nest to feed the larvae. Yellowjackets are attracted to ripe and injured fruit to feed on fluids and sugars, especially in late summer and during dry weather. Populations of yellowjackets peak in late summer.

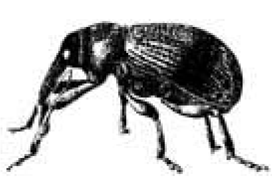
**Cultural Control:** Yellowjackets can be discouraged by sanitation, which is regular and thorough picking of all berries as soon as they begin to ripen, and frequent removal of overripe fruit and fruit debris. Do not allow pickers to bring sweet drinks, lunches, or other attractants into the planting.

**Mechanical Control:** Where yellowjackets are attracted to brambles despite good harvest practices, traps offer the only practical method for reducing problems. The key to trapping success is to get traps out early. Traps should be put up around the perimeter of the planting before the berries begin to ripen. Although commercial traps are marketed for some yellowjackets, these traps do not work for all species. For example, traps that contain heptyl butyrate to attract *Vespula pensylvanica*, the western yellowjacket, do not attract the German yellowjacket, *Paravespula germanica*, or several other common species in eastern North America. There are many yellowjacket traps on the market, and various baits such as fish, meat, jam, honey, beer, and yeast have been used with some success. Different baits and traps may have to be tried to determine which combination will work in a particular raspberry planting. Fish traps, made with a fish suspended over a tub of soapy water, can be effective against all species.

**Control by Insecticides:** Insecticides can not be used effectively in bramble plantings for yellow- jacket control.

### Strawberry Bud Weevil or Strawberry Clipper

**(A*nthonomus signatus*; order Coleoptera, family Curculionidae)**



Strawberry Clipper

**Damage:** Stems of infested flower buds are girdled; buds then dry and dangle from the stem, eventually falling to the ground. The strawberry clipper is an important pest of strawberries (see page 30), but will also attack raspberries. This pest is not always present and may cause only minimal damage in raspberries.

**Appearance:** This insect is a tiny beetle, 1/8 inch long, with a copper-colored body and a black head with a long snout.

**Life Cycle and Habits:** The female weevil chews a small hole in unopened flower buds, then feeds on pollen and lays an egg in the hole. She then girdles the stem just below the bud. The immature weevils, or grubs, develop in the girdled buds, emerging as adults in the early summer, and then migrating to wooded areas.

**Management:** Examine the plants before bloom, and look for dead or clipped-off buds. Insecticide applied prebloom for control of raspberry fruitworm should also control the bud weevil

---

# Chapter 2 Brambles (Raspberries and Blackberries)

---

## Cane- or Crown-Feeding Pests of Brambles

### Raspberry Crown Borer

**(*Pennisetia marginata*; order Lepidoptera, family Sesiidae)**

Raspberry Crown Borer

**Damage:** Canes damaged by crown borer will wilt and become weak and spindly. Foliage may turn prematurely red then die, even on fruit-bearing canes. Crowns infested by crown borer larvae often swell, and all canes from those crowns can die. The entire crown might eventually die. Infested canes will break easily when given a sharp tug, and a larva may be found at the break point. When injured plants are dug up, roots and crowns may be girdled and marked with swellings, galls, cracks, or cavities. Piles of sawdust-like frass may be present.

**Appearance:** The adult of the raspberry crown borer is a clearwing moth with a wingspan of 1 1/4 inches. Yellow bands across its black abdomen allow this moth to resemble a yellowjacket wasp. Larvae are dull white with a brown head. Larvae are 1/2 to 3/4 inch long by the end of their first full summer, and they reach a length of 1 1/4 inches when fully grown during their second summer. Larvae have three pairs of true legs and four pairs of hooked prolegs.

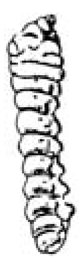
**Life Cycle and Habits:** This pest takes two years to complete its life cycle. Moths are active during daylight hours beginning in late July or August, and live for about one week. Starting the day after emergence, females lay eggs singly on the lower surface of leaves. Eggs take 30 to 60 days to hatch. In September and October, newly hatched larvae crawl down the cane and form a blister-like hibernation cavity at the base of a cane, below the soil line. The following spring, they tunnel into and girdle new canes and the crown. They pass the second winter in bramble roots. They pupate inside the plant base in mid- to late-summer of the second year, and new adults emerge from late July to September.

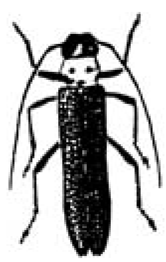
**Cultural and Mechanical Control:** To control raspberry crown borer, infested canes and crowns should be removed and destroyed. Eliminating nearby wild brambles also reduces infestations.

**Control by Insecticides:** Insecticide may be used as a drench around the base of plants in early spring to provide some control of larvae. Insecticide may be applied to lower canes after harvest in the fall to reduce egg-laying by adults. Control may not be achieved until after two or three years of treatment.

**Raspberry Cane Borer**

**(*Oberea bimaculata*; order Coleoptera, family Cerambycidae)**





Raspberry Cane Borer, Larva Raspberry Cane Borer, Adult

**Damage:** Canes infested by raspberry cane borer show tip dieback. Wilted tips are usually observed in June. Cane tips wilt, blacken, and may fall off after they are girdled by the female beetles. The beetles girdle the tips of young raspberry canes by chewing two rings of punctures, about 1/2 inch apart, around the stems about 3 to 8 inches below the tip or a lateral shoot.

**Appearance:** Adult beetles are about 1/2-inch long, and black with a bright yellow/orange thorax (neck) that is marked with two or three black spots. This beetle's black antennae are nearly as long as its body. The larvae are white, legless, 3/4 inch when fully grown, and round-headed.

**Life Cycle and Habits:** The raspberry cane borer has a two-year life cycle. Adult beetles feed on the epidermis of cane tips from June through August. Females use their mouthparts to chew two rings of punctures around canes. They then deposit an egg between the rings of punctures. Eggs hatch into larvae, or grubs, that feed inside the cane. Larvae bore down to the base of the cane by fall, and into the crown by the next summer. Larvae feed at the crown level for the next full season, then pupate the following spring; adult beetles emerge in June through August.

**Cultural and Mechanical Control:** This pest is controlled most effectively by pruning and destroying canes that exhibit wilted tips in July and August. As soon as the wilted tips are noticed, they should be cut off, several inches below the lowest girdle mark. Remove the infested tips from the field and destroy them. Also prune and destroy damaged canes and roots during the fall and winter. Eliminating nearby wild brambles also reduces populations.

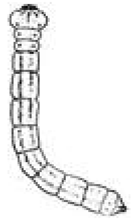
**Control by Insecticides:** Foliar sprays of insecticide provide some control if applied when beetles are present on lower foliage, usually just before blossoms begin to open.

### Red-necked Cane Borer

**(*Agrilus ruficollis*) and**

### Bronze Cane Borer

**(*Agrilus rubicola*; order Coleoptera, family Buprestidae)**



Bronze Cane Borer, Larva Bronze Cane Borer, Adult

Two flat-headed cane borers attack brambles: the red-necked cane borer and the bronze cane borer. The red-necked cane borer is the more common.

**Damage:** Infested canes develop galls at the site where larvae are tunnelling. These galls are symmetrical swellings, usually 1 to 3 inches in length, usually within one foot (but up to 4 feet) above the soil surface. Canes often break near these swellings, and unbroken canes wither and die. Swollen canes are usually observed in July or August. Spiral tunnels just below the bark are another symptom of attack.

**Appearance:** The adult is a slender, metallic black beetle, about 1/4-inch long, with a reddish or coppery thorax (neck) and short antennae. The larvae are white, legless, 3/4 inch when fully grown, and flat-headed.

**Life Cycle and Habits:** Adults feed along leaf margins from May through early August. During May and June, females deposit eggs on the bark of new growth, usually within 10 inches of the base of the cane. Eggs hatch into larvae, or grubs, that tunnel upward or downward in a spiral pattern through canes, feeding in sapwood, hardwood, then in the pith. Larvae reach full size by fall. They overwinter in canes, and pupate in the spring.

**Cultural and Mechanical Control:** Pruning and destroying infested canes in late fall or early spring helps to reduce infestations during the new year. Eliminate any nearby wild brambles that act as hosts for this pest.

**Control by Insecticides:** Insecticide applied just before bloom provides some control by targeting emerging new adult beetles.

### Raspberry Cane Maggot

**(*Pegomya rubivora*; order Diptera, family Anthomyiidae)**

**Damage:** A wilted cane tip, or a cleanly cut tip, results from a cane maggot tunneling around inside the stem and girdling it. A gall-like swelling forms where the cane was girdled. Damage is apparent in May. Tips of infested canes wilt rapidly and darken in color, producing a symptom sometimes called "limberneck." Although the raspberry cane maggot is a common pest of brambles throughout North America, it rarely causes economically significant damage.

**Appearance:** The adult is a small, dark gray fly, about 1/4 inch long; it is similar to a house fly but about half as large. The larvae are legless maggots; they are white, tapered in shape, and 1/3 inch when fully grown.

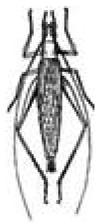
**Life Cycle and Habits:** This pest overwinters as pupae in the soil. Adult flies emerge from pupae in early spring and deposit eggs on terminal leaves of rapidly growing primocanes. Larvae tunnel into the pith and downward, destroying water-conducting tissues and eventually girdling the stem.

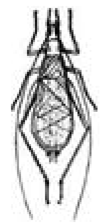
**Cultural and Mechanical Control:** Cut off the infested part of canes a few inches below the girdle, and burn the prunings. This should be done as soon as wilted tips are detected in early summer. Lower pruning and burning during the winter reduces fly populations the next spring.

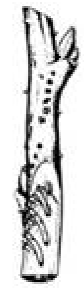
**Control by Insecticides:** Not recommended for this pest.

## Tree Crickets

**(*Oecanthus species*; order Orthoptera, family Gryllidae)**







Tree Cricket, Male Tree Cricket, Female Damage by Tree Cricket

**Damage:** Canes are injured in late summer by female tree crickets that chew small holes in the cane then insert eggs into the punctures. Punctures are usually in single rows, one to three inches long, lengthwise on the cane, and located in the top two feet of the cane. Each row of punctures contains about 30 eggs, but up to 80 eggs is possible. Egg-laying punctures weaken the plant. Canes damaged by tree crickets usually split or break, and punctures allow the entry of pathogens that can further damage the plant.

**Appearance:** Nymphs and adults are slender, somewhat flattened insects that are pale whitish green. They have long hindlegs, antennae longer than the body, and a small head. Adults are about 1 inch long and have soft transparent wings that fold over their backs. Eggs are pale yellow and 1/8 inch long.

**Life Cycle and Habits:** This pest overwinters in the egg stage. Eggs hatch in early summer, and nymphs feed primarily as predators, eating aphids and a variety of other insects. There are five nymphal instars. Tree cricket nymphs and adults become noticeable on bramble canes in midsummer, where they may feed occasionally on foliage and ripening fruit, rarely causing much damage. In late summer, female tree crickets lay eggs in canes.

**Cultural and Mechanical Control:** Prune out and destroy damaged canes, especially old fruiting canes after harvest, to reduce the overwintering population and help reduce damage the next season.

**Control by Insecticides:** If infestation is severe, an insecticide may be applied when adults are present in August or September but before they lay eggs, or when young nymphs appear in the spring.

## Periodical Cicada

**(*Magicicada septendecim*; order Homoptera, family Cicadidae)**

Periodical Cicada  Damage by Periodical Cicada

**Damage:** The adult female cicadas make rows of pocket-like slits in canes in which to deposit their eggs. Each female makes 5 to 20 of these pockets, laying from 24 to 28 eggs in two rows in each pocket. For laying eggs, the females prefer oak, hickory, apple, peach, and pear trees and grapevines. Injured twigs turn brown and die, sometimes breaking off. The damage may be severe in newly planted orchards or on new plantings of shade trees or shrubs. Heavy populations of nymphs in the soil may also affect the growth and vigor of certain trees. In contrast to periodical cicadas, annual cicadas ordinarily do not cause much damage.

**Appearance:** Periodical cicadas are orange to black, about 1 1/2 inches long with black transparent wings. Annual or dog-day cicadas are larger, green to black.

**Life Cycle and Habits:** Annual or dog-day cicadas appear each year from July to September, while periodical cicadas appear from May to July only in certain years. The total life cycle of the periodical cicada takes either 13 or 17 years. There are 17 broods of the 17-year race (I-XVII) and 13 broods (XVIII-XXX) of the 13-year race. Each year, somewhere in the United States at least one of these broods emerges; any one brood will emerge only once every 13 or 17 years. The adult females lay eggs in small branches. The eggs hatch in 6 or 7 weeks; the newly hatched nymphs fall to the ground and burrow until they find suitable roots, usually 1 1/2 to 2 feet beneath the soil. With their sucking mouth parts, they immediately begin to suck juices from the root. During the spring of the 13th or 17th year, depending on which brood is involved, the cicadas burrow upward until they are about one inch below the soil surface. When the proper night comes, they leave the ground in large numbers and head for the nearest upright object, preferably a tree. The nymph attaches itself firmly to this object. By splitting its skin down the middle of the back, it emerges as a winged adult. At first, the adults are soft and white, but they become harder and darker as the tissues dry. Cicada males announce their presence to the voiceless females by making a continuous, high-pitched shrill sound. The sound is produced by vibrating membranes on the underside of the first abdominal segment. Mating takes place within a few weeks, and eggs are laid for the next brood.

**Mechanical Control:** Egg-laying damage by cicadas on young fruit trees or shrubs can be prevented by covering the plant with a protective netting such as cheesecloth. Cover the plant and tie the netting to the trunk below the lower branches. Remove the covering when egg-laying is over.

**Control by Insecticides:** Apply an insecticide when egg-laying begins and repeat 7 to 10 days later.

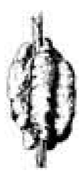
### Rose Scale

**(Aulacaspis rosae; order Homoptera, family Diaspididae)**

The rose scale is an armored scale that attacks stems of brambles growing in damp, shady places. Scales may overlap and encrust the bark. The scale is white, circular, and 1/10 inch in diameter. The scale covers the insect, which is orange-pink. Scale insects suck sap from the plant, and infestation reduces plant vigor and can cause poor fruit sizing. There are at least two generations per year. Rose scale is managed by pruning out and burning all heavily infested canes that can be spared, and eliminating wild brambles in the vicinity.

### Blackberry Gall Maker

**(*Diastrophus nebulosis*; order Hymenoptera, family Cynipidae)**



Blackberry Gall

The blackberry gallmaker causes the formation of large knot galls on the stems of brambles. The galls are first green and later red or brown. The causal agent is a tiny wasp. If this pest becomes noticeable, remove the galls by pruning, and destroy them.

### Stalk Borer

**(*Papaipema nebris*; order Lepidoptera, family Noctuidae)**

Stalk Borer

The primary symptoms of the stalk borer in a raspberry field are wilted tips and a large hole in the side of the cane about six to eight inches back from the tip. Damage is done primarily by boring and tunneling in the stems. Bramble plantings adjacent to weedy areas of the favored host such as giant ragweed are most often attacked. The stalk borer is a general feeder that attacks stems of any plant large enough to shelter it and soft enough to bore into.

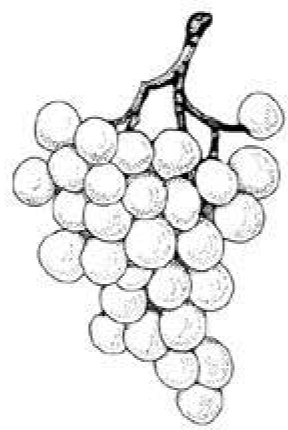
*Chapter Three Blueberries Not applicable for this examination.*

---

# Chapter 4

# Grapes

## General



Diseases represent a major threat to the commercial production of grapes in the Midwest. Climatic conditions are conducive to the development of several major grape diseases, including: black rot, downy mildew and powdery mildew. Each of these diseases has the potential to destroy the entire crop under the proper environmental conditions. In addition, there are several other diseases (Phomopsis cane and leaf spot, Botrytis gray mold, Eutypa dieback and crown gall) that can also result in economic loss. It is important to note that most of these diseases can occur simultaneously within the same vineyard during the growing season.

The development and implementation of Integrated Pest Management (IPM) programs for grapes has great potential for improving our current pest control strategies and reducing our use of pesticides in general. Much of the potential for reducing pesticide use will be in the area of insect control. Many of the IPM methods for monitoring and controlling insects give the grower more flexibility in the decision making process as to whether or not insecticides are needed, which insecticides to apply and when to apply them.

Our currently available disease management programs and recommendations have much less flexibility and the level to which we will be able to reduce fungicide use is largely limited by the degree of susceptibility of the cultivars being grown and environmental conditions during the growing season (the most important of which is wet rainy weather). The introduction of new fungicide chemistry, such as the sterol inhibitors or SIs (Bayleton and Nova), and new information related to the disease cycles of the various pathogens is providing opportunities for new disease control strategies that can be implemented in IPM programs.

# Chapter 4 Grapes

## Integrated Management of Grape Diseases

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

# Chapter 4 Grapes

## Identifying and Understanding the Major Grape Diseases

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

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

**Grapes: Production, Management and Marketing**. Bulletin 815 from Ohio State University Extension can be obtained from: Ohio State University Extension

Publications, 2120 Fyffe Rd., Columbus, OH 43210. Phone 614-292-1607. The following information gives a description of symptoms and causal organisms for the most common grape diseases in the Midwest.

---

# Chapter 4 Grapes

---

### Black Rot

Much of the fungicide applied to grapes in the Midwest is directed at control of black rot. Therefore, growers should develop a thorough understanding of the black rot disease cycle and the fungicides used to control it.

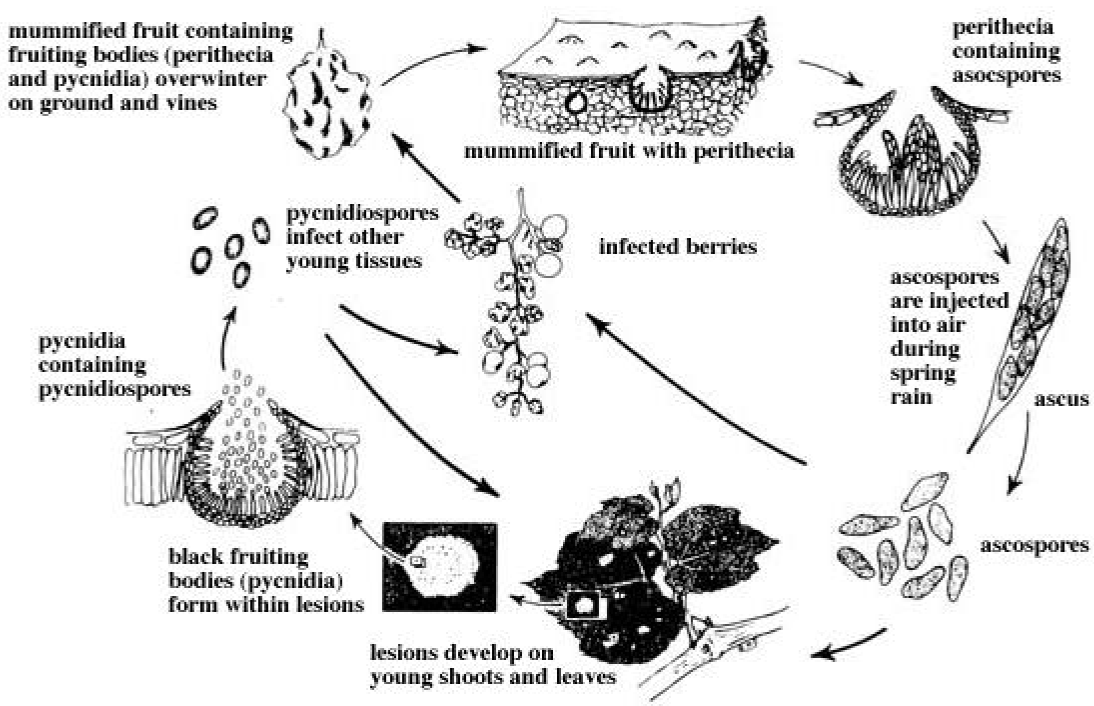



Figure 12. Disease cycle of Grape Black Rot. We wish to thank the New York State Agricultural Experiment Station for use of this figure. Figure taken form the Grape IPM Disease Identification Sheet No. 4.

The causal fungus overwinters in mummified fruit on the vine or on the ground. Spring rains trigger the release of airborne ascospores and/or rain splashed conidia from the mummies. Primary infections occur on green tissues if temperatures and duration of leaf wetness are conducive (Table 4.1). Recent research indicates that the majority of ascospores from mummies on the ground are discharged within a time period from one inch shoot growth to 10-14 days after bloom. If mummies are allowed to hang on the vines, they can discharge ascospores and conidia throughout the growing season.

**Table 4.1. Grape Black Rot. Leaf wetness duration-temperature combinations necessary for grape foliar infection by black rot.**

| Temperature degrees F | Minimum leaf wetness duration for light infection (hr) |
|---|---|
| 50 | 24 |
| 55 | 12 |
| 60 | 9 |
| 65 | 8 |
| 70 | 7 |
| 75 | 7 |
| 80 | 6 |
| 85 | 9 |
| 90 | 12 |

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

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

The fruit infection phase of the disease can result in serious economic loss. Berries are susceptible to the infection from bloom until they begin to ripen (reach 5 to 8 percent sugar). An infected berry first appears light brown in color. Soon the entire berry turns dark brown, and then black pycnidia develop on its surface. Infected berries eventually turn into shriveled, hard, black mummies. These mummies also serve as a source of secondary inoculum later in the growing season and are the primary means by which the fungus overwinters.

#### The bottom line for black rot control

In order to effectively control black rot with minimal fungicide use, primary infections that develop from ascospores must be controlled. If ascospores are prevented from infecting fruit and leaves early in the season, no further black rot control measures are needed after the supply of ascospores is depleted. However, if early season infections are not controlled, additional fungicide protection may be needed throughout the summer to protect fruit against secondary infections by conidia. The number of conidia produced in just a few early-season leaf lesions is tremendous.

#### Important cultural note

Sanitation is critical to successful black rot control. As mentioned above, mummies are an important overwintering source of the black rot fungus. If all mummies and infected canes are removed from the vineyard, there is no source of primary inoculum in the spring and, thus, the disease is controlled. Any practice that removes mummies and other infected material from the vineyard will be beneficial to the disease management program. If all mummies cannot be removed from the vineyard, it is extremely important that they are not left hanging in the trellis. As mentioned previously, mummies on the ground appear to discharge their ascospores early in the season, while those hanging in the trellis may discharge ascospores throughout the growing season.

---

# Chapter 4 Grapes

---

## Powdery Mildew

Powdery mildew is an important fungal disease of grapes. If not controlled on susceptible cultivars, the disease can reduce vine growth, yield, quality, and winter hardiness. Cultivars of Vitis vinifera and its hybrids (French hybrids) are generally much more susceptible to powdery mildew than are native American varieties such as "Concord" (Table 4.2). On susceptible cultivars, the use of fungicides to control powdery mildew is an important part of the disease management program.

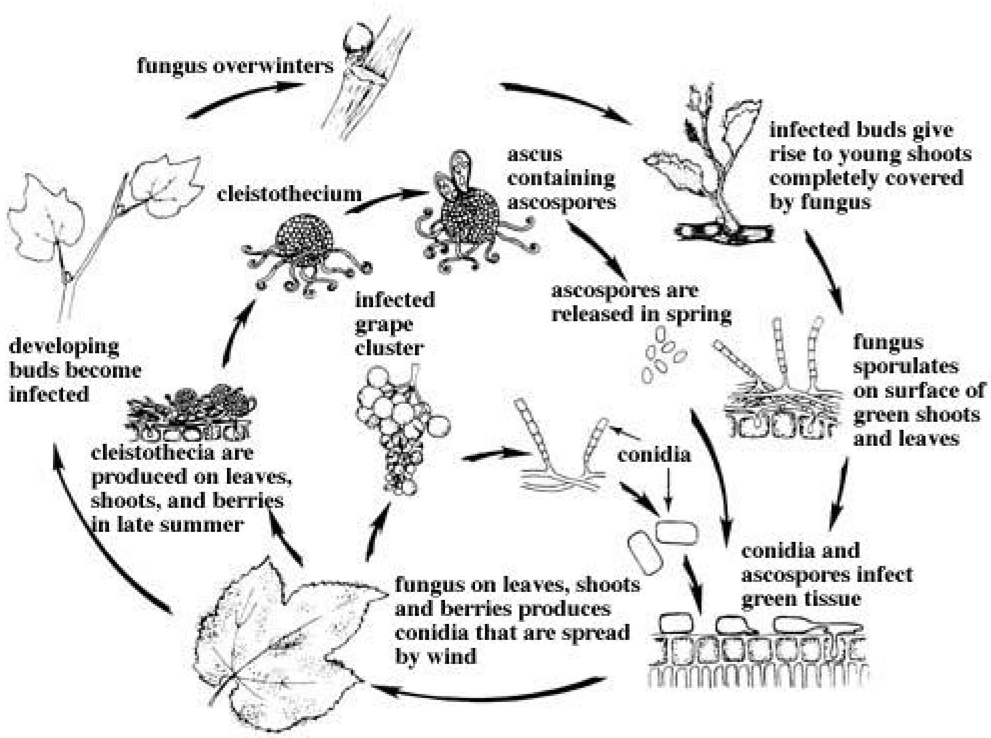



Figure 13. Disease cycle of Grape Powdery Mildew. We wish to thank the New York State Agricultural Experiment Station for use of this figure. Figure taken form the Grape IPM Disease Identification Sheet No. 2.

**Table 4.2. Relative disease susceptibility and Sulfur, Karathane, and Copper sensitivity among grape cultivars.**

**The relative ratings in this chart apply to an average growing season under conditions unusually favorable for disease development. Any given cultivar may be more severely affected.**

| | | | | | | | | | Susceptible or Sensitive to | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cultivar** | **BR** | **DM** | **PM** | **Bot** | **Phom** | **Eu** | **CG** | **Als** | **S[1]** | **K[1]** | **C[2]** |
| Aurore | +++ | ++ | ++ | +++ | + | +++ | ++ | +++ | No | +++ | ++ |
| Baco Noir | +++ | + | ++ | ++ | + | ++ | +++ | ++ | No | ++ | ? |
| Cabernet Franc | +++ | +++ | +++ | + | ? | ? | +++ | ? | No | ? | ? |
| Cabernet Sauvignon | +++ | +++ | +++ | + | +++ | +++ | +++ | ? | No | ? | + |
| Canadice | +++ | ++ | + | ++ | ? | ? | ++ | ++ | ? | ? | ? |
| Cascade | + | + | ++ | + | ++ | ++ | + | ? | No | + | ? |
| Catawba | +++ | +++ | ++ | + | +++ | + | + | + | No | No | ++ |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cayuga White | + | ++ | + | + | + | + | ++ | ++ | No | ++ | + |
| Chambourcin | +++ | ++ | + | ++ | ? | ? | ++ | ? | Yes | ? | ? |
| Chancellor | + | +++ | +++ | + | +++ | + | +++ | +++ | Yes | + | +++ |
| Chardonnay | ++ | +++ | +++ | +++ | +++ | ++ | +++ | ++ | No | +++ | + |
| Chelois | + | + | +++ | +++ | +++ | +++ | ++ | +++ | No | + | + |
| Concord | +++ | + | ++ | + | +++ | +++ | + | + | Yes | + | + |
| DeChaunac | + | ++ | ++ | + | +++ | +++ | ++ | +++ | Yes | + | + |
| Delaware | ++ | +++[3] | ++ | + | +++ | + | + | + | No | +++ | + |
| Dutchess | +++ | ++ | ++ | + | ++ | + | ++ | + | No | ? | ? |
| Elvira | + | ++ | ++ | +++ | + | + | ++ | ++ | No | No | ++ |
| Einset Seedless | +++ | ++ | +++ | + | ? | ? | + | ? | ? | ? | ? |
| Foch | ++ | + | ++ | + | ? | +++ | + | + | Yes | ++ | ? |
| Fredonia | ++ | +++ | ++ | + | ++ | ? | + | + | No | ? | ? |
| GewÄrztraminer | +++ | +++ | +++ | +++ | ? | ? | +++ | + | No | ? | + |
| Himrod | ++ | + | ++ | + | ? | ? | ? | + | No | ? | ? |
| Ives | + | +++ | + | + | ? | ++ | + | + | Yes | ? | ? |
| Limberger | +++ | +++ | +++ | + | ? | +++ | +++ | ? | No | ? | ? |
| MarÚchal Foch | ++ | + | ++ | + | ? | +++ | ? | + | Yes | ? | ? |
| Melody | +++ | ++ | + | + | ? | ? | ? | ? | No | ? | ? |
| Merlot | ++ | +++ | +++ | ++ | + | +++ | +++ | ? | No | ? | ++ |
| Moore's Diamond | +++ | + | +++ | ++ | ? | ++ | ? | ? | No | No | ? |
| Muscat Ottonel | +++ | +++ | +++ | ++ | ? | +++ | +++ | ? | No | ? | ? |
| Niagara | +++ | +++ | ++ | + | +++ | + | ++ | + | No | 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 | ? | ? |
| Vidal blanc | + | ++ | +++ | + | + | + | ++ | + | No | +++ | ? |
| Vignoles | + | ++ | +++ | +++ | ++ | ++ | ++ | ++ | No | ++ | ? |
| Villard noir | ? | + | +++ | + | ? | ? | ? | ? | ? | ? | ? |
| Key to susceptibility or sensitivity: BR=black rot; DM=downy mildew; PM=powdery mildew; Bot=Botrytis; Phom=Phomopsis; Eu=Eutypa; CG=crown gall; ALS=angular leaf scorch; S=Sulfur; K=karathane; C=Copper | | | | | | | | | | | |
| Key to ratings: +=slightly susceptible or sensitive; ++=moderately susceptible or sensitive; +++= highly susceptible or sensitive; No=not sensitive; Yes=sensitive; ?=relative susceptibility or sensitivity not established. | | | | | | | | | | | |
| 1 Slight to moderate sulfur and Karathane injury may occur even on tolerant cultivars when temperatures are 85 degrees F or higher during or immediately following the application. | | | | | | | | | | | |
| 2 Copper applied under cool, slow-drying conditions is likely to cause injury. | | | | | | | | | | | |
| 3 Berries not susceptible | | | | | | | | | | | |
| We wish to thank the New York Cooperative Extension Service for the use of this table. | | | | | | | | | | | |

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

NOTE: Ascospore discharge from cleistothecia is initiated if 0.10 inch of rain occurs at an average temperature of 50 degrees F. Most mature ascospores are discharged within 4 to 8 hours.

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

**Conditions that favor disease development**

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

It is important to remember that powdery mildew can be a serious problem during growing seasons when it is too dry for most other diseases, such as black rot or downy mildew, to develop.

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

---

# Chapter 4 Grapes

---

### Phomopsis Cane and Leaf Spot

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

Disease incidence of Phomopsis cane and leaf spot appears to be increasing in many vineyards throughout the Midwest; however, only under conditions of very high disease pressure does crop loss occur. The most commonly observed symptoms are on shoots where infections give rise to black elliptical lesions that are most numerous on the first 4-

6 basal internodes. Although this phase of the disease can appear quite severe, crop loss due to shoot infections has not been demonstrated. Heavily infected shoots are more prone to wind damage.

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

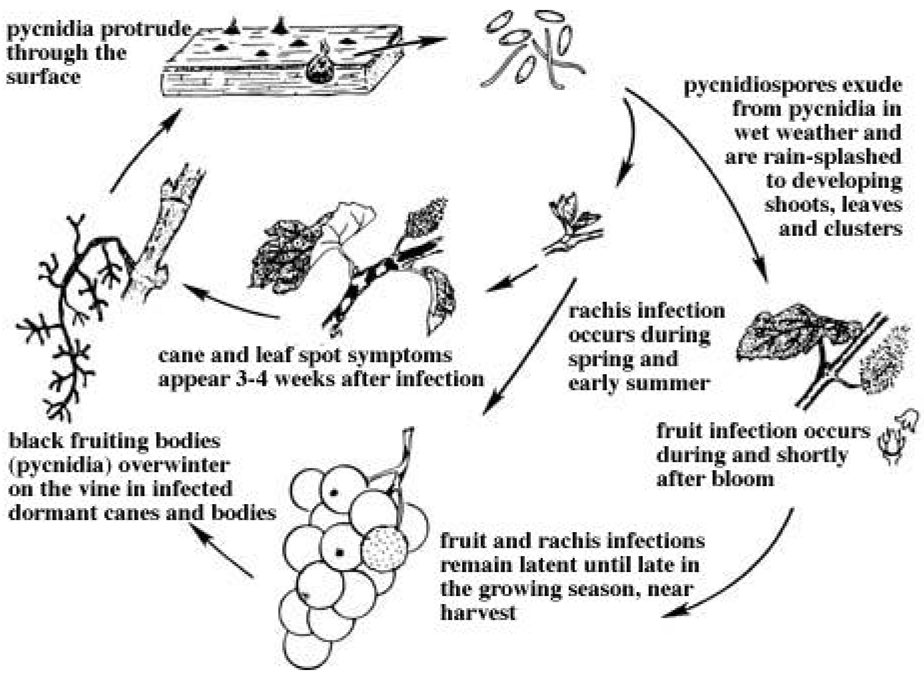



Figure 14.Disease cycle of Phomposis Cane and Leaf Spot. We wish to thank the New York State Agricultural Experiment Station for use of this figure. Figure taken form the Grape IPM Disease Identification Sheet No. 6.

The fungus overwinters in lesions or spots on 1- to 3- year-old wood infected during previous seasons. It requires cool weather and rainfall for spore (conidia) release and infection. Conidia are released from pycnidia in early spring and are spread by rain to developing shoots and leaves. Shoot infection is most likely during the period from bud break until shoots are 6 to 8 inches in length. Lesions appear 3 to 4 weeks after infection. The critical period for fruit and rachis infection is also early in the season. The rachis and young fruits are susceptible to infection from the time they are first exposed until temperatures after bloom become high enough to prevent infection. The fungus does not appear to be active during warm summer months. Thus, the critical period to provide fungicide protection for fruit infection is from when the clusters are first exposed until 10 to 14 days after bloom.

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

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

At this advanced stage, Phomopsis fruit rot can be easily mistaken for black rot. Growers must remember that the black rot fungus does not infect berries as they start to mature (reach 6 to 8 percent sugar). Fruit infection by Phomopsis generally does not appear until this time. Although the fungus does not appear to be active during the warm summer months, it can become active during cool, wet weather later in the growing season.

---

# Chapter 4 Grapes

---

## Eutypa Dieback

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

#### Symptoms

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

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

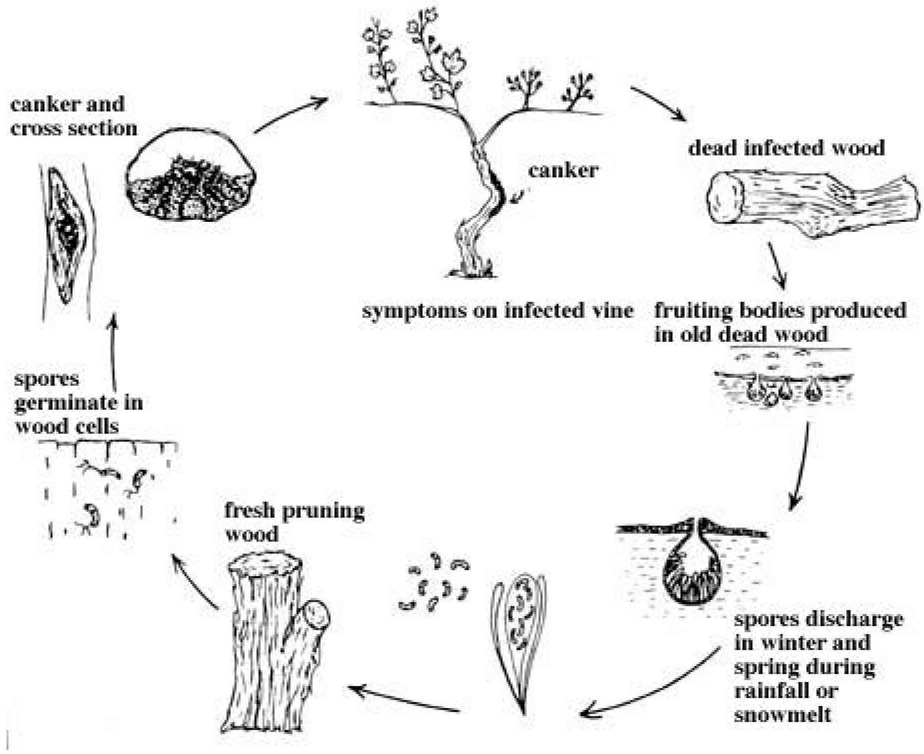



Figure 15. Disease cycle of Eutypa Dieback. We wish to thank the New York State Agricultural Experiment Station for use of this figure. Figure taken form the Grape IPM Disease Identification Sheet No. 1.

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

**Control of Eutypa Dieback**

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

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

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

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

---

# Chapter 4 Grapes

---

## Downy Mildew

Downy mildew is a major disease of grapes throughout the eastern United States. The fungus causes direct yield losses by rotting inflorescences, clusters and shoots. Indirect losses can result from premature defoliation of vines due to foliar infections. This premature defoliation is a serious problem because it predisposes the vine to winter injury. It may take a vineyard several years to fully recover after severe winter injury. In general, vinifera (*Vitis vinifera*) varieties are much more susceptible than American types and the French hybrids are somewhat intermediate in susceptibility (Table 4.2).

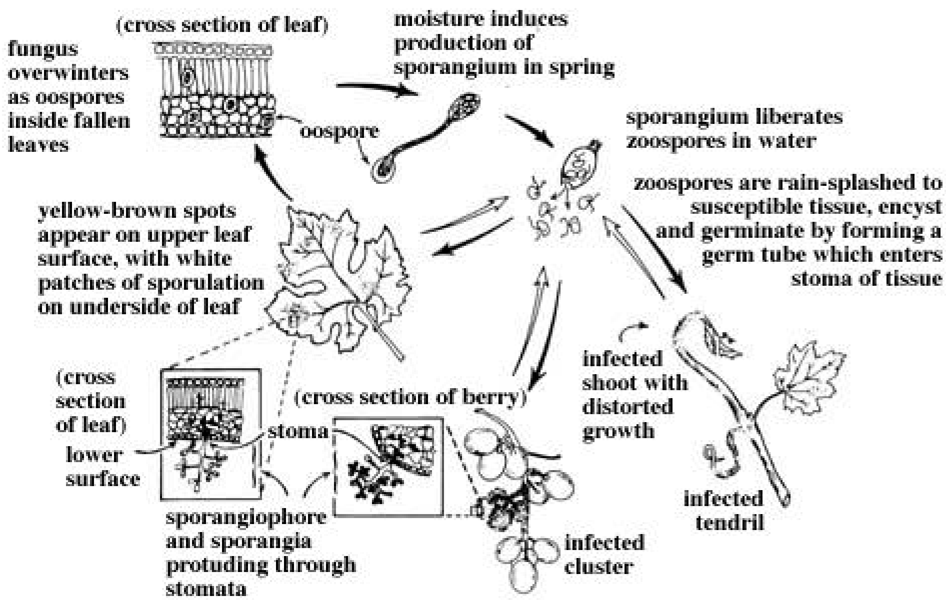



Figure 15. Disease cycle of Eutypa Diaback. We wish to thank the New York State Agricultural Experiment Station for use of this figure. Figure taken form the Grape IPM Disease Identification Sheet No. 1.

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

Infected leaves develop yellowish-green lesions on their upper surfaces, 7 to 12 days after infection. As lesions expand, the effected areas turn brown, necrotic or mottled. At night, during periods of high humidity and temperatures above 55 degrees F, the fungus sporulates by forming sporangia on numerous branched structures, called sporangiophores, that protrude out through stomata. Sporulation only occurs on plant surfaces that contain stomata, such as the underside of leaves, and it gives the surface of the lesion its white, downy appearance, which is characteristic of the disease. Sporangia are disseminated by wind or rain splash. On susceptible tissue they liberate zoospores into water films formed by rain or dew. These zoospores initiate secondary infections which can occur in as little as two hours of wetting at 77 degrees F or up to 9 hours at 43 degrees F. Infections are usually visible as lesions in about 7 to 12 days, depending on temperature and humidity. The number of secondary infection cycles depends on the frequency of suitable wetting periods that occur during the growing season and the presence of susceptible grape tissue. In general, Catawba, Chancellor, Chardonnay, Delaware, Fredonia, Ives, Niagara, White Riesling, and Rougeon are highly susceptible cultivars (Table 4.2).

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

**Throughout most of the Midwest, downy mildew symptoms often do not appear until after bloom. This is why we often refer to it as a "late season" disease. The role of oospores in causing early season primary infections is not clear at present. Although we emphasize the use of fungicides for downy mildew control after bloom, early season fungicide applications appear to provide some level of control later in the season. Especially on highly susceptible cultivars, the early season fungicide program should contain a fungicide that has efficacy ag**

---

# Chapter 4 Grapes

---

## Botrytis Bunch Rot

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

#### Symptoms

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

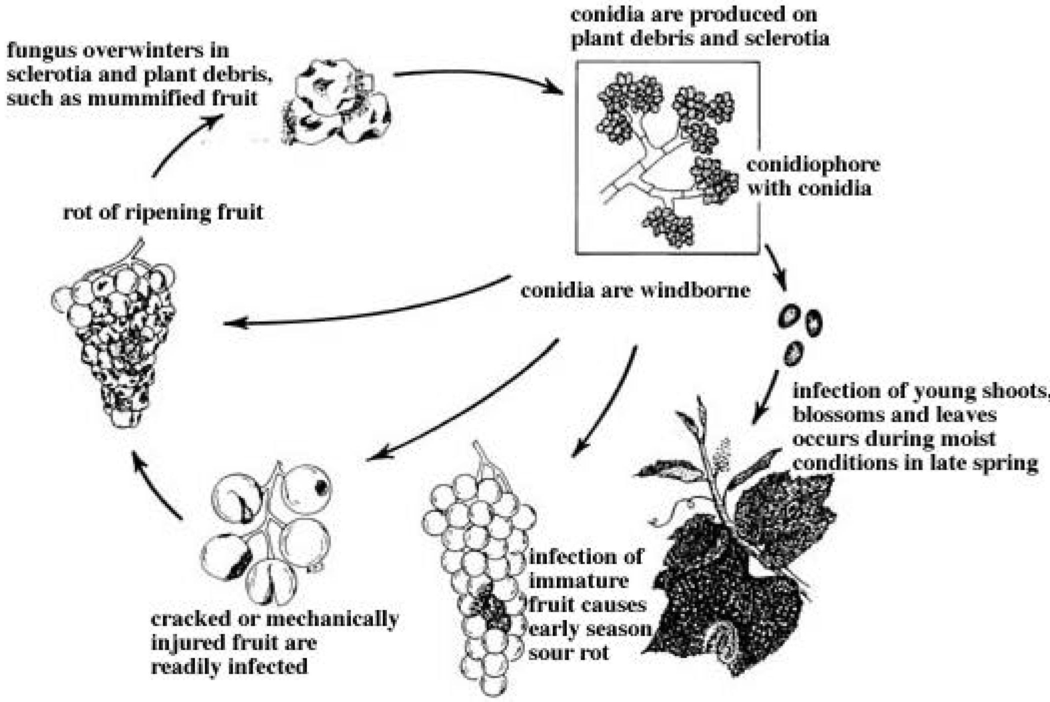



Figure 17. Disease cycle of Botrytis Bunch Rot. We wish to thank the New York State Agricultural Experiment Station for use of this figure. Figure taken form the Grape IPM Disease Identification Sheet No. 5.

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

---

# Chapter 4 Grapes

---

## Crown Gall

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

#### Symptoms

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

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

#### Life Cycle

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

#### Control of Crown Gall

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

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

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

---

# Chapter 4 Grapes

---

## Use of Resistant Cultivars for Grape Disease Management

In an integrated disease management program where emphasis is placed on reducing overall fungicide use, it is essential that any available disease resistance be identified and used. If resistance is not available, we should at least identify and **avoid** those cultivars that are highly susceptible to important diseases. Unfortunately, good resistance to most of the major diseases is not available in most commercially grown grape cultivars in the Midwest. Thus, the disease management program must rely mainly on the use of cultural practices and efficient fungicide use. Whereas resistance is generally not available for most diseases, some grape cultivars are known to be much more susceptible to certain diseases than others (Table 4.2). For example, the cultivar Chancellor is highly susceptible to downy mildew, whereas downy mildew is seldom a serious problem on Concord. Growers should consider disease susceptibility before establishing the vineyard. Segregating highly-susceptible cultivars into blocks that can be easily treated separately allows growers to apply more fungicide when needed to highly susceptible cultivars while reducing fungicide use on less susceptible cultivars.

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

---

# Chapter 4 Grapes

---

## Cultural Practices For Disease Control

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

**Vine Microclimate**

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

**Use Virus-Indexed Planting Stock**

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

**Site Selection**

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

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

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

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

**Avoid Excessive Fertilization**

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

**Control Weeds in and Around the Planting**

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

**Canopy Management**

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

**Avoid Winter Injury**

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

**Sanitation (Removal of Overwintering Inoculum)**

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

# Chapter 4 Grapes

## Using Fungicides for Controlling Grape Diseases

Fungicides are an important part of the grape disease management program. Due to the lack of good disease resistance in most of our currently grown cultivars, combined with our environmental conditions (abundant moisture) that are highly conducive to disease development, successful commercial grape production in the Midwest is highly unlikely without the use of at least some fungicide. Whereas fungicides are important, growers need to recognize that they are only one part of the overall "integrated" disease management program. The effectiveness of the fungicide program is greatly influenced by use of the various cultural practices described previously and the level of disease susceptibility of the varieties being grown. For example, given a poorly pruned (dense canopy) vineyard of Chancellor grapes (highly susceptible to downy mildew) planted on a poor site (little air circulation) and with poor weed control, the chance of any reasonable fungicide program providing an acceptable level of disease control is highly unlikely.

To use any fungicide effectively the following points must be considered:

**Correct Disease Identification**
If you do not know what disease or diseases are present in the vineyard, you cannot choose the most effective fungicide or fungicides for their control. Descriptions mentioned in this bulletin and in other resources listed in Appendix D can assist you in making the proper diagnosis.

**Selection of the Proper Fungicide**
Fungicides differ greatly in their spectrum of activity (which fungi they can control). Selection of the wrong fungicide for use on a specific disease can result in financial loss and no control. For example, if a grower misidentified downy mildew for powdery mildew and sprayed Nova or Bayleton to control it, neither of these fungicides would have any effect on the downy mildew, although they would provide excellent control of powdery mildew.

**Proper Timing of Application**
For most diseases it takes at least a week from the time the fungus enters the plant until the symptoms appear. In the case of Phomopsis fruit rot, the fungus enters the fruit during bloom and symptoms do not appear until the fruit begins to ripen (harvest). Depending upon the weather, it may take two weeks for black rot symptoms to appear. Once symptoms appear, it is too late to control the disease; therefore, proper timing of the

application is critical. The fungus must be controlled before or shortly after it enters the plant.

**Thorough Coverage of All Susceptible Plant Parts**
If the fungicide is not on or in susceptible plant parts, it can't control the fungus. Cultural practices that open the plant canopy greatly improve fungicide coverage. Proper calibration and use of the sprayer is also critical to good coverage.

**Fungicide Use Strategies for Grapes**

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

**Do not use Fungicides**

This is always an option, but it is not recommended for commercial plantings. This option should not be confused with "organic" production. Grape growers in "organic" production systems will most probably use sulfur or copper to some extent for disease control. Sulfur, lime-sulfur, and copper are fungicides. Growers that choose not to use fungicides must rely completely on cultural practices and disease resistance for disease control.

**Protectant Fungicide Program**

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

Protectant fungicide programs have been and still are very effective; however, they generally result in a fairly intensive use of fungicides. Protectant fungicides are usually applied on a 7- to 14-day schedule early in the growing season and on a 10- to 14-day schedule later in the season. Obviously, maintaining a protective barrier on the plant surface throughout the growing season requires many applications.

**Postinfection or Curative Fungicide Program**

The development and introduction of new "systemic" fungicides allows the use of a postinfection or curative fungicide use strategy. In a postinfection program, fungicides are applied only after infection periods occur. The systemic properties of the fungicide allow it to move into plant tissues where it stops further development of the fungus after it has penetrated the plant. In the postinfection program, the fungicide is applied after the initiation of an infection period, but before symptoms develop. Thus, the fungicide must be applied within 3 to 4 days (72-96 hrs) after the initiation of an infection period in order to be effective.

The sterol inhibiting (SI) fungicides (Bayleton and Nova) have excellent postinfection activity against black rot and powdery mildew. Ridomil and Aliette have excellent postinfection activity against downy mildew. In dry growing seasons, with few or no infection periods, a postinfection program should result in reduced fungicide use.

**Important points to remember about the postinfection program:**

a) In order to use a postinfection program you must be able to monitor the environment to determine when infection periods occur. **If growers do not have the capability to accurately monitor the environment, they should not use a postinfection program.**

b) Know what an infection period is for a specific disease. This requires a great deal of knowledge about the biology of the pathogen. At present we have this information for black rot (Table 4.1). There are also predictive capabilities for powdery mildew and downy mildew, and Botrytis bunch rot. Predictive programs are currently being developed and evaluated for these diseases.

c) **Timing is critical.** Postinfection applications must be made as soon as possible, but within 3 to 4 days (72-96 hours) after the initiation of an infection period and before symptom development. In most situations, once symptoms develop the damage is done.

---

# Chapter 4 Grapes

---

## Fungicides for Controlling Black Rot

**Protectants:**
**Mancozeb, Ferbam** and **Ziram** are all highly effective against black rot (Table 4.3). Because these fungicides are strictly protectants, they must be applied before the fungus infects or enters the plant. They protect fruit and foliage by preventing spore germination. They will not arrest lesion development after infection has occurred. Mancozeb provides an excellent foundation for a protectant spray program for grapes in the Midwest. It is a good protectant fungicide that will provide good to excellent control of downy mildew and Phomopsis cane and leaf spot in addition to black rot. The major problem with mancozeb is a 66 day preharvest interval (PHI) on grapes. It cannot be applied within 66 days of harvest. Mancozeb is available under many trade names and formulations. Some

common trade names are Manzate 200, Penncozeb, Dithane DF, Dithane M-45 and Dithane F45.

It is important to note that some food processors may not accept mancozeb-treated fruit or may have special restrictions on its use. This also applies to captan. Growers need to know where they are selling their fruit and if the buyer has any restrictions on pesticide use prior to initiating a control program in the spring.

**Ziram** is similar in efficacy to Mancozeb. It is highly effective against black rot, and provides good to moderate control of downy mildew and phomopsis cane and leaf spot. Ziram was recently labeled for use on grapes. The federal label reads "Apply before buds swell. Repeat after blossoming but before fruit forms," Ziram cannot be applied after bloom. This restriction gives Ziram no advantage over Mancozeb, so Mancozeb would remain the protectant fungicide of choice for black rot. Remember the 66 day PHI for Mancozeb.

Growers of processing grapes who cannot apply Mancozeb past the initiation of bloom should be able to make good use of Ziram. It could be used in the period from initiation of bloom to fruit formation (post bloom). This would allow at least one and possibly two additional fungicide applications after Mancozeb could no longer be used.

**Ferbam** will provide excellent control of black rot, but is not highly effective against the other grape diseases. In addition, there are restrictions on the number of applications that can be used. Always read and understand the label before using or purchasing a pesticide.

Captan, Benlate and copper fungicides (fixed copper or Bordeaux mixture) are only slightly to moderately effective against black rot and will probably not provide adequate control under heavy disease pressure.

**Sterol Inhibiting (SI) Fungicides**

The locally systemic fungicides, Bayleton and Nova, are also highly effective against black rot and will provide some post-infection (curative) activity of the disease if applied at the higher labeled rates and within 72 to 96 hours after the initiation of an infection period. Postinfection or curative control must be achieved prior to symptom development on leaves or fruit. Once the symptoms are present, these fungicides will not eradicate or burn out the fungus. Both Bayleton and Nova also appear to provide good protectant activity against black rot if applied at the lower labeled rates in a protectant program. These fungicides also have excellent activity against powdery mildew as well.

**Rubigan** and **Procure** are other SI fungicides that are registered for use on grapes and will provide moderate control of black rot if applied in a protectant program. These fungicides are in the same general class of fungicides as Bayleton and Nova, however, they do not provide adequate curative or post-infection control of black rot. Nova and Bayleton are the preferred SI fungicides for black rot control.

# Chapter 4 Grapes

## Fungicides for Powdery Mildew

Protectants: Sulfur is highly effective against powdery mildew if used in a protectant program with a minimum of 7 to 14 days between applications (Table 4.3). There are many formulations of sulfur (wettable powders, dusts, dry flowables and flowables). The flowable formulations appear to be most effective and result in much less applicator exposure when preparing sprays.

**Table 4.3. Effectiveness of fungicides for the control of grape diseases.**

| Fungicide | Phomopsis Cane and Leaf Spot | Black Rot | Downy Mildew | Powdery Mildew | Botrytis Rot |
|---|---|---|---|---|---|
| Bayleton | 0 | +++ | 0 | +++ | 0 |
| Benlate* | ++ | + | 0 | +++ | ++ |
| Captan | +++ | + | +++ | 0 | + |
| Ferbam | + | +++ | + | 0 | 0 |
| Fixed Copper and Lime | + | + | +++ | ++ | + |
| JMS Stylet Oil | 0 | 0 | 0 | +++ | ? |
| Mancozeb | +++ | +++ | +++ | 0 | 0 |
| Nova | 0 | +++ | 0 | +++ | 0 |
| Ridomil/Copper | + | + | +++ | ++ | + |
| Ridomil MZ-58 | 0 | + | +++ | 0 | 0 |
| Ridomil MZ-72 | 0 | + | +++ | 0 | 0 |
| Rovral | 0 | 0 | 0 | 0 | +++ |
| Rubigan | 0 | ++ | 0 | +++ | 0 |
| Sulfur | 0 | 0 | 0 | +++ | 0 |
| Ziram | ++ | +++ | ++ | 0 | 0 |

+++=highly effective, ++=moderately effective, +=slightly effective. 0=not effective, ?=activity unknown.

* Where Benlate-resistant strains of the powdery mildew and Botrytis fungi are present, Benlate will be ineffective and should not be used. Benlate is generally not recommended

| |
|---|
| for powdery mildew control in the midwest. |
| Note: The above ratings are intended to provide the reader with an idea of relative effectiveness. They are based on published data and/or field observations from various locations. Ratings could change based on varietal susceptibility and environmental conditions for disease development, or changes in fungal sensitivity to specific fungicides. |

**NOTE:** On sulfur-tolerant varieties that are susceptible to powdery mildew (Table 4.2), sulfur will be a major component of the fungicide program. On highly-susceptible varieties, spray intervals shorter than 14 days (7-10 days) will probably be required with sulfur. Although sulfur is highly effective for powdery mildew control, it has little or no effect on the other grape diseases (Table 4.3) it is important to remember that sulfur will cause severe injury on some grape varieties. Sulfur should only be used on varieties known to be sulfur tolerant (Table 4.2).

**NOTE: Chancellor, Concord, DeChaunac, Foch and Rougeon** grapes are *highly* sensitive to sulfur. Sulfur injury may occur even on sulfur tolerant cultivars when temperatures of 80 to 85 degrees F or higher are experienced during or immediately after application.

Copper fungicides (fixed coppers or Bordeaux mixture) have been rated moderately effective against powdery mildew, however, care must be taken when using copper due to the danger of foliage injury (phytotoxicity). Under heavy disease pressure, copper fungicides may not provide adequate control. Copper is not the preferred fungicide for powdery mildew control. However, if copper is applied for downy mildew control, it will provide some protection against powdery mildew. On less susceptible cultivars, such as Concord, copper fungicides may provide satisfactory control.

Benomyl was very effective against powdery mildew when it was first introduced, however, the development of resistant strains of the fungus to Benomyl have made it generally ineffective for powdery mildew control. Where resistant strains are not present, Benomyl should provide control; however, Benomyl is generally not recommended for powdery mildew control in the Midwest.

**Sterol Inhibiting (SI) Fungicides**

**Bayleton, Nova, Procure and Rubigan** are highly effective for control of powdery mildew. Bayleton and Nova will also provide excellent control of black rot, but it is important to remember that they will not control downy mildew.

**JMS Stylet-Oil** is a highly refined petroleum distillate that is registered for use on grapes in the United States. It has provided excellent powdery mildew control in fungicide tests in Ohio and New York and is currently being used rather extensively by California grape growers for powdery mildew control. It is registered for use at the rate of 1 to 2 gallons oil per 100 gallons water (1 to 2% concentration). The label states on grapes: "Make first application pre-bloom and continue sprays every two to three weeks depending on level of disease pressure. Use higher rates and shorter spray interval when disease conditions are severe."

Although this fungicide has not been used on grapes extensively in the Midwest or Northeast United States, it appears to have good potential as an alternative fungicide for powdery mildew control on grape.

**NOTE:** One potential problem with stylet oil is that it removes the "bloom" or waxy coating from the grape berry. This apparently has no effect on quality of wine or juice grapes, but it does affect the appearance of the berry and probably should not be used for fresh market "table" grapes.

DO NOT use CAPTAN or SULFUR within two weeks after applying JMS STYLET-OIL. Mixing Captan or Sulfur with oil could result in severe damage to the vine.

**Fungicide Resistance Management for Powdery Mildew**

The development of strains of the powdery mildew fungus with resistance to the sterol inhibiting (SI) fungicides (Bayleton, Nova, Procure and Rubigan) is a serious threat to their continued use for powdery mildew control on grapes. There is good evidence that strains of the fungus with resistance to Bayleton have developed in New York, Pennsylvania, and California. In order to prevent or delay the development of resistance, Bayleton, Nova, Procure or Rubigan should not be used alone for season long control of powdery mildew. This means another fungicide with good activity against powdery mildew should be incorporated into the spray program at some point during the growing season. If **Benomyl** cannot be used due to the presence of benomyl-resistant strains, the only alternatives at present are **sulfur, copper fungicides** or **JMS Stylet-Oil.** New fungicides with good efficacy against powdery mildew could be registered soon. Check with your local extension service for the most current fungicide recommendations.

One strategy for resistance management is to use the SI fungicides early in the season (bud break through 10-14 days after bloom) for control of primary infections of powdery mildew and black rot. At 14 days after bloom, the SI fungicides are replaced with either a sulfur fungicide, Copper fungicide or JMS Stylet-Oil.

---

# Chapter 4 Grapes

---

## Fungicides for Phomopsis Cane and Leaf Spot

At present **mancozeb, Ziram** or **Captan** are the fungicides recommended for control of this disease (Table 4.3). They are ranked as moderately to highly effective. Benlate has also been shown to be effective.

Fungicide test results indicate that **Bayleton** and Nova are not highly effective. Copper and sulfur fungicides appear to be ineffective.

NOTE: **Especially where Phomopsis is a problem or a concern, mancozeb, Ziram or Captan should be included in the early season fungicide program.**

---

# Chapter 4 Grapes

---

## Fungicides for Downy Mildew

### Protectant Fungicides

**Mancozeb, Captan and Copper fungicides** (fixed coppers and Bordeaux mixture) are highly effective for control of downy mildew (Table 4.3). Ziram is moderately effective. All of these fungicides are only effective when used in a protectant spray program. They will not provide post-infection or curative activity and will not eradicate or "burn out" the fungus after symptoms appear. Of the protectant fungicides currently available, mancozeb is an excellent choice. Mancozeb is highly effective against downy mildew, black rot and Phomopsis cane and leaf spot. One problem with Mancozeb is that it cannot be applied within 66 days of harvest. Even with this restriction, Mancozeb is an excellent protectant fungicide for early-season disease control, and can also be used on later maturing varieties for post bloom disease control (prior to 66 days of harvest).

**Captan** is also excellent for downy mildew and Phomopsis cane and leaf spot, but is weak for controlling black rot. A good approach to using Mancozeb and Captan for downy mildew control is to use Mancozeb early in the season then switch to Captan within the 66 day preharvest interval for Mancozeb. Currently Captan does not have a preharvest interval for grapes.

**NOTE:** Although Captan has no preharvest interval on grapes, it does have a 4-day reentry restriction. The following information is taken from the Captan label: "Do not allow persons to enter treated areas within 4 days following application unless a long-sleeved shirt and long pants or a coverall that covers all parts of the body except the head, hands and feet and chemically resistant gloves are worn. Conspicuously post reentry information at site of application." Remember, always read the label.

If these restrictions prevent you from using Captan, then Mancozeb, Ziram, Ridomil and Copper fungicides are the only alternatives at present.

**Ziram** is similar in efficacy to mancozeb. It provides moderate control of downy mildew, and excellent control of black rot and Phomopsis cane and leaf spot. A problem with Ziram is that it cannot be applied on grapes past fruit set.

**Locally Systemic Fungicide with Curative Properties**

**Ridomil (metalaxyl)** is by far the most efficacious fungicide available for control of downy mildew. Ridomil is "locally systemic" and has good post-infection or curative activity. If used in post- infection control programs, it should be applied as soon as possible, **but within** 2 to 3 days after the initiation of on infection period. Ridomil **should not** be applied after symptom development on sporulating lesions. Use of Ridomil in this manner (as an eradicant) will probably lead to a rapid buildup of Ridomil-resistant strains of the downy mildew fungus in your vineyard. If resistance develops in the vineyard, the use of Ridomil as a tool for downy mildew control is lost.

Ridomil also has excellent protectant activity against downy mildew. It should provide at least two weeks of protection, and in some tests in Ohio, it has provided up to 3 weeks of protection.

As mentioned previously, Ridomil has a strong potential for fungicide resistance development by the downy mildew fungus. For this reason the manufacturer (CIBA) has registered its use only as a **Package Mix** with a protectant fungicide. The two formulations available for use on grapes are Ridomil MZ 58 (10% Ridomil and 48% Mancozeb) and Ridomil/Copper 70W (10% Ridomil and 60% Copper hydroxide). The purpose of the package mix (at least in theory) is to delay the development of strains of the downy mildew fungus with resistance to Ridomil. The Ridomil MZ 58 formulation is being replaced by Ridomil MZ72 (8% Ridomil and 64% Mancozeb).

Both formulations are equally effective for controlling downy mildew. The Ridomil/Mancozeb formulation has the following advantages over Ridomil/Copper: 1) no lime is required; 2) more flexible timing of application; 3) can be applied on copper sensitive cultivars; and 4) up to four applications can be made.

Although Ridomil is very effective, the current label use recommendations restrict the timing of its use on grapes. The current labels read as follows:

**Ridomil MZ58:** "Apply 1.5 to 2.0 lbs per acre of Ridomil MZ58. Make up to 4 applications beginning before bloom; do not make an application within 66 days of harvest. For late season downy mildew control, apply other registered fungicides."

**Ridomil MZ72** has the same use recommendations as Ridomil MZ58, only it is used at the rate of 2 to 2 1/2 lbs. per acre.

**NOTE:** Other restrictions also apply. Always read the label.

**Ridomil/Copper 70W**--"Apply 1-2 lbs of Ridomil/Copper 70W at early bloom, 1-2 lbs at late bloom, and 1-2 lbs at cluster closing. Use lime with each Ridomil/Copper 70W application according to its label and individual state recommendations. For late season downy mildew control apply other registered fungicides. Do not apply within 66 days of harvest."

**NOTE:** Other restrictions also apply. Always read the label.

Based upon the above recommendations, Ridomil will be of limited use for late season downy mildew control in the Midwest. In seasons when downy mildew is a problem and on highly susceptible varieties, pre-bloom and post-bloom applications of Ridomil will aid greatly in disease control. However, additional fungicide protection may be required within the 66-day preharvest interval for both Ridomil formulations on late-harvested, highly susceptible varieties. The only alternative fungicides for use during this period are Captan and Copper fungicides.

**Copper fungicides** are highly effective against downy mildew and are moderately effective against powdery mildew. Copper fungicides are weak for controlling black rot. A major concern with the use of copper fungicides is the potential they have for phytotoxicity or "vine damage."

**NOTE:** Certain food processors, such as The National Grape Cooperative, will not accept grapes treated with mancozeb past the initiation of bloom, and the use of captan is not permitted at any time. If growers cannot use Mancozeb or Captan, Ridomil/Copper 70W or copper fungicides are the only other chemical alternatives for downy mildew control. Thus, copper is an important fungicide for producers of processing grapes that have these fungicide use restrictions.

**Botrytis Bunch Rot**
**(New York State Recommendations)**

Use Rovral 50WP at the rate of 1.5 to 2 lb per acre. Botrytis bunch rot is most commonly a problem on tight-clustered French hybrids and *Vitis vinifera* cultivars. Proper timing and thorough spray coverage are essential for good control. Make two applications: 1) when the disease is first observed or when the first berries reach 5 degrees Brix (5% soluble solids-/sugars), which ever comes first; and 2) 14 days after the first application. A third spray may be necessary on late cultivars, e.g., White Riesling, if the interval between the second spray and harvest is greater than 4 weeks. Field experience suggests that effectiveness of the fungicide is reduced following a heavy, prolonged rainfall. If such conditions occur after the last intended spray has been made, an additional application may be necessary. If only one application can be made, wait until the crop average is 5 degrees Brix. Direct the spray toward the fruit; use a minimum of 100 gal/A of water. Include a spreader-sticker, especially at the 1.5 lb rate.

NOTE: Growers in Europe and Canada have experienced loss of disease control due to the development of fungicide resistance when more than 3 sprays/year of Rovral were applied over a period of 3 to 5 yr. It is, therefore, strongly recommended that Rovral use be limited to a maximum of 3 application/year to reduce the probability of developing strains of Botrytis that are resistant to this material.

NOTE: Removal of leaves around clusters on mid- or low-wire cordon-trained vines before bunch closing has been shown to reduce losses caused by Botrytis in New York and California vineyards due to improved air circulation and improved spray penetration and coverage.

**Postharvest Applications**

On cultivars highly susceptible to downy mildew and powdery mildew, some post harvest application may be required to protect foliage and prevent premature defoliation. This is especially true on early harvested cultivars in southern regions of the Midwest.

---

# Chapter 4 Grapes

---

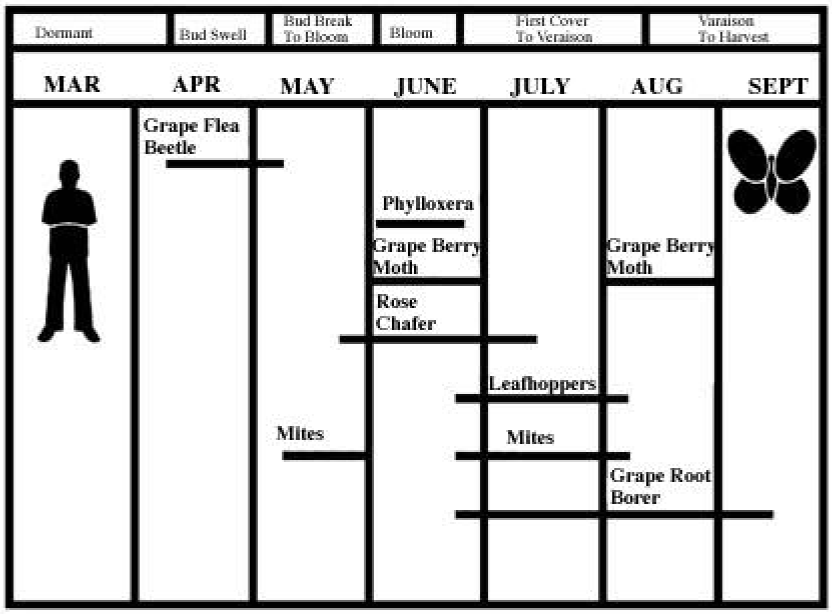
## Grape Insects and Their Management

### Introduction

The objective of the integrated pest management (IPM) program is to provide a commercially acceptable level of insect and mite control with minimal use of pesticides, applied at the appropriate times. This is accomplished by following an integrated insect management program which integrates the use of insect monitoring devices, cultural practices, resistant cultivars, a knowledge of insect behavior and biology, and pesticides (Table 4.4).

| Table 4.4. Effectiveness of Pesticides Used for the Control of Major Grape Pests in the Midwest. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Grape Berry Moth** | **Leafhoppers** | **Grape Flea Beetle** | **Japanese beetle** | **Grape phylloxera (foliar)** | **Rose Chafer** | **Mites** | **Grape Root Borer** | **PHI** |
| **Insecticides** | | | | | | | | | |
| Diazinon | ++ | ++ | - | - | - | - | - | - | 28 |
| Guthion (azinphosmethyl) | +++ | ++ | ++ | - | - | - | - | - | NTL,10* |
| Imidan (phosmet) | ++ | ++ | + | ++ | - | ++ | - | - | 14 |
| Lannate (methomyl) | ++ | ++ | - | - | - | - | - | - | 1,14** |
| Lorsban (chlorpyrifos) | - | - | - | - | - | - | - | ++ | 35 |
| Malathion | + | ++ | - | ++ | - | ++ | - | - | 3 |
| Marlate (methoxychlor) | + | ++ | ++ | ++ | - | + | - | - | 14 |
| Penncap-M (m. parathion) | +++ | +++ | +++ | +++ | - | +++ | - | - | 40 |
| Provado (imidacloprid) - | +++ | - | + | - | + | - | - | NTL | |
| Sevin (carbaryl) | ++ | +++ | +++ | +++ | - | +++ | - | - | 7 |
| Thiodan (endosulfan) | - | + | - | - | +++ | ++ | - | - | 7 |
| **Miticides** | | | | | | | | | |
| Kelthane (dicofol) | - | - | - | - | - | - | +++ | - | 7 |
| Vendex (fenbutatinoxide) | - | - | - | - | - | - | +++ | - | 28 |
| Rating system: +++ = highly effective; ++ = moderately effective; + = slightly effective; - = not sufficient data available. | | | | | | | | | |
| *See label restrictions on use. | | | | | | | | | |
| **One day fresh grapes, 14 days for wine grapes. | | | | | | | | | |
| PHI = preharvest interval; NTL = no time limitations. | | | | | | | | | |

Several species of insects and mites infest or feed on grapes in the Midwest. Damage is direct to the berry clusters or indirect to vines, shoots, roots, or leaves. Many of the pests are found only in certain regions, others only occasionally reach damaging population levels. Periodic vineyard inspections for these grape pests are an important part of the integrated pest management program for grapes (Figure 18). Much of the potential for reducing pesticides used on grapes will be in the area of insect control. IPM methods have been developed for monitoring and controlling insects which allow the grower more flexibility in making decisions on whether or not insecticides are needed, alternative control methods that might be applied, which control measure to apply, and when to apply them.




---

# Chapter 4 Grapes

---

## Insect Monitoring Devices

These devices are an important part of any IPM program. They have been developed for the most part to monitor adult activity. The devices themselves usually consist of some type of insect trap and a lure developed for a particular pest. Lures may consist of a feeding attractant, sex pheromone, or in some cases the shape or color of the trap alone is alluring. These devices provide a good indicator of adult activity and will help in the timing of cover sprays, increasing their effectiveness and eliminating the need for additional sprays. In some cases monitoring devices have been developed to the extent that they alone provide adequate control of the targeted pest, thus eliminating the need for pesticide completely. Most IPM programs use devices for monitoring and in some cases controlling insect outbreaks. See Appendix C for information on where to obtain various types of IPM supplies.

# Chapter 4 Grapes

### Cultural Practices

It is important to understand that insect pests may occupy different habitats during their life cycle. These include the grape canopy, weeds, sod or soil within the vineyard, and adjacent fields, fence rows, and woodlots. These habitats may provide refuge for vineyard pests and should be considered in any vineyard IPM program. Proper management of these habitats may be an important part of controlling a given vineyard pest.

---

# Chapter 4 Grapes

### Resistant Cultivars

**Cultivars that are known to be partially to fully resistant to certain insect pests should be considered when renovating an existing vineyard or planting a new one. Some cultivars have demonstrated resistance or tolerance to certain root dwelling insects. It should be noted however, that in many situations growers do not have the flexibility of avoiding susceptible cultivars. The demand for a specific juice or wine often dictates which cultivars are planted.**

---

# Chapter 4 Grapes

### Behavior and Biology

Understanding an insect's behavior and its biology helps determine the best method for controlling an individual pest. Knowing an insect's overwintering, reproductive, and feeding habits allows one to determine the best control method available as well as the best time to initiate it.

---

# Chapter 4 Grapes

---

## Identifying and Understanding the Major Insects and Mites on Grapes

Growers must be able to identify major grape pests so that correct management decisions may be made. It is also important that growers understand the life history and biology of the vineyard pest complex. Threshold levels and scouting techniques must be understood for each vineyard pest so that appropriate action may be taken. Management decisions should be made with a thorough understanding of the impact that pesticides might have on nontarget species, crop residues, water contamination, and the applicator's safety.

---

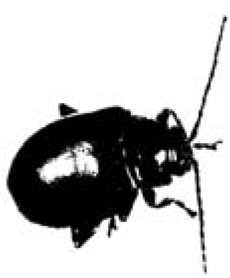
# Chapter 4 Grapes

---

### Insects That Attack Buds

#### Grape Flea Beetle

**(*Altica chalybea Illiger*; order Coleoptera, family Chrysomelidae)**



Grape Flea Beetle

**Description and Life Cycle**

The grape flea beetle occasionally is a serious pest of grapes in the Midwest. It is dark metallic greenish-blue or steel-blue and about 3/16 inch long. The most serious damage occurs in the spring. The flea beetles overwinter as adults and emerge during April. Upon emergence adult beetles begin to feed upon newly swollen grape buds, chewing holes in the ends and sides. Such damage destroys the capacity of a bud to develop a primary or secondary shoot. Once the buds have grown to a length of 1/2 inch or more, the beetles cannot cause significant injury.

Female beetles lay eggs mainly under loose bark of the grapevine. Larvae hatch and crawl to the developing grape leaves, where they feed on the upper surfaces. Adult beetles and larvae also feed on leaves, but the injury they cause usually is negligible. Newly hatched larvae of the grape flea beetle are dark brown and approximately 1/16 inch long. As they grow, their color lightens and they reach a length of almost 1/3 inch. The head is black, and there are six or eight shining black dots on each of the other segments of the body, each dot emitting a single brownish hair. The under surface is paler than the dorsum. Its legs, six in number, are black, and there is a fleshy, orange-colored proleg on the terminal segment. When they are fully developed, the larvae drop to the soil, burrow one inch or less and pupate. They emerge later as adults. There may be a partial or full second generation each year.

**Damage symptoms**

Flea beetles cause two types of damage. Larvae and adults feed on the upper and lower leaf surfaces, although this injury usually is not serious. The most serious damage occurs in the spring as the adults emerge from overwintering sites and feed on newly swollen grape buds. They chew holes in the sides and ends of the newly developing grape buds, damaging primary and occasionally secondary and tertiary buds. If all three buds are destroyed, no berries will be produced. If secondary or tertiary buds are not destroyed, a partial crop may develop, but could be lost to an early frost. These beetles do not cause major damage once the buds have grown to 1/2 inch or more.

**Management**

Grape flea beetles are most damaging in the spring, when they feed on buds. The adult beetles eat the contents of the buds, destroying foliage and fruit that normally would develop. Fortunately, the beetle attacks usually are confined to limited areas, so if growers are aware of these infestations, they can make an early-season insecticide application the following year to keep populations in check. Another application of spray in June, when larvae are feeding on the grape foliage, may help to control an outbreak the following year. Woodlots and wasteland areas near cultivated vineyards are a possible source of flea beetles and should be avoided if possible. This will help to reduce overwintering sites for the beetles. Cultivating between rows may contribute to control of the flea beetle pupae by exposing the delicate pupae to desiccation and death. Cultivating does not eliminate emerging beetles from under the trellis and adjoining woodlots.
Monitoring

Grape bud damage caused by the grape flea beetle is most often concentrated in vineyard borders near wooded areas. Early vineyard monitoring and past evidence of beetles in the vineyard will help determine the need for an early-season application of insecticide. Scouting of the vineyard for grape flea beetle should begin in late April and continue until bud development is past the critical stage. These shiny metallic beetles are easily spotted on grape canes and buds on warm, sunny days in the spring. Surveys looking for adult beetles should be conducted along the vineyard perimeter, on all sides and near the center of the vineyard. At least twenty-five vines should be surveyed at each of the five locations. If bud damage averages 4% or more, one should apply an insecticide.

**Control**

Brush and woodlots located near a vineyard can be a continual source of flea beetles and these areas should be cleaned up if possible. Cultivation of open areas between rows and around the vineyard can reduce the number of newly-emerging adults. However, one can not depend on this practice to control flea beetles. If beetles are present at bud swell, a broad-spectrum insecticide should be applied to prevent bud damage. This should be effective against adults migrating to vines from their hibernation sites; timing is critical. The following list of chemicals may be used for control of grape flea beetle.

| Chemical | Rate/acre of the commercial formulation |
|---|---|
| Sevin 50WP | 4 lbs. |
| Sevin 80S | 2.5 lbs. |
| Sevin XLR Plus (4L) | 2 qts. |

---

# Chapter 4 Grapes

---

## Insects Attacking Flower Clusters and Berries

### Grape Berry Moth

**(*Endopiza viteana* Clemens; order Lepidoptera, family Tortricidae)**

Grape Berry Moth

**Description and Life Cycle**

This is the major insect pest of grape berries in the eastern United States and Canada. When vineyards are left unmanaged, up to 90 percent of the fruit often is destroyed by the larvae and the diseases facilitated by the damage inflicted upon the fruit. Infestations vary greatly from vineyard to vineyard, from year to year, and within a vineyard. However, infestations bordering wooded areas are most vulnerable.

The adult is a mottled-brown-colored moth with some bluish-gray on the inner halves of the front wings. The larvae of this small moth are active, greenish to purplish caterpillars about 3/8 inch long when fully grown. Grape berry moths overwinter in cocoons within folded leaves in debris on the vineyard floor and within adjacent woodlots. After emerging in the spring, the adults mate and females lay eggs on or near flowers or berry clusters. Newly hatched larvae feed upon the flowers and young fruit clusters. Larvae that hatch in June make up the first generation of grape berry moth and will mature from mid to late-July or August. After mating, females lay eggs on developing berries, and this second generation matures in August or September. Larvae of the second generation, after completing their development, form cocoons in which they overwinter. A third generation occurs commonly in the southern range of the pest and occasionally in the northern tier of states.

**Damage Symptoms**

First-generation larvae web small flower buds or berries together in early June and feed externally on them or on tender stems. Larvae that attack grape bunches during this time are difficult to see.

Second generation larvae tunnel directly into the green berries and feed internally. Conspicuous reddish spots develop on the berries at the point of larval entry. Berries affected in this manner are known as "stung" berries. The second generation is potentially more damaging than the first. A single larva may destroy 2 to 6 berries in a cluster, depending on berry size, and several larvae frequently inhabit a single cluster.

At harvest, severely infected bunches may contain several larvae, and many of the berries may be completely hollowed. In many cases, bunches are covered with bunch rot fungi and infested with Drosophila spp. fruit flies, and often have an unhealthy appearance.

**Management**

**(How to survey a vineyard to determine percentage of clusters damaged.)**

A protectant insecticide may be needed to prevent damage in areas heavily infested by grape berry moth. The number of spray applications depends on the amount of infested berries the grower is willing to accept. Table grapes require more attention than grapes grown for juice. Corrective measures are usually suggested if more than 5% of the clusters are injured. To determine the percentage of clusters damaged, you should randomly inspect 100 clusters along the perimeter of the vineyard and 100 clusters toward the center of the vineyard. This method will tell you if treatment of the entire vineyard is necessary. Treatment of perimeter rows may be all that is necessary to control this pest. Control of maturing larvae in mid-to late-July is particularly important.

Cultural controls can be used to kill the overwintering pupae in leaves. Leaves can be gathered and destroyed in the fall, or leaves can be buried within the soil in the spring, two weeks before bloom, by rototilling or cultivating.

An alternate method of control using pheromone rope ties to disrupt the males of the grape berry moth was approved by the EPA in 1990. This method prevents mating, thus reducing the number of fertile grape berry moth females in a treated vineyard. This method is most effective in vineyards at least 5 acres in size. Ties are dispensed manually at a rate of 400 ties per acre. When a vineyard is under heavy pressure from berry moth, it may require spot treatment with an effective insecticide applied at the source of the infestation.

**Monitoring Male Moths**

Pheromone traps are available to monitor the emergence of male grape berry moths during the season. This information may be useful for optimal spray timing; sprays should target egg hatch and young larval activity, which occurs several weeks after the first moths are trapped. A minimum of three traps for monitoring a single block of approximately 10 to 15 acres is recommended. Traps hung from the top wire of the trellis should be placed around the perimeter of the vineyard before bloom and should be at least 100 feet apart. Sticky trap bottoms should be checked weekly for moths, and pheromone caps should be changed monthly to obtain accurate flight information. Every vineyard location is unique, and growers should not rely on pheromone trap data from other vineyards for timing insecticide sprays.

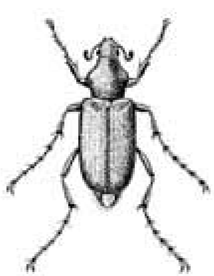
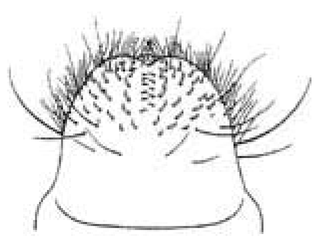
**Control**

Pheromone traps should be used in vineyards with a history of grape berry moth problems. Trapping of adult male moths indicates the beginning of flight activity. Mating and egg laying will occur over a 2 to 3 week period following the first detection of flight activity. A protective cover spray may be required during this period to prevent egg laying and hatch. Early season control of this pest may prevent it from becoming well established within the vineyard, and may eliminate the need for control later in the season. It should be noted that the second flight activity period occurring in late July and August is the most important. These adult moths in late summer produce the eggs which hatch into larvae capable of causing major damage to the maturing fruit. One should not depend solely upon a pheromone trap for detecting this late season threat. Scouting should be implemented on a weekly basis after bloom. If berry cluster damage reaches 6% in grapes used for processing or 3% in those grown for fresh market, a protective cover spray should be applied. The following list of chemicals may be used for control of grape berry moth.

| Chemical | Rate/acre of the commercial formulation |
|---|---|
| Guthion 35W | 2.1-2.8 lbs. |
| Guthion 50WP | 1.5-2.5 lbs. |
| Guthion 2 S | 3-4 pts. |
| Sevin 50WP | 4 lbs. |
| Sevin 80S | 2.5 lbs. |
| Sevin XLR Plus (4L) | 2 qts |
| . Imidan 50WP | 2 lbs. |
| Penncap-M[1] | 2 qts. |
| Isomate GBM[2] | 400 ties |
| 1 Studies indicate that Penncap-M provides the best control of grape berry moth. This is probably due to its microencapsulated, slow release formulation. | |
| 2 Studies indicate that vineyards in close proximity to external berry moth sources, such as woodlots, may require an application of insecticide in addition to the ties for control of this pest. Vineyards using these ties should continue to scout their plantings in the same manner as previously mentioned. If thresholds are reached, the decision to apply an insecticide should be considered. | |

## Rose Chafer

**(*Macrodactylus subspinosus* Fabricius; order Coleoptera, family Scarabaeidae)**

Rose Chafer, Adult  Rose Chafer Larva Raster Pattern

#### Description and Life Cycle

Rose chafer adults attack grapes at bloom as they emerge from the soil. Not only do they destroy the fruit at blossom, in addition, they frequently skeletonize the leaves, leaving only the large veins intact. This insect is especially abundant in areas of light, sandy soil where beetles may appear suddenly as grapes begin to bloom.

The ungainly beetles have a straw-colored body, reddish-brown head and thorax with a black undersurface. The adult rose chafer is about 0.5 inches in length with long, spiny, reddish-brown legs that gradually become darker near the tip. As they age, hairs are worn off the head and thorax with normal activity revealing the black color below. Thus, they become mottled in color as they mate and move around in the flower clusters, making it possible to distinguish newly emerged adults from older specimens. Females frequently lose more hairs, particularly on the thorax, in the mating process.

Eggs of the rose chafer are oval, white, shiny in appearance, and about 0.05 inches long and 0.03 inches in width. Larvae are C-shaped white grubs about 0.8 inches long and 0.12 inches wide when fully grown. Mature larvae have three distinct pairs of legs, a brown head capsule, and a dark rectal sac visible through the integument. Larvae are found in sandy soil feeding on grass roots and can be identified by a distinctive rastral pattern. The pupae are light yellowish-brown in color and have prominent legs. They measure about 0.63 inches in length.

Adult rose chafers become active in northeastern North America from late May to early June. The adults appear suddenly. It seems as though the entire population reaches maturity practically at the same time, and multitudes of beetles suddenly make their appearance. Beetles feed and mate soon after emerging from the soil. It is common to see mating pairs in the newly formed grape clusters. Females deposit eggs singly a few centimeters below the soil surface. Mating and egg laying occur continuously for about two weeks with each female depositing 24 to 36 eggs. The average life-span of the adult is about three weeks.

Approximately two weeks after being deposited, eggs hatch into tiny, white, C-shaped grubs. The larvae feed on the roots of grasses, weeds, grains, and other plants throughout the summer, becoming fully developed by autumn. However, it is not easy to collect the larvae of rose chafer. They have been found occasionally on the roots of orchardgrass but never in proportion to the numbers found in adjacent grapes. Larvae move downward in the soil as soil temperatures decline and form an earthen cell in which they overwinter. In the spring, larvae return to the soil surface, feed for a short time, and pupate in May. After two weeks in the pupal stage, the adults emerge and crawl to the soil surface to begin their cycle again. There is but one generation per year.

**Damage Symptoms**

Despite its common name, the rose chafer attacks the flowers, buds, foliage, and fruit of numerous plants including grape, rose, strawberry, peach, cherry, apple, raspberry, blackberry, clover, hollyhock, corn, bean, beet, pepper, cabbage, peony, and many more plants, trees, and shrubs. Adults emerge about the time of grape bloom and often cause extensive damage to foliage. Blossom buds are often completely destroyed, resulting in little or no grape production. Feeding activity on various plants may continue for four to six weeks. Damage can be especially heavy in sandy areas, the preferred habitat for egg-laying. A toxin present in the beetles may kill poultry.

**Management**

Adult chafers begin emerging in late May and early June at the time of grape bloom. A spray application is recommended if more than two beetles per vine are present. If only a few beetles are present, they may be handpicked from the vine and destroyed. The pupal stage is extremely sensitive to disturbance, therefore cultivating between rows may be effective in destroying a good number of chafers. However it is our experience that growers with numbers of beetles sufficient to inflict economic damage will not be able to control this pest by this method of cultural control. An alternative method to chemical control has been developed by the department of Entomology at Ohio State University for this pest. This method uses a very powerful feeding attractant and a Japanese beetle trap. Intensive trapping over a four year period reduced the population to below the threshold level of two beetles per vine. An application of insecticide may be required in combination with the trapping effort if the population is extremely high. It is our experience that it takes a couple years of intensive trapping to reduce the population within a heavily infested vineyard to the point that chemicals are no longer needed to control this pest.

**Monitoring**

Scouting for this pest within your vineyard should begin in late May and continue through late June. Newly emerged adults may be found feeding upon young grape buds and foliage. If numbers reach two beetles per vine, control methods should be used. Monitoring may also be conducted by using the attractant developed for rose chafer. Traps should be placed around the perimeter and dissecting the vineyard. For monitoring purposes, these traps may be spaced every 100 ft. and should be checked daily for newly emerged chafers. If beetles are encountered, control methods should be considered if beetles average two or more per vine.

**Control**

When only a few beetles are present, one may handpick them from the plant and destroy them. Where populations are large and pose a threat to the grape crop, massive trapping may be a safe alternative to applying insecticide. Results using this new powerful attractant have been very positive. The desired effect of mass trapping, which is to bring the beetle population to below threshold level, is usually achieved after a couple years of trapping. Chemical control methods should be used when beetle pressure exceeds an average of two beetles per vine. To determine the number of beetles per vine, one should randomly survey 25 vines at all four corners of the vineyard and 25 in the center of the vineyard. This will give you the total number of beetles present on 125 vines surveyed. Divide the number of vines (125) by the number of beetles present to obtain the average number of beetles per 125 vines. If this average is above two beetles per vine, then treatment is recommended. It should be noted that with this survey method, one can determine if the chafer infestation is present throughout the vineyard or just located in a specific area. If the area is localized, spot treatment of the infestation may be all that's required. Treatment with an insecticide should be after bloom when the first newly emerged beetles are detected in adequate numbers to pose concern. A second application may be required if pressure is severe and rainfall is frequent. Protection of the young grape cluster is critical and should be maintained throughout June. The following list of chemicals may be used for control of rose chafer.

| Chemical | Rate/acre of the commercial formulation |
|---|---|
| Guthion 35W | 2.1 - 2.8 lbs. |
| Guthion 50WP | 1.5 - 2.5 lbs. |
| Guthion 2 S | 3 - 4 pts. |
| Sevin 50WP | 4 lbs. |
| Sevin 80S | 2.5 lbs. |
| Sevin XLR Plus (4L) | 2 qts |
| . Penncap-M | 2 qts. |
| RC Feeding Attractant | 35 traps per acre |

---

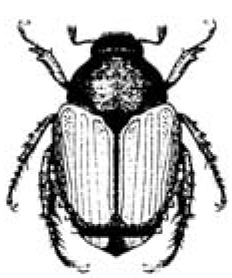
# Chapter 4 Grapes

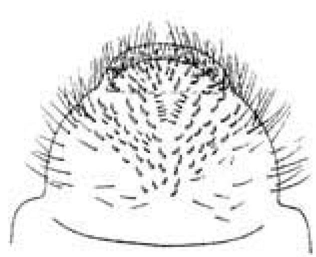
---

## Insects Attacking Grape Foliage

### Japanese Beetle

**(*Popillia japonica* Newman; order Coleoptera, family Scarabaeidae)**





Japanese Beetle Larva Raster Pattern

#### Description and Life Cycle

The adult beetles feed on the foliage and fruits of more than 250 kinds of plants, but grape is one of the preferred hosts. The larvae are C-shaped grubs found in the soil, and are serious pests of grass roots. The adult beetle has a shiny, metallic-green head and thorax, and coppery-brown wing covers. Tufts of white hairs are located along the sides of the body. Adult beetles are about 1/2 inch long.

This insect overwinters as a larva below the soil surface (Figure 19). Larvae feed principally on grass roots. During late spring, larvae move closer to the soil surface and complete their development; adults emerge in late-June or early-July. Eggs are laid in the thatch layer of soil and take 10 days to hatch. There is one generation per year.

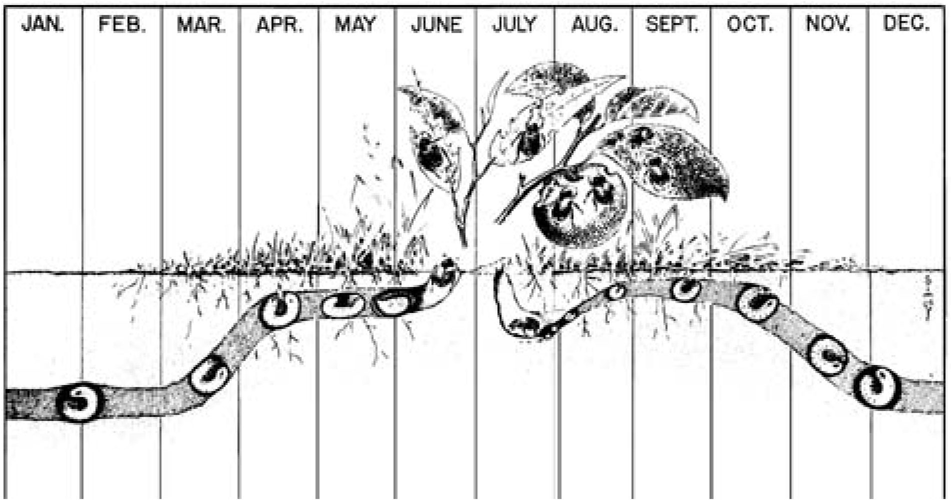



Figure 19. Life cycle of Janapese Beetle.

Adult beetles emerge from the ground in June and July, and begin feeding upon foliage. Mating occurs at this time and eggs are laid in the ground. Eggs hatch in August and young grubs begin feeding on plant roots. Grubs continue to feed and grow until cold weather, at which time they tunnel 3 to 12 inches down and make overwintering cells. In the spring when soil begins to warm, grubs move toward the surface where additional feeding may occur before pupation in May.

**Damage Symptoms**

The adults feed on the leaves of both wild and cultivated grapevines. Beetles prefer foliage exposed to direct sunlight and often are seen clustered together feeding on tender vegetative parts. Vines with thin, smooth leaves, such as French hybrids, are preferred over those with thick, pubescent leaves, such as Concord. Concord vineyards rarely need special control sprays for Japanese beetles. On the other hand, French hybrids and other thin-leaved cultivars require frequent inspection to prevent damage. Damaged leaves have a laced appearance, and severely affected leaves will drop prematurely.

**Management**

There is no economic threshold on the number of beetles or amount of damage that requires treatment. If a susceptible cultivar is being grown and growers previously have experienced high populations of Japanese beetles, an insecticide should be applied when beetles emerge and thereafter as needed.

**Monitoring**

A Japanese beetle lure and trap is available for monitoring this pest, however these beetles are easily detected while walking through the vineyard. If skeletonizing of leaves becomes evident, thin leaved cultivars may need to be protected with an application of insecticide. The usual threshold for making a spray application is about 15% of the leaves damaged.

#### Control

Insecticide is usually applied when feeding is apparent on most vines and skeletonized leaves are found. Spot treatment is adequate in some cases. An insecticide with long residual activity is needed when beetle populations are high. Repeated applications may be needed to control new beetles flying in from surrounding areas.

A microbial insecticide is available to control Japanese beetle grubs in turf, although it is slower acting and more expensive than conventional insecticides. This substance is bacterial in nature and causes milky spore disease within the grub stage of development. This microbial insecticide can not be relied upon to protect grapes from Japanese beetle. The following list of chemicals may be used to control Japanese beetle.

| Chemical | Rate/acre of the commercial formulation |
|---|---|
| Guthion 35W | 2.1-2.8 lbs. |
| Guthion 50WP | 1.5-2.5 lbs. |
| Guthion 2 S | 3-4 pts. |
| Sevin 50WP | 4 lbs. |
| Sevin 80S | 2.5 lbs. |
| Sevin XLR Plus (4L) | 2 qts. |
| Penncap-M | 2 qts. |

### Grape Phylloxera

#### (Daktulosphaira vitifoliae [Fitch]); order Homoptera, family Phylloxeridae)

#### Description and Life Cycle

Phylloxera is one of the most destructive grape pests worldwide. This small aphid-like insect has a complex life cycle that involves survival on the roots throughout the year, and on the leaves during the growing season (Figure 20). The sequence of events in the life cycle is different for the foliar and root forms of this insect. The foliar form survives the winter as an egg under the bark of the grapevine. Asexual, wingless forms hatch in the spring and crawl onto the new leaves, where they develop galls. Young crawlers settle on the upper surface of immature leaves, causing galls to form on the under surface of the leaves. The only opening in a gall is to the upper leaf surface. Once mature, the female begins to lay eggs within a gall. Nymphs hatching from these eggs crawl to new leaves at shoot tips, settle on the leaves, and form new galls.

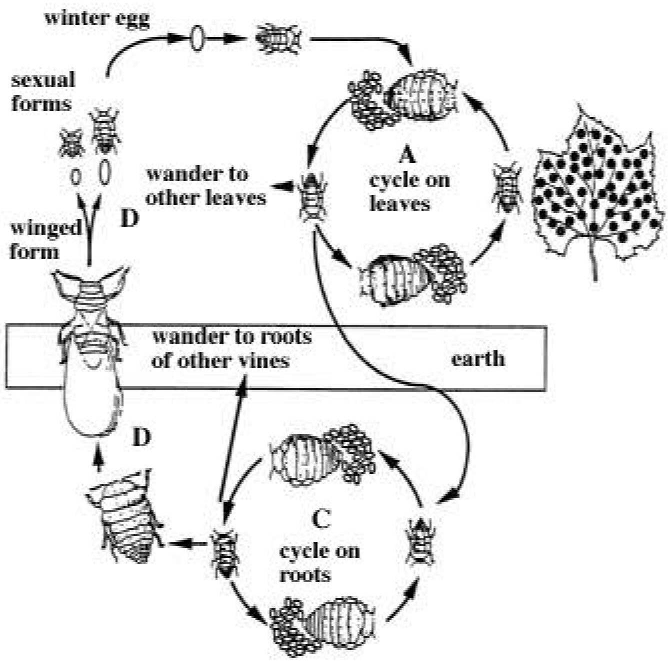



Figure 20. Life cycle of the Grape Phylloxera

In the case of the root form of grape phylloxera, the insects overwinter as immature forms on the roots. These forms mature in the spring and produce eggs that hatch into nymphs. The nymphs then start new galls on the roots. Winged forms develop in the spring, summer or fall and emerge from the soil to lay eggs on stems. These eggs hatch and produce the true sexual forms that produce the overwintering eggs laid under the bark. Several generations of each form of phylloxera may occur each season. Although the two forms behave differently, both belong to the same species of phylloxera that occurs on the leaves and roots of grapes.

**Damage Symptoms**

The insect forms galls on the leaves and roots of grapevines. The vine will die if its roots become heavily infested with phylloxera. If leaves become heavily infested, premature defoliation and retarded shoot growth may result.

**Management**

In many areas of the world, susceptible cultivars are grafted onto resistant rootstocks to prevent damage by the root form. However, the foliar form still may occur in such cases. Currently only one insecticide is labeled for the foliar form of grape phylloxera. There are some natural predators which feed upon the foliar form of grape phylloxera, but none of these provide adequate control of the pest. There is no known completely successful chemical control for the root form of grape phylloxera. Eastern growers usually do not have a problem with the root form of the phylloxera.

**Monitoring**

Phylloxera is usually spotty in Ohio vineyards, so identifying these areas within your vineyard is important. Spot treatment may be all that is required to control this pest. To identify the location and extent of phylloxera within a vineyard, one should begin scouting for infested leaves after shoot length has reached five inches. Young galls will be forming on the underside of the terminal leaves; they are not easily noticed early in the season without taking the time to inspect the leaves closely. These galls should not be confused with grape tumid galls, commonly called the grape tomato gall. Tumid galls have a smooth outer surface and take on a reddish tomato-like appearance whereas the grape phylloxera gall is green in appearance except early in the season when young grape leaves tend to have more of a reddish cast to them. The gall itself has a rough looking surface rather than the smooth surface of the tumid gall. Tumid gall is present but not a problem in Midwestern vineyards.

**Control**

Native American grapes tend to have resistance to grape phylloxera and are not a problem, however French hybrid and vinifera grapes are usually very susceptible and control of phylloxera on these cultivars is recommended. One can not usually completely eradicate phylloxera from a vineyard that is already infested but can take measures to keep the infestation at a tolerable level. Control of the foliar form of phylloxera may be achieved by applying insecticide at bloom and again 10 to 14 days later. Late season treatment of grape phylloxera is not effective and is a waste of time and money. Early season control of this pest is critical. Currently endosulfan (Thiodan) is the only insecticide labeled for controlling the foliar form of grape phylloxera. This compound may be phytotoxic to some cultivars under certain environmental conditions. The product label lists cultivars that are sensitive to endosulfan.

| Chemical | Rate/acre of the commercial formulation |
|---|---|
| Thiodan 50WP | 2 lbs. |
| Thiodan 3EC | 1 1/3 qt. |

# Chapter 4 Grapes

## Leafhoppers

### Potato Leafhopper

**(*Empoasca fabae* [Harris]) order Homoptera, family Cicadellidae)**

**Description and Life Cycle**

The potato leafhopper, a sucking insect, feeds sporadically on grape foliage. The adult leafhopper is pale to bright green, wedge-shaped 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 run forward, backward or sideways rapidly when threatened. The potato leafhopper feeds on more than 200 plant species.

The potato leafhopper does not overwinter in areas north of the Gulf States. Each year large numbers of potato leafhoppers are carried to northern areas by warm spring air currents. Injury to grapes occurs when the adults fly into vineyards and feed on the leaves. Toxins injected while feeding cause leaves to cup and be misshapen. These leaves are often in the top of the vine and are quite obvious, especially at the end of the growing season.

### Eastern Grape Leafhopper

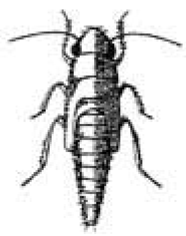
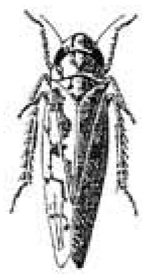
**Erythroneura comes [Say]**

### Three-banded Leafhopper

**Erythroneura tricincta Fitch**

### Virginia Creeper Leafhopper

**Erythroneura ziczac Walsh**

Leafhoper, Nymph Leafhopper, Adult

These are three of the most common leafhoppers found on grapes in Ohio and they belong to the same genus *Erythroneura*. These three species vary in their coloration and markings.

The adults of these leafhoppers are about 1/8 inch long. *E. comes* is pale yellow or white with yellow, red, and blue markings. Overwintering adults are often nearly all red. *E. tricincta* is brown and black with touches of orange on the wings. *E. ziczac* is pale yellowish or white with a zigzag stripe down each wing and cross veins distinctly red.

The biology of these three species is similar. They overwinter as adults in sheltered places such as the remains of old plants. During the first warm spring days the leafhoppers become active, and they feed on the foliage of many different plants until grape leaves appear. Eggs are deposited under the leaf epidermis; they hatch in about two weeks. The immature leafhoppers, or nymphs, are wingless; they remain and feed on the leaves where they hatch. Nymphs molt five times, then transform into adults. There are two or three generations of leafhoppers each season.

**Damage Symptoms**

Adults and nymphs feed on leaves by puncturing the leaf cell and sucking out the contents. Each puncture causes a white blotch to appear on the leaf. In heavy infestations, the leaves turn yellow or brown, and many will fall off. Feeding by these leafhoppers may reduce the photosynthetic capacity of the plant, and the quality and quantity of the fruit may be affected.

Grapevines can tolerate populations of up to 15 insects per leaf with little or no economic damage. However, heavy leafhopper feeding may result in premature leaf drop, lowered sugar content, increased acid and poor coloration of the fruit.

The sticky excrement (honeydew) of the leafhoppers affects the appearance, and supports the growth of sooty molds. Severely infested vines may be unable to produce sufficient wood the following year. Damage to the vine can be serious if infestations are allowed to persist unchecked for two or more years.

**Management**

Weeds and trash in and around a vineyard is a source of leafhoppers. If this material is cultivated before spring, the adults lose their protection and feeding sites, although in areas with extensive agriculture this practice has less value as the adults will just move to an adjacent crop or weedy area.

Certain cultivars are likely to suffer higher leafhopper populations than others. Wine and table grape varieties fit this criteria. Moreover, late-producing cultivars are more likely to favor leafhoppers than early maturing cultivars.

#### Monitoring

Vigorous vines are preferred by leafhoppers. The heaviest populations are normally found on end vines and on outside rows. This is partly because these vines are usually the most vigorous and therefore the most attractive. It also is partly because of the border or boundary effect. Vigorous vines fortunately can tolerate the highest populations.

Sampling for leafhoppers should be done at 10 days post-bloom, the third week in July, and again the third to fourth week of August. This is approximately the same time one should be assessing grape berry moth risk and both surveys may be conducted at the same time.

**Ten Days Post-bloom**--Only adult leafhoppers are present at this time of the year, so it is not necessary to count them. If leafhoppers are present, you should see stippling damage on the lower "sucker" leaves and interior leaves of the grape canopy. By shaking the vines, adult leafhoppers, if present, will fly around the vine. If stippling damage is present throughout the vineyard, an application of insecticide is recommended to prevent later damage from occurring. Early season damage may indicate that populations may potentially build up to damaging levels later in the season. In vineyards that are at high risk for grape berry moth, insecticide is usually applied at this time, so scouting for leafhoppers at this time is not necessary.

**Third Week in July**--By mid-to-late-July, first generation nymphs are present and feeding on the undersides of grape leaves. At this time, the need to apply an insecticide for leafhopper control should be determined on a block by block basis. Sampling for grape berry moth and leafhoppers can be done with a single pass through the vineyard.

The first step in evaluating leafhopper damage is to look for stippling on leaves while you are doing counts of grape berry moth damage. Most damage will be found on the first seven leaves from the base of the shoot. If no stippling or minimal stippling is visible on the leaves, there is no point in counting how many leafhoppers are present. If moderate to heavy stippling is visible, then it is necessary to do counts of leafhopper nymphs to determine if damage levels warrant treatment. The sampling procedure for leafhoppers requires counting all leafhoppers on the undersides of the third through seventh leaves of one shoot on each of five vines. Sampling for leafhoppers should take only a few minutes per vineyard.

**Late August**--In years when leafhoppers do build up to damaging levels in vineyards, it is most common for them to do so in late August. Vineyards with greater than 10 leafhoppers per leaf should be treated at this time. If there is very little visible stippling, sampling will not be necessary. Vineyards that had insecticides applied to them earlier in the season will probably not need treatment at this time. In Ohio we experience more of a problem with leafhoppers on the islands in Lake Erie and in vineyards near Lake Erie.

#### Control

Leafhoppers have few natural enemies. Cold and wet weather conditions in spring and fall are damaging to leafhopper populations, as are wet winters. Cultivation and cleanup of adjacent weedy land in the fall will eliminate favorable overwintering sites in and near a vineyard.

When high populations of leafhoppers are encountered, an application of a contact insecticide may be required. In order to obtain good control of leafhoppers, complete coverage of the undersides of the leaves is important. Coverage of the fruit is of secondary importance. The following compounds are registered for control of leafhoppers on grapes.

| Chemical | Rate/acre of the commercial formulation |
|---|---|
| Guthion 35W | 2.1-2.8 lbs. |
| Guthion 50WP | 1.5-2.5 lbs. |
| Guthion 2 S | 3-4 pts. |
| Sevin 50WP | 4 lbs. |
| Sevin 80S | 2.5 lbs. |
| Sevin XLR Plus | (4L)2 qts. |
| Penncap-M | 2 qts. |

# Chapter 4 Grapes

## Insects Attacking the Roots and Crown

### Grape Root Borer

**(*Vitacea polistiformis* [Harris]; order Lepidoptera, family Sesiidae)**

Grape Root Borer

**Description and Life Cycle**

Larvae of the grape root borer attack the larger roots and crown of grapevines. They tunnel into these parts of the plant and feed internally. The feeding and boring of the larvae will weaken and may eventually kill the vine.

The adult is a clearwing moth, with the forewings brown and the hindwings clear with brown borders. The body mimics that of a wasp, brown with yellow markings. Male moths measure about 5/8 inch in length, while the female is larger, about 3/4 inch long. The moths emerge from the soil during July and August (Figure 21). Eggs are deposited individually on grape leaves or weeds, or dropped on the ground close to the trunk. The larvae hatch and burrow into the soil, find their way to the roots and crown, and feed on them. Larvae continue to feed within the vine's root system for about 22 months. A fully developed larva is about 1 1/2 inches long and white with a brown head capsule. Mature larvae move to places just under the surface of the soil and pupate in earthen cells. Adults start emerging in July and continue to emerge through August.

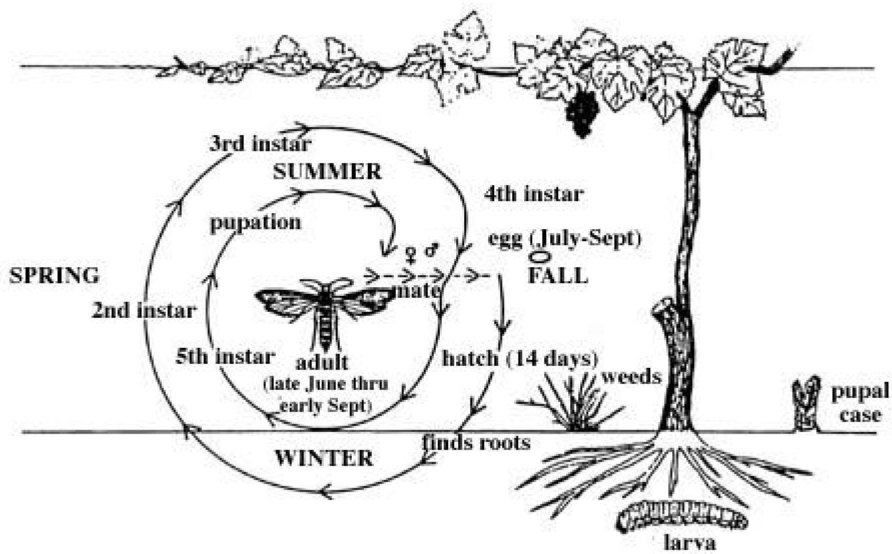



Figure 21. Life cycle of grape root borer.

#### Damage Symptoms

Larvae attack the roots and crown of grapevines. They tunnel into the roots or crown and feed internally. Feeding and boring weaken the grapevine and may eventually kill it. Larvae also provide entry points for disease organisms. Vines that are severely infested may wilt under stress; sometimes only part of the vine will show stress.

#### Management

Weed control is important in managing this insect pest. Weed control decreases the number of oviposition sites and provides an area under the trellis suitable for applying an insecticide. Researchers in North Carolina also have achieved good control of root borers with polyethylene mulch; this technique can be easily accomplished at planting. It works well for a while but the mulch must be maintained over the years in order to be successful.

An alternative method of control using pheromone rope ties to disrupt the males of the grape root borer is being tested by researchers at Ohio State University. This method prevents the male root borers from locating the female borers and mating, thus reducing the number of fertile root borer females in a treated vineyard. Ties are dispensed manually at a rate of 100 ties/acre. They should be placed on the top trellis wire every 6 or 7 vines. Results from these trials look promising, but bringing the borer population down to acceptable levels requires several years. Another method of using the grape root borer pheromone for control is being studied at two southern Ohio vineyards. This method uses the sex pheromone and 1C pherocon traps. Traps baited with the pheromone are placed throughout the vineyard in an attempt to reduce the number of males available for mating. Three years of study has shown the male population is continuing to decline by an average of about 30% per year.

External woodlots containing wild grapes are a good source of grape root borers. Such areas adjacent to vineyards should be considered when trying to manage this pest. Extermination of wild grapes from within these areas may help to reduce root borer pressure.

Chemical control of this pest is difficult due to its cryptic nature. Chlorpyrifos is the only chemical currently labeled for control of grape root borer.

This treatment should be applied to the ground immediately under the grape trellis when the first adults are captured in the pheromone traps. This application provides a toxic barrier which newly hatched larvae must penetrate to gain access to the grape vine's root system.

#### Monitoring

Pheromone traps are the only means to easily monitor this pest. Response by male root borers to this sex pheromone is strong. A minimum of three pheromone traps should be placed transecting the vineyard in a diagonal manner. Traps should be in place by late June and checked on a weekly basis thereafter. A single pheromone cap within a trap will last the entire season.

#### Control

Trapping-out uses the sex pheromone placed within 1C pherocon sticky traps. This method is still experimental at this time but certainly appears to be working. Traps are placed around the vineyard perimeter in late June at 35 to 50 foot intervals. These traps should be checked on a weekly basis. Where infestations are high, many borers will be trapped resulting in the need for removal of some of the trapped adults or replacement of the trap bottoms. This method requires a continued effort year after year to reduce pressure in subsequent years.

Chemical control of emerging adults or entering newly hatched larvae will give some assistance if repeated over a wide area. Applications of chlorpyrifos (Lorsban) to the ground immediately under the grape trellis should be made when the first adult males are trapped. Use Lorsban 4E for control of grape root borer by treating just before the pest emerges from the soil. In southern Ohio this would be the last week of June or very early in July. Mix 4 nitrogen 1/2 pints of Lorsban 4E with 100 gallons of water and apply 2 quarts of the diluted spray mixture to the soil surface on a 15 square foot area around the base of each vine. Do not allow spray to contact fruit or foliage. Do not make more than one application per season or apply within 35 days before harvest. Based on residue data, the use of Lorsban 4E in grapes is restricted to states east of the Rocky Mountains.

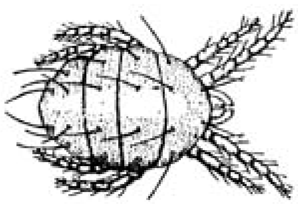
| Chemical | Rate/acre of the commercial formulation |
|---|---|
| Isomate GRB ties | 100 ties |

# Chapter 4 Grapes

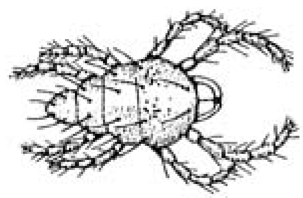
## Mites that Attack Grapes

### European Red Mite

**(*Panonychus ulmi* [Koch]; order Acari, family Tetranychidae)**



European Red Mite, Female



European Red Mite, Male

#### Description and Life Cycle

The European red mite causes considerable damage to apples in some orchards; it also becomes a problem in vineyards from time to time.

The adult female of the European red mite is dark red to reddish-brown, has eight legs and is about 1ò50 inch long. Adult male mites are smaller than females and have a pointed abdomen; they are usually dull green to brown. Eggs, which are globe-shaped and red, are laid on the undersides of leaves in the summer. The eggs are tiny and require a magnifying glass to be seen. During late summer and early fall, eggs are laid around cane nodes, where they overwinter. Several generations occur each season.

#### Damage Symptoms

The adults and nymphs of this species feed on the undersurfaces of leaves, and in heavy infestations, the leaves turn a bronze color. If bronzing occurs early enough in the season, a negative effect on fruit ripening may occur as feeding may interfere with the normal photosynthetic process of the leaves.

#### Management

Growers should apply miticide sprays before bronzing occurs. In some vineyards, this pest is kept at low levels by naturally occurring predatory mites and predaceous insects.

#### Monitoring

Monitoring for European red mite can be accomplished by looking at the underside of the leaves for their presence at the same time you are scouting your vineyard for leafhoppers and grape berry moth. You may also keep a close eye out for bronzing while traveling through the vineyard on your tractor. This can be done at the same time you're applying fungicide sprays to the vineyard.

**Control**

Fortunately, predaceous mites on grapes show considerable resistance to a number of organic pesticides, in particular the organic phosphates. Some chemicals reduce leafhopper and/or spider mite populations while allowing predaceous mites to maintain control of the latter. Ideally, treatments should be applied so that mites are reduced below economic levels without killing predaceous mites or reducing their food source to the extent that they starve. The following list of miticides are available for controlling mites in the Midwest.

| Chemical | Rate/acre of the commercial formulation |
|---|---|
| Vendex 50WP | 1-2.5 lbs. |
| Vendex 4L | 1-2.5 pts. |
| Kelthane 35WP | 1.5-3.5 lbs. |
| Kelthane 50WP | 1-2.5 lbs. |

# Ohio State University Extension Fact Sheet


## Horticulture and Crop Science

**2021 Coffey Rd., Columbus, Ohio 43210-1086**

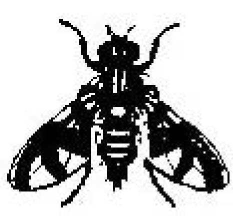

---

# Apple Maggot And Its Control

**HYG-2041-88**

**Richard L. Miller**
**Julie A. Steele**
**Alan W. Smith**

The apple maggot, *Rhagoletis pomonella* (Walsh), is a native insect widely distributed from North Dakota to Oklahoma and eastward. It is a major pest of homegrown apples in Ohio and, occasionally, is damaging in commercial orchards when certain insecticides are omitted. Hawthorn, plum, pear, crab apple, and cherry may serve as alternate hosts.



**Apple Maggot**

### Nature and Cause of Injury

The adult fly is a little more than 6 mm in length, dark brown, with light and dark markings on the wings. The larvae are white, tapered maggots. Female flies lay eggs just under the skin of the apple. The larvae, or maggots, which hatch from the eggs, tunnel at random throughout the flesh of the fruit, usually avoiding the core. External signs of maggot infestation are the minute brownish egg punctures in the skin. These are often small, distorted or pitted areas on the surface of the apple, and sometimes a white wax covers the puncture. In early-maturing apple varieties, small tunnels occur throughout the flesh and under the skin through which the trails of the larvae may be visible.

Rapid decay and browning along the trails in infested fruit occur as the maggots feed. In late-maturing apples, there are less distinct external signs of infestation, but the flesh may contain small corky spots and discolored trails or streaks.

## Life Cycle

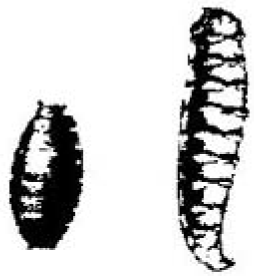
In Ohio, the apple maggot overwinters as a pupa in the soil. Adult flies begin emerging from their pupae in late June, continuing for a month or more. The peak emergence occurs from late July to early August, but some adults emerge in September.

When flies emerge, they usually spend about 10 to 14 days flying from tree to tree. During this period, the adults mate and females feed by lapping up moisture from the surface of leaves and fruits. Then they begin laying eggs.

The female has a needle-sharp egg-laying structure (ovipositor) at the tip of her abdomen that enables her to puncture the skin of the fruit. Each female is capable of depositing an average of 200 eggs. Eggs hatch in a few days, and the small, legless, white maggots immediately start to burrow through the flesh of the fruit. This burrowing often causes premature dropping of the fruit. Infested fruits have very little (if any) market value.

The maggots feed by tearing open cells in the apple flesh with a pair of black mouth hooks. They then absorb the cell juices. If the fruit is near maturity, growth is rapid and the larvae become fully grown and leave the fruit in 8 to 12 days. However, if eggs are laid in firm, immature fruit or in winter apple varieties, growth is much slower and many maggots may die due to the hardness of the fruit. If apples fall to the ground, the number of surviving larvae is larger.

The maggot leaves through a small opening made in the side of the fruit and enters the soil. Maggots usually settle in the top 1 to 3 inches of soil. The maggot transforms into a brown, hard, oval puparium within which the true pupa is formed. Some of the first brood pupae transform to adults and emerge in late August and September. However, the majority remain in the soil through two winters before appearing as adult flies.



**Puparium and Larva**

## Control Measures

### Non-Chemical Control

Few maggots leave the fruits while they are still hanging on the trees. Usually a few days elapse between the time an apple maggot-infested apple falls to the ground and the maggots leave it.

Dropped fruits of early varieties should be collected two to three times a week and those of later varieties at least once a week. Collected fruits should be put in a tightly sealed plastic bag and placed in a garbage can. In addition, the removal of hawthorn or other alternate hosts in the vicinity is a good practice.

### Chemical Treatment of the Soil

As mentioned, maggots leave the fruit that has fallen to the ground, burrow into the soil and change to the pupa stage. Therefore, an insecticide applied to the ground around the trees should aid in killing apple maggots. The timing of the application must be around July 1-15.

### Chemical Spraying of Trees

Newly emerged female flies feed for a short time before they deposit their eggs. The flies obtain moisture by lapping up water droplets that collect on the fruits and leaves.

You can take advantage of this feeding habit to eliminate the females before they lay eggs. If you can apply an insecticide spray to the trees, at the right time, the flies will be killed as they feed on the toxic water and before they can harm the fruit. Spraying is the most reliable method of reducing maggot injury to apples. The use of an all-purpose fruit spray mixture plus the insecticides phosmet (Imidan) or carbaryl (Sevin 50 WP) should produce a spray that will adequately control the flies. Sprays for maggots should be applied in late June, mid-July, late July, and again in mid-August.

For more detailed information on apple maggot and other fruit pests, obtain a copy of Bulletin L-1, "*Backyard Fruit Sprays for Insects and Diseases*," or Bulletin #506A, entitled "*Commercial Tree Fruit Spray Guide*," from your county Extension agent.

**Waiting Time Between Spraying and Harvesting**

When using an insecticide on edible fruits, a period of time must be observed when no spray is applied to prevent excessive residues of the insecticide on the harvested fruit. Examine your pesticide label to determine these day limitations.

---

NOTE: Disclaimer - This publication may contain pesticide recommendations that are subject to change at any time. These recommendations are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. Due to constantly changing labels and product registrations, some of the recommendations given in this writing may no longer be legal by the time you read them. If any information in these recommendations disagrees with the label, the recommendation must be disregarded. No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned. The author and Ohio State University Extension assume no liability resulting from the use of these recommendations.

---

# Ohio State University Extension Fact Sheet

## Entomology

**1991 Kenny Road, Columbus, Ohio 43210-1000**

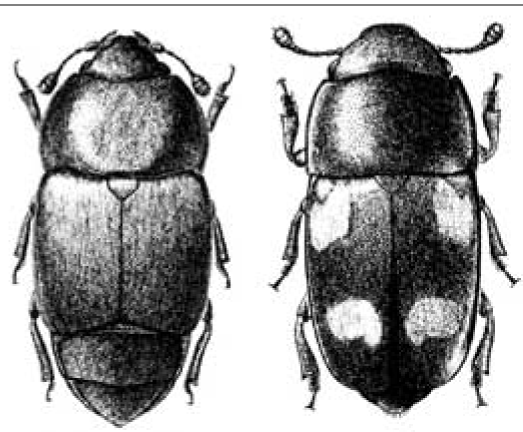
---

# Sap Beetles

**HYG-2047-97**

**William F. Lyon**
**Roger N. Williams**

| Common Name | Scientific Name |
|---|---|
| Picnic Beetle | *Glischrochilus quadrisignatus* (Say) |
| Dusky Sap Beetle | *Carpophilus luqubris* Murray |
| Strawberry Sap Beetle | *Stelidota geminata* (Say) |
| | |



**Dusky Sap Beetle** **Picnic Beetle**

Sap beetles often fly to ripening or damaged raspberries, strawberries, melons, early apples, tree wounds, corn, tomatoes, and osage orange fruits. They may bore into the fruit, eat a portion and make it unfit for human consumption. The picnic beetle is essentially a secondary invader of damaged plants and decomposing plant tissue, but in undamaged ear corn silks and ripe raspberries, it can be a primary invader. The strawberry sap beetle is a primary invader of ripe and nearly ripe strawberries. As a nuisance, sap beetles may congregate in annoying numbers on screen doors, around garbage cans, invade homes, backyards, picnic areas, food processing plants, and roadside fruit and vegetable stands.

## Identification

One of the identifying characteristics of all sap beetles is their "knobbed" antennae.

Picnic beetle adults are about 1/4-inch long and black with four orange-red spots on the wing covers. Eggs are milky-white, sausage-shaped, and about 1/32-inch long.

Dusky sap beetle adults are about 1/8-inch long with short wing covers and are uniform dull black in color.

Strawberry sap beetle adults are slightly less than 1/8-inch long, light to dark brown, oval, and somewhat flattened. Larvae of all three are white. Pupae are white, turning cream-colored and later tan before adult emergence.

## Life Cycle and Habits

All of the sap beetles in Ohio overwinter as adults in protected places such as decaying vegetation, debris or fruit buried in the ground. In the spring, picnic beetle adults come out of hibernation and mate. Egg laying begins in April and continues in May and June. Females lay 5 to 15 eggs per day, scattered at random near decomposing plant material rather than on the material itself. Larvae develop in spilled grain, feed, corn ears, waste onion piles, and soil saturated with juices and food material in contact with the soil. Full-grown larvae leave their food when mature, wander through the soil and change to the pupa stage. Adults then emerge in June and July. The cycle from egg to adult takes about 30 to 35 days. There is usually only one generation per year.

Newly emerged adults do not lay eggs but congregate on screen doors, around garbage cans, in picnic areas and parks, and about anywhere food is grown or being served. They are a general nuisance, attracted to sweet or fermented plant juices. Beetles are found on cracked tomatoes, damaged sweet corn ears, overripe muskmelons, strawberries, and raspberries.

The life cycle of the dusky sap beetle is about 30 days with three to four generations per year. Some females lay more than 300 eggs and live as long as 147 days. The strawberry sap beetle primarily attacks strawberries. Sap beetles also disseminate organisms that cause rots in the fruits. Some sap beetles bore into the fruit, devour a portion, and lay eggs. Larval damage is usually only slight and often goes unnoticed.

## Control Measures

### *Sanitation*

It is helpful to harvest sweet corn, tomatoes, melons, berries and other produce immediately as soon as they ripen. Remove any damaged, diseased, and overripe fruits and vegetables from the area at regular intervals. The collecting of apples, peaches, melons, tomatoes, and other decomposing fruits and vegetables and by burying deep in the soil or destroying is needed to eliminate beetle food sources.

### *Baits*

Research has shown that picnic beetles prefer banana, whole wheat bread dough, and muskmelon. As a bait, muskmelon rinds or pineapple scraps, sprinkled with a pesticide, kills the strawberry sap beetle and other scavenger beetles attracted to the fruits and vegetables. Take extra precautions to keep treated baits away from humans, domestic animals and other non-target organisms. Bait trapping shows some promise in the reduction of beetle populations. Place traps several feet away from the picnic table or outside the garden. Discard trap contents frequently, every three or four days, and rebait traps with pineapple scraps and a bait consisting of stale beer, vinegar, molasses and water with yeast. Research has shown that carbaryl (Sevin) hardly kills sap beetles. Malathion gives better control and azinphosmethyl (Guthion) the best control. However, no pesticides are legally labeled for home owner use.

### *Sprays*

Raspberries can be protected somewhat with repeat sprays of malathion as sap beetles begin to enter the fields. Treat three to five days before the first picking date. Use malathion 25 percent WP at the rate of four to five pounds per 100 gallons of water. Do not use malathion liquid as it can cause burning of the plant leaves. There is a one-day waiting period between application of malathion and harvest. Some sweet corn growers have reported limited success in killing sap beetles with carbaryl (Sevin). **Read the label** and follow directions and safety precautions as to which crops can be sprayed and the waiting period interval for harvest to avoid illegal chemical residues.

---

This publication contains pesticide recommendations that are subject to change at any time. These recommendations are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. Due to constantly changing labels and product registration, some of the recommendations given in this writing may no longer be legal by the time you read them. If any information in these recommendations disagrees with the label, the recommendation must be disregarded. No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned. The author, The Ohio State University and Ohio State University Extension assume no liability resulting from the use of these recommendations.

---



Keith L. Smith, Associate Vice President for Ag. Adm. and Director, OSU Extension.

TDD No. 800-589-8292 (Ohio only) or 614-292-1868

# Ohio State University Extension Fact Sheet

## Entomology

**1991 Kenny Road, Columbus, Ohio 43210-1090**

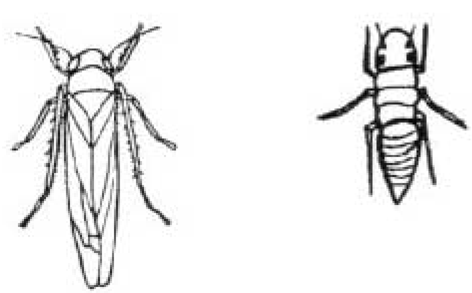
---

# White Apple Leafhopper

**HYG-2202-92**

**Janet L. Murphy**
**Celeste Welty**
**Frank R. Hall**

The white apple leafhopper (*Typhlocyba pomaria* McAtee; Homoptera: Cicadellidae) is a native insect that is widely distributed throughout the apple growing regions of the United States and Canada. Several leafhopper species are found in abandoned apple orchards, but the white apple leafhopper is the species that predominates in commercial plantings. While apple is probably the only host on which this leafhopper overwinters, it may also infest peach, plum, cherry, and hawthorn during the growing season.



**Adult (left) and nymph (right) of the white apple leafhopper**

## Damage

The white apple leafhopper is a leaf feeder and does not directly attack the fruit. Leafhopper nymphs and adults insert their piercing/sucking mouthparts into plant cells and remove the contents. As sap is sucked from the leaves, green tissue is destroyed causing foliage to become speckled or mottled with white spots. Heavy feeding may cause the entire tree to appear white or silver. Damaged foliage interferes with photosynthesis and reduces plant vigor resulting in smaller fruit size, poor fruit color, decreased bud formation, and fruit drop.

In addition to direct leaf injury, these leafhoppers excrete resin-like material, in deposits called tarspots. Tarspots on the fruit substantially reduce quality and value. Most of the significant fruit spotting is associated with the second generation of white apple leafhopper.

Damage by white apple leafhopper is usually more prevalent in well-maintained orchards with succulent leaves. It is more common on Rhode Island Greening, McIntosh, and Red Delicious than on other apple varieties. White apple leafhopper outbreaks are favored by moderate drought conditions.

## Description and Life Cycle

White apple leafhopper adults are creamy white to yellowish-green in color and about 3 to 4 mm (1/8 inch) long. They hold their wings in a roof-like position when resting and appear as tiny wedges when seen from above. Adults are active and fly readily when disturbed.

The white apple leafhopper overwinters in the egg stage under the thin bark of twigs that are approximately 1.25 cm (1/2 inch) in diameter. The eggs are less than 1 mm (1/25 inch) long, cylindrical with tapering ends, and creamy white in color. The egg-laying sites appear as elongate, oval, blister-like swellings about 1.5 mm (1/16 inch) in length, which characteristically run perpendicular to the terminal growth. Overwintering eggs are found on one- to five-year-old wood, but are most often present on two-year-old wood.

Overwintering eggs begin to hatch just before apple blossoms open and usually complete hatching by petal fall. The emerging nymphs move to the undersides of older leaves and feed almost exclusively on the same leaf throughout development. The nymphs, which are wingless, move little as they feed, but will run actively when disturbed.

White apple leafhopper has five nymphal stages. First and second stage nymphs are about 1.0 to 1.5 mm (1/16 inch) long, pale white, with dull red eyes. The third stage nymphs have dull white eyes and developing wing pads. The fourth and fifth stage nymphs are similar in appearance to third stage nymphs, but reach a length of 2.8 mm (1/8 inch). Later stages also become more yellowish or yellow-green in color. The nymphal stages are separated by molting periods when the exoskeleton is shed. These transparent cast "skins" frequently remain hanging from the underside of the leaf. Nymphs of the first generation are most abundant in May and early-June. They are found on cluster leaves close to the trunk or large limbs; they are not found on actively growing terminal shoots.

First generation adults begin to appear in early-June, with males emerging a few days before females. They mate early in the morning and lay eggs about two weeks later. Eggs that will hatch into second generation nymphs are laid in petioles, mid-ribs and large secondary veins on the undersides of leaves. Females lay eggs for about three weeks, each depositing up to 60 eggs. First generation adults gradually die off after five or six weeks and are not observed during mid- to late-July.

Second generation nymphs appear in early-August with adults appearing from mid- to late-August. Adults remain active throughout September but diminish rapidly in number by October. The overwintering eggs are laid under apple tree bark from mid-August to mid-October.

## Contrast with Potato Leafhopper

The damage caused by white apple leafhopper feeding is different than that caused by the potato leafhopper, *Empoasca fabae* (Harris) on apple; feeding by potato leafhopper causes the tips of leaves to turn yellow and brown and to curl up. The bronzed, dried appearance of leaf tips is referred to as "hopper burn," and heavy infestations can result in stunted plant growth. While white apple leafhopper is found on cluster leaves and not on actively growing terminal shoots, potato leafhopper is more of a threat to young, non-bearing fruit trees and young, tender foliage.

Potato leafhopper is light green. White apple leafhopper can be distinguished from potato leafhopper by the tendency of white apple leafhopper to walk forward and backwards while potato leafhopper walks sideways as well as forwards and backwards. Potato leafhopper has a wide host range, including potatoes, beans, and alfalfa. Potato leafhopper develops throughout the year in the southern United States near the Gulf of Mexico, and migrates northward each growing season rather than overwintering in northern states. The appearance of potato leafhopper is therefore less predictable because its migration is dependent upon the jet stream and weather patterns. White apple leafhopper overwinters in northern areas.

## Monitoring and Action Threshold

The need for control of white apple leafhopper should be determined at petal-fall, when wingless nymphs of the first generation can be found. The presence of white stippling on the upper surface of leaves indicates that nymphs are feeding beneath. Leafhoppers should be sampled from the underside of leaves, especially on suckers or older terminal growth. When monitoring the second generation, keep in mind that watersprouts often have heavier populations of leafhoppers than other areas of the tree. Count the number of leafhoppers on ten leaves from each of ten trees, and calculate the average number of leafhoppers per leaf. Treatment is suggested if there is an average of more than 0.5 leafhopper nymphs per leaf.

## Control

Natural enemies include parasitic wasps that attack leafhopper eggs; predators such as spiders, lacewings, and minute pirate bugs; and a fungus. In commercial orchards, natural enemies usually do not adequately control the white apple leafhopper.

The insecticides most effective in the control of leafhoppers are methomyl (Lannate*) and formetanate (Carzol*). Dimethoate (Cygon) and endosulfan (Thiodan*) are also effective. Carbaryl (Sevin) and oxamyl (Vydate*) are very effective but will cause fruit thinning if used within 30 days of bloom; if they are used, it is best during very early petal-fall rather than late petal-fall for minimal thinning. Be careful with emulsifiable concentrate (EC) formulations used near petal-fall as they tend to increase the potential for fruit russetting. Note that insecticides commonly used at petal-fall for control of plum curculio and codling moth, such as phosmet (Imidan) and azinphos-methyl* (Guthion) are not effective in controlling leafhoppers. Good control of the first generation should help suppress second generation leafhoppers so that additional control is not needed.

Young leafhoppers are easier to control than adults. The first brood is a better target than the second brood because the hatch is relatively synchronous, making a greater proportion of the more susceptible nymphs present at one time. Thorough spray coverage of upper and lower leaf surfaces is necessary and considered essential for effective control with contact insecticides.

* indicates a restricted-use material.

---

NOTE:Disclaimer - This publication contains pesticide recommendations that are subject to change at any time. These recommendations are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. Due to constantly changing labels and product registration, some of the recommendations given in this writing may no longer be legal by the time you read them. If any information in these recommendations disagrees with the label, the recommendation must be disregarded. No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned. The author, The Ohio State University and the Ohio State University Extension assume no liability resulting from the use of these recommendations.

---

THE OHIO STATE UNIVERSITY FactSheet Extension

# Ohio State University Extension Fact Sheet

## Entomology

**1991 Kenny Road, Columbus, OH 43210-1090**

---

# Codling Moth On Fruit Trees



### HYG-2203-92

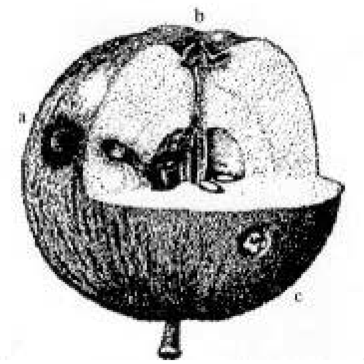


**Celeste Welty**

The codling moth [*Cydia pomonella* (formerly *Laspeyresia pomonella* and *Carpocapsa pomonella*); Order Lepidoptera, Family Tortricidae] is one of the most serious pests of apples, but the larvae may also attack pears, crabapples, English and black walnuts, quince, and other fruits. The larva is the familiar "apple worm." It is not a native insect of the United States; it was introduced from Europe by early settlers more than 200 years ago. It became a serious pest in Ohio shortly after the Civil War. Since then, it has continued to be a problem on apples if insecticides are not used.

### Damage

The larva usually tunnels to the core of the apple, greatly lowering the market value and storage quality of the fruit, as well as making it unfit for people to eat. As it feeds, it pushes out a mass of chewed material, or excrement, called "frass," which accumulates around the entrance hole. Sometimes an apple exhibits injury from more than one entrance hole, each of which is surrounded by a tiny amount of frass.



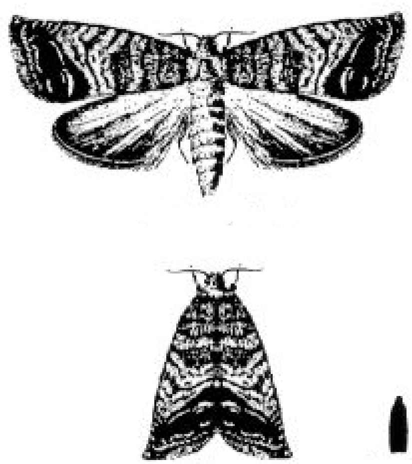

**Picture caption: Codling moth damage:**
**(a) exit hole; (b) entrance hole in calyx; (c) entrance hole in side.**

Another type of codling moth injury is known as "stings." A sting is a place where the larva chews only a short distance into the apple. The larva either dies or leaves the sting and enters at another place.

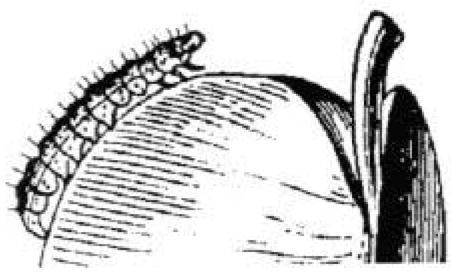
## Appearance and Life Cycle

The codling moth overwinters as a fully grown larva in a silken cocoon, usually located under loose bark on the tree trunk and limbs. Cocoons may also be found in other places in the orchard such as in brush, on posts, in cracks in the soil, and on harvesting crates. The packing building, which holds apples while the fruit is being graded and packed, is a common overwintering site for larvae.

The larva transforms into a pupa and later into a grayish-brown moth. The moth is distinctive because its wings are crisscrossed with lighter gray lines, and there is a bronze or copper-colored patch near the outer margins of the forewings. The moth is 5/16 inch (8 mm) long when it is at rest with its wings folded, and has a 11/16 inch (17 mm) wingspan. The first moths of the season usually appear as the last petals fall from the apple blossoms. The peak of moth emergence occurs 4 to 12 days later, depending on weather conditions. The last moths of the overwintering brood may not appear until six or seven weeks after petal fall.



**Adult, wing spread**
**Adult, wings folded**
**Actual size**



**Codling Moth Larva**

About three days after emergence, the female moths begin to lay single eggs on the fruit and leaves. Each female lays an average of 50 to 60 eggs. When temperatures are below 60 degrees F, few eggs are laid and there is little mothflight activity. The egg is tiny (1/32 inch diameter [1.2 mm]), whitish, flattened disc-shaped, and almost transparent. Eggs hatch in 8 to 14 days.

The newly hatched larva is yellowish-white with a black head; it immediately begins crawling to seek a fruit on which to feed. On the fruit, the larva wanders about seeking a rough area, such as the calyx end or scab spot, in which to make an easier entrance into the fruit. Early in the season the favorite point of entrance is apparently through the calyx, but later many larvae attack the side of the apple. The larva spends about three weeks feeding and growing. The fully grown larva is 1/2 inch (12 mm) long, white with a pinkish tinge on the upper surface, and has a brown head.

When nearly full-grown, the larva leaves the fruit by either enlarging the entrance burrow or cutting a new channel to the outside. On leaving the fruit, it seeks a suitable place to spin a cocoon similar to the type described for the overwintering larva. Although a number of these larvae may remain in cocoons until the following spring, especially in northern Ohio, many emerge as adults in 12 to 21 days. This summer brood of adults usually starts emerging sometime in July. The peak of summer moth emergence occurs about the first of August in northern Ohio, with the last emergence about September 1. In southern Ohio, these dates may be seven to ten days earlier, and in extreme northern Ohio, two to eight days later.

There may be a partial second summer brood of moths in September, especially in southern Ohio. The time period occupied by each stage of the codling moth during the summer is usually shorter in southern Ohio than in northern Ohio because higher temperatures accelerate development.

## Monitoring

A pheromone (sex-attractant) trap can be used to determine exactly when the codling moth is flying. The wing-type sticky trap with the codling moth pheromone lure should be hung in the tree at bloom. See North Central Regional Extension Publication 359, Insect Traps Home Fruit Insect Control for further information on where to obtain traps.

## Control

**Natural control** Birds are important predators of hibernating larvae that are under loose bark. Parasites can attack eggs and larvae of the developing codling moth. Some worms always escape natural control; chemical controls are thus usually needed because of consumer demand for blemish-free fruit.

**Physical control** Pick up and place fallen fruits in a plastic bag and put the bag in the trash weekly; larvae in these fruit will then not reach adulthood in your orchard.

**Physical control** Attach corrugated cardboard strips (two to four inches wide) tightly to the tree trunk and scaffold branches in June and August to provide a site for the larvae to make their cocoons. Remove and destroy the strips after cocoons are formed. Before the bands are attached, the bark should be scraped to remove loose pieces that would prevent a tight fit by the strips.

**Chemical control** Repeated applications of insecticide every 10 to 14 days are usually needed from petal-fall to near harvest. Sprays are most effective when applied just before newly hatched larvae attempt to enter the apples. If you are using a pheromone trap to monitor codling moth, the best time to spray is two weeks after the first moth catch or one week after a peak catch. Use an all-purpose fruit tree mixture or the insecticide phosmet (Imidan). Carbaryl (Sevin) will also control codling moth, but it should not be used within 30 days of full bloom because fruit thinning will result.

For more information on fruit pests, obtain a copy of Bulletin 780, Controlling Diseases and Insects in Home Fruit Plantings, and Bulletin 591, Growing and Using Fruit at Home, from your County Extension Office. Commercial growers should refer to Bulletin 506A2, Ohio Commercial Tree Fruit Spray Guide and Bulletin 506-B2, Ohio Commercial Small Fruit and Grape Spray Guide.

The author gratefully acknowledges Richard L. Miller and Alan W. Smith for authoring the 1988 version on which this fact sheet is based.

---

NOTE:Disclaimer - This publication contains pesticide recommendations that are subject to change at any time. These recommendations are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. Due to constantly changing labels and product registration, some of the recommendations given in this writing may no longer be legal by the time you read them. If any information in these recommendations disagrees with the label, the recommendation must be disregarded. No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned. The author, The Ohio State University and the Ohio State University Extension assume no liability resulting from the use of these recommendations.

---

THE OHIO STATE UNIVERSITY FactSheet Extension

# Ohio State University Extension Fact Sheet

## Entomology

**1991 Kenny Road, Columbus, OH 43210-1090**

---

# Rosy Apple Aphid

**HYG-2207-94**

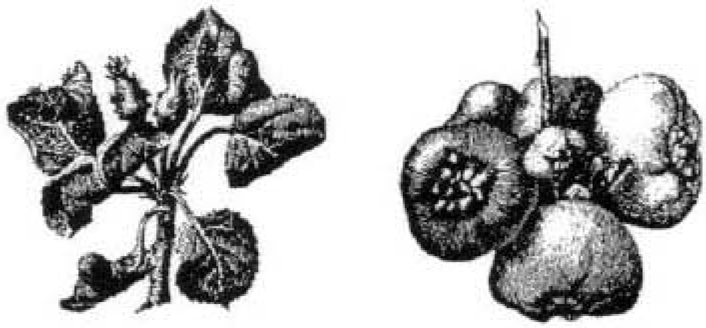
**Celeste Welty**
**Janet Murphy**

Rosy apple aphid, *Dysaphis plantaginea*, is one of several species of aphids that infest commercial apple orchards and backyard apple trees in Ohio. It is the most destructive of the aphid species that feed on apple trees; other aphids found on apple are green apple aphid (see Extension Fact Sheet, HYG-2206-94) and woolly apple aphid (see Extension Fact Sheet, HYG-2208-94). Rosy apple aphid feeds on pear and hawthorn as well as apple. Because rosy apple aphid does not occur in most orchards in most years in Ohio, it is important to determine each spring whether or not this pest is present in individual orchards.

### Damage

Rosy apple aphid feeding causes deformed and stunted fruit and leaves. Aphid nymphs and adults are usually found on the expanding leaf buds and fruit bud clusters, where they use their piercing-sucking mouthparts to draw sugary sap from the phloem of succulent shoots and leaves. During feeding, rosy apple aphids inject their saliva into the plant. The saliva contains chemicals that alter plant growth, and these chemicals move from leaves to fruits, causing fruits to remain small or become deformed and unmarketable. Feeding causes severe curling, stunting, and deformity of leaves, and leaves may turn bright crimson. Leaf curling is not usually noticeable until petal-fall, which is past the best time for control. Leaves may drop early, and shoot growth may be stunted or stopped completely. Golden Delicious, Ida Red, Rome, Cortland, York, and Stayman apple varieties are especially susceptible to injury.

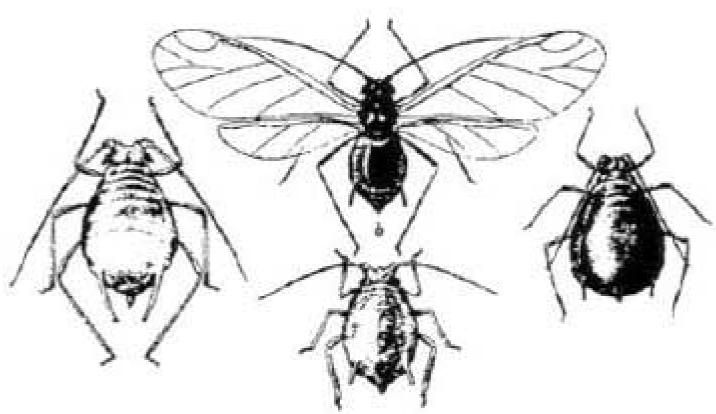
In addition to damage caused by feeding, aphids are associated with the development of black sooty mold. As they feed, aphids excrete excess sap in a form known as honeydew. Honeydew on leaves and fruit provides a medium for growth of black sooty mold. Sooty mold on leaves can affect photosynthesis and may reduce fruit yield, while sooty mold on fruit can lower fruit quality and marketability.



**Leaves infested with rosy apple aphid (left)**
**fruit affected by rosy apple aphid (right)**
**(From Lovett and Fulton 1920, Oregon Agric. Expt. Stn. Circ. 22)**

## Appearance

Like other aphids, rosy apple aphid is a small, soft-bodied insect with piercing-sucking mouthparts and two cornicles (or "tailpipes") projecting from the back of the abdomen. Nymphs of rosy apple aphid are yellow or pink when first hatched; as they grow, they turn purple with a gray, waxy covering. Wingless adults are rosy or purple, and covered with a powdery, greyish-white wax; winged adults are brownish-green. The cornicles are long. They have dark legs and antennae. Nymphs are 0.4 to 2 mm long; adults are 2 to 2.5 mm long.



**Rosy apple aphid; winged female (top); summer wingless adult**
**female that produces live young (left); Spring wingless female that**

**produces live young (right); adult female produces eggs in the fall (bottom) (from USDA)**

## Life Cycle

Rosy apple aphid overwinters in the egg stage. In the fall, oval yellow eggs about 0.5 mm long are laid in crevices in the bark of larger branches. Eggs begin to darken, and after one to two weeks, they become shiny black and are impossible to differentiate from those of green apple aphid and apple grain aphid. In the spring, eggs hatch for about two weeks while the buds are in the silver-tip to half-inch green stage. Newly hatched nymphs feed on expanding buds and undergo five molts until they mature into wingless adult females that give birth to live young without being fertilized by males. Each female produces an average of 185 offspring, which can lead to rapid buildup of large populations. Nymphs cluster around each mother to the extent that infested leaves may be covered by more than one layer of aphids.

One generation is completed in two to three weeks. Adult aphids in a colony are generally wingless until crowded conditions induce the formation of winged individuals that can disperse to new hosts. The winged aphids often fly to a different plant species which is called the secondary host. Rosy apple aphid may remain on apple throughout the summer, but usually moves to narrow-leaf plantain or dock in early-summer. By late-July, most of the rosy apple aphids have left the apple trees.

Reproduction without mating continues on secondary hosts (plantain, dock) until late-summer or autumn when winged forms develop and return to the primary host (apple). Here a generation is produced that will develop into sexual adult males and females; these mate, then the females deposit overwintering eggs on the primary hosts.

## Natural Control

Small parasitic wasps attack aphids; they lay their eggs in aphids by stinging with their ovipositor (egg-laying organ). The wasp egg hatches within the aphid and the young wasp larva consumes the aphid. Parasitized aphids turn brown or black. In time, the wasp larvae emerge as adults from the aphids, leaving behind empty aphid skins. These skins, called "aphid mummies," can be found attached to leaves.

Other natural enemies of apple aphids include predators such as hover fly larvae (white legless maggots), lacewing larvae, lady beetle larvae, lady beetle adults, and gall-midge larvae (orange maggots). These predators feed on many different aphid species in addition to other insect pests. A cool, wet spring favors aphid development because these conditions are unfavorable for the aphid's natural enemies.

## Monitoring During the Pre-bloom Period

A sample of 10 clusters from each of 10 trees should be examined for rosy apple aphid at the early pink bud stage, and insecticide applied if more than the threshold level of one colony per 100 terminals is found; this procedure was developed in New York. A sampling plan used for rosy apple aphid in Pennsylvania is to select 5 to 10 trees from each block at early pink, and count the number of fruit spurs with curled leaves on each tree for three minutes; if more than an average of 0.75 aphid-infested clusters are found per three-minute search, then an insecticide application is recommended. Varieties sensitive to rosy aphids should be sampled first.

## Chemical Control

Good control depends on proper timing of insecticide applications. Overwintering aphid eggs can be targeted with a delayed dormant spray to prevent early damage to fruit or expanding leaves, although a spray at the pink bud stage, after eggs have hatched, is usually more effective for control of rosy apple aphid.

Good control depends on choosing a material that will kill aphids but will not kill natural enemies. Systemic insecticides such as dimethoate are more effective than contact materials. After the leaves begin to curl, contact insecticides usually do not provide adequate control unless applied with large volumes of water to thoroughly cover the curled leaves. Keep in mind that use of most broad-spectrum insecticides encourages aphid outbreaks by killing predators and parasitoids.

**Delayed dormant (green tip to half-inch green bud stages)** Spray with superior oil plus an organophosphate such as chlorpyrifos (Lorsban) in commercial orchards. In backyard plantings, oil plus diazinon can be used. Oil alone is not effective against aphid eggs. Methidathion (Supracide) is an alternative aphicide that can be used during the delayed dormant period in commercial orchards.

**Pink bud stage or post-bloom** Endosulfan (Thiodan), dimethoate (Cygon), or chlorpyrifos (Lorsban) are the most effective insecticides for rosy apple aphid control. Methomyl (Lannate), oxamyl (Vydate), or pyrethroids (Ambush, Asana, Pounce) also control aphids. In backyard plantings, diazinon can be used for rosy apple aphid control.

---



---

ohioline.ag.ohio-state.edu -- your Link to Information, News, and Education

FactSheet

# Ohio State University Extension Fact Sheet

## Plant Pathology

**2021 Coffey Road, Columbus, Ohio 43210-1087**

---

# Fire Blight of Apples, Crabapples and Pears

**HYG-3002-94**

**Michael A. Ellis**
**Jim Chatfield**
**Eric Draper**

Fire blight on apple twigs. Note the curved "Sheperd's Crook" at the tip of infected twigs.

Fire blight is a common and very destructive bacterial disease of apples and pears. The disease is so named because infected leaves on very susceptible trees will suddenly turn brown, appearing as though they had been scorched by fire. As a result of this disease, blight susceptible pear cultivars are no longer grown in many parts in the Midwest. Damage and losses from fire blight on apple result from: death or severe damage to trees in the nursery; death of young trees in the orchard; delay of bearing in young trees due to frequent blighting of shoots and limbs; loss of limbs or entire trees in older plantings as the result of girdling by fire blight cankers; and direct loss of fruit due to blighting of blossoms and young fruit. Fire blight may cause severe damage to many other members of the Rosaceae family. Quince, crabapple, mountain ash, spirea, hawthorn, pyracantha, and cotoneaster are all susceptible. Cultivars within some of these species are resistant.

## Symptoms

Blossom and twig blight symptoms appear in the spring. Diseased blossoms become water-soaked and turn brown. The bacteria may then grow down into the blossom bearing twigs (spurs). Leaves on the spur become blighted, turning brown on apple and black on pear. Droplets of milky tan-colored bacterial ooze may be visible on the surface of diseased tissue. These droplets contain millions of bacteria which can cause new infections.

Twig blight starts at the growing tips of shoots and moves down into older portions of the twig. Blighted twigs first appear water-soaked, then turn dark brown or black. Blighted leaves remain attached to the dead branches through the summer. The end of the branch may bend over, resembling a shepherd's crook or an upside down "J". As the fire blight bacteria move through blighted twigs into main branches, the bark sometimes cracks along the margin of the infected area on the main branch causing a distinct canker.

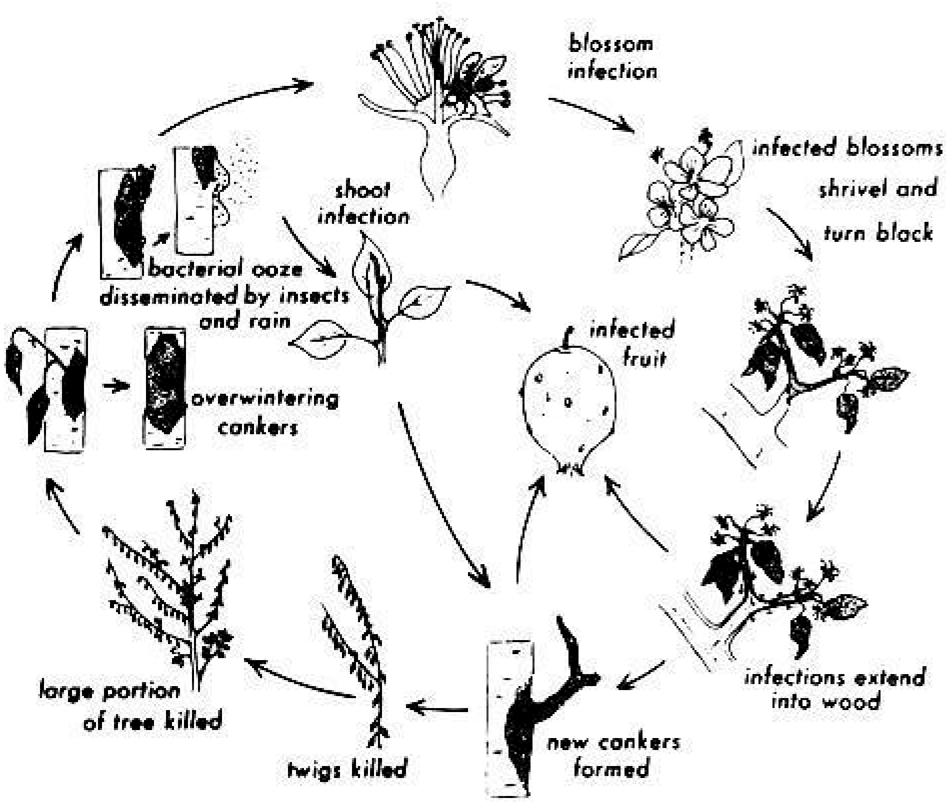
Both apple and pear fruit may be blighted. Rotted areas turn brown to black and become covered with droplets of ooze. The fruit remains firm but later dries out and shrivels into mummies.

## Causal Organism


Fire blight canker on apple trunk.

Fire blight is caused by the bacterium, *Erwinia amylovora*. The fire blight bacteria overwinter in living tissue at the margins of cankers on the trunk and main branches. The bacteria become active in the spring when temperatures get above 65 degrees F. Their growth is favored by rain, heavy dews, and high humidity. By the time trees are blossoming, droplets of ooze containing the bacteria are present on the surface of cankers. Relatively few overwintering cankers become active and produce bacteria in the spring, but a single active canker may produce millions of bacteria, enough to infect an entire orchard. The bacteria in droplets of ooze are spread by splashing rain or insects (mostly bees, flies, and ants) to open blossoms. The bacteria multiply rapidly in the blossom nectar, and invade the blossom tissue through natural openings called nectaries. The optimum temperature range for blossom blight infection is 65 to 86 degrees F. The bacteria are spread from blossom to blossom by rain or pollinating insects.

Actively growing shoot tips are infected by bacteria that have been spread by rain or insects from both cankers and infected blossoms. Invasion can occur directly through natural openings, such as lenticels and stomata, under conditions of prolonged rain and high humidity. However, shoot infection more commonly occurs through wounds created by sucking insects, such as aphids, leafhoppers, and tarnished plant bugs; by wind whipping; or by hail. Fire blight bacteria multiply rapidly within an infected shoot. Droplets of ooze can form on the shoots within 3 days. Shoots remain highly susceptible to infection until vegetative growth ceases and the terminal bud is formed.




Disease cycle of fire blight.

## Control

Fireblight is one of the most difficult diseases of apple to control, and there is no one procedure that will give complete control. Though control is not an easy task, the use of several practices in an integrated manner should result in minimal damage from fire blight.

1. Plant apple, crabapple, and pear varieties that are less susceptible to fire blight. Table 1 gives a listing of the relative susceptibility of some of the more common apple and pear varieties. Fireblight is not as severe a disease problem on most crabapple varieties. A few crabapple varieties which can develop severe fireblight include: Silver Moon, Snowdrift, Red Jade, and Van Esseltine.
2. Prune out fire blight cankers and blighted twigs. To decrease the inoculum level for the following season, prune out blighted twigs and cankers during the dormant season. During the dormant season (winter) there is much less chance of spreading bacteria. Branches that are more than half-girdled by cankers should be

removed. Cut off blighted twigs by making cuts at least 4 inches below the visible dead wood. Cankers can be cut out of trunks or large branches by removing dead tissue down to wood that appears healthy. If blighted twigs are pruned out during summer, cuts should be made l2 to l5 inches below diseased wood and pruning tools should be disinfested by dipping in a 2:10 solution of household bleach in water after each cut. We recommend that commercial growers do a thorough job of pruning out blighted wood in the dormant season and not in summer.

3. Follow proper pruning and fertilization practices. Excessive nitrogen fertilizer and heavy pruning will promote vigorous growth of succulent tissue which is more susceptible to fire blight. Adjust management practices on susceptible varieties to promote moderate growth. Make fertilizer applications in early spring or late fall after growth has ceased.
4. Sucking insects create wounds through which fire blight bacteria can enter. These pests should be controlled throughout the growing season. To protect bees, do not apply insecticides during bloom.
5. Commercial growers should consider following a recommended spray program for fire blight. Sprays for fire blight control are generally not recommended for backyard growers. Instead, backyard growers are encouraged to plant less susceptible varieties and use other nonchemical control measures. For the most current spray recommendations, commercial growers are referred to Bulletin 506-A2 "Ohio Commercial Tree Fruit Spray Guide," and backyard growers are referred to Bulletin 780 "Controlling Diseases and Insects in Home Fruit Plantings." These publications can be obtained from your county Extension agent or the Extension Publications Office, The Ohio State University, 385 Kottman Hall, 2021 Coffey Road, Columbus, Ohio 43210-1044.

**Table 1: Relative susceptibility of common apple and pear cultivars to Fire Blight**

| **Highly susceptible** | **Moderately susceptible** | **Moderately resistant** |
|---|---|---|
| | | |
| **Apple** | | |
| | | |
| Beacon | Dutchess | Jonafree |
| Cortland | Empire | Melrose |
| Fuji | Golden Delicious | Northwestern Greening |
| Gala | Haralson | Nova Easygro |
| Granny Smith | Jonagold | Prima |
| Idared | Jonamac | Priscilla |
| Jonathan | Jerseymac | Quinte |
| Lodi | Liberty | Red Delicious |
| Monroe | McIntosh | Red Free |

| | | |
|---|---|---|
| Mutsu (Crispin) | Minjon | Sir Prize |
| Paulared | Northern Spy | Winesap |
| Rome Beauty | Novamac | |
| Wayne | Spartan | |
| Wealthy | | |
| Yellow Transparent | | |
| | | |
| **Pear** | | |
| | | |
| Aurora | Maxine | Kieffer |
| Bartlett | Seckel | Magness |
| Bosc | | Moonglow |
| Clapp's Favorite | | Old Home |
| Red Bartlett | | |
| Reimer Red | | |
| Starkrimson | | |

---



Keith L. Smith, Associate Vice President for Ag. Adm. and Director, OSU Extension.

TDD No. 800-589-8292 (Ohio only) or 614-292-1868

ohioline.ag.ohio-state.edu -- your Link to Information, News, and Education

THE OHIO STATE UNIVERSITY

FactSheet Extension

# Ohio State University Extension Fact Sheet

## Plant Pathology

**2021 Coffey Road, Columbus, Ohio 43210-1087**

---

# Scab of Apple and Crabapple

**HYG-3003-94**

**Michael A. Ellis**
**Jim Chatfield**
**Eric Draper**

Apple scab is one of the most serious diseases of apple and ornamental crabapple. Disease development is favored by wet, cool weather that generally occurs in spring and early summer. Both leaves and fruit can be affected. Infected leaves may drop resulting in unsightly trees, with poor fruit production. This early defoliation may weaken trees and make them more susceptible to winter injury or other pests. Infected fruits are blemished and often severely deformed. Infected fruits may also drop early.

### Symptoms


Apple scab lesions on apple leaves.

Symptoms first appear in the spring as spots (lesions) on the lower leaf surface, the side first exposed to fungal spores as buds open. At first, the lesions are usually small, velvety, olive green in color, and have unclear margins. On some crabapples, infections may be reddish in color. As they age, the infections become darker and more distinct in outline. Lesions may appear more numerous closer to the mid-vein of the leaf. If heavily infected, the leaf becomes distorted and drops early in the summer. Trees of highly susceptible varieties may be severely defoliated by mid to late summer.

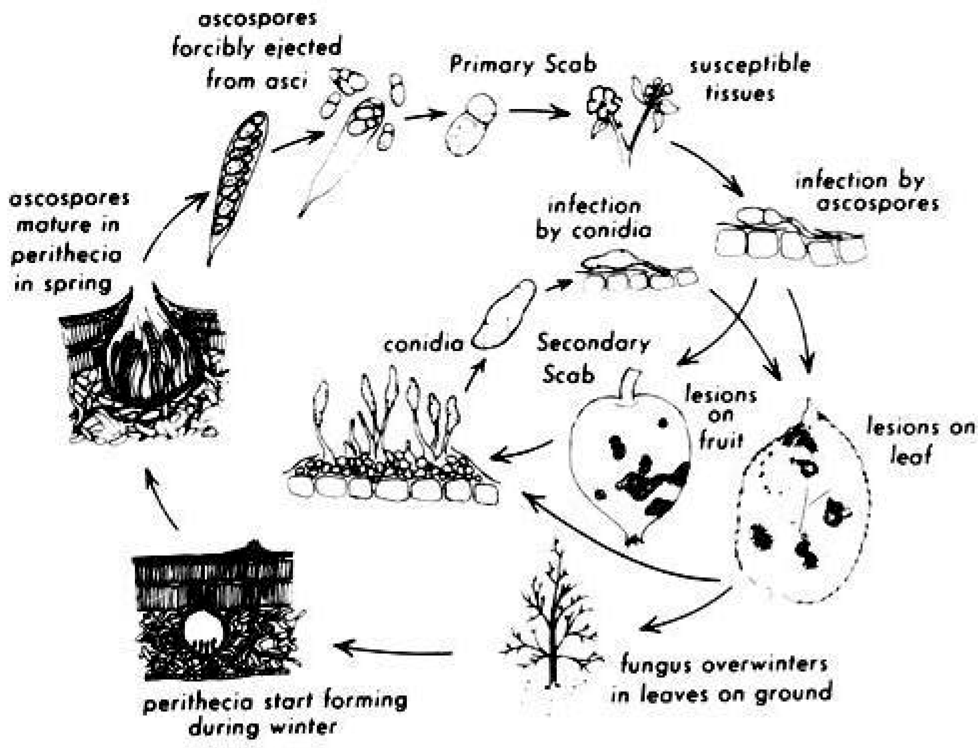
Fruit symptoms are similar to those found on leaves. The margins of the spots, however, are more distinct on the fruit. The lesions darken with age and become black and "scabby." Scabs are unsightly, but are only skin deep. Badly scabbed fruit becomes deformed and may fall before reaching good size.

## Causal Organism


Apple scab lesions on fruit.

Apple scab is caused by the fungus, *Venturia inaequalis*. It survives the winter in the previous year's diseased leaves that have fallen under the tree. In the spring, the fungus in old diseased leaves produces millions of spores.These spores are released into the air during rain periods in April, May and June. They are then carried by the wind to young leaves, flower parts and fruits. Once in contact with susceptible tissue, the spore germinates in a film of water and the fungus penetrates into the plant. Depending upon weather conditions, symptoms (lesions) will show up in 9 to 17 days.

The fungus produces a different kind of spore in these newly developed lesions. These spores are carried and spread by splashing rain to other leaves and fruits where new infections occur. The disease may continue to develop and spread throughout the summer. Because a film of water on leaves and fruit is required for infection to occur, apple scab is most severe during years with frequent spring rains.




**Apple scab disease cycle.**

## Control

1. The use of resistant or scab immune varieties is the ideal method for controlling scab. Currently there are several apple varieties that are totally resistant to scab. Backyard growers are strongly encouraged to consider using these resistant varieties in order to reduce or eliminate the need for fungicide applications around the home. Scab resistant apple varieties include: Prima, Priscilla, Sir Prize, Freedom, Liberty, Jonafree, Enterprise, Goldrush, Redfree, Pristine, Williams Pride, Novamac and Nova Easygro. All other varieties, including most commercially grown varieties are susceptible to scab; however, they differ in their degree of susceptibility. McIntosh, Cortland, Red Delicious and Rome Beauty are all very susceptible to scab. Golden Delicious and Jonathan are less susceptible. Lists of scab resistant ornamental crabapples are available from many nurseries and garden centers. Some of the many crabapples with both excellent scab resistance and superior horticultural characteristics for Ohio include: Anne E, Bob White, Molten Lava, Ormiston Roy, Prairifire, Red Jewel, Sargent, Sentinel, Strawberry Parfait and Sugar Tyme.
2. Rake and destroy fallen leaves. This will reduce the number of spores that can start the disease cycle the next year.
3. Where resistance to scab is not present, fungicide application is the primary method of control.

For the most current fungicide recommendations and spray schedules, backyard growers are referred to Bulletin 780 "*Controlling Diseases and Insects in Home Fruit Plantings*," and commercial apple growers are referred to Bulletin 506-A2 "*Ohio Commercial Tree Fruit Spray Guide*."

Ornamental crabapple sprays are mentioned in Bulletin 614 "*Disease Control in the Landscape*."

These publications can be obtained through your county extension agent or the Extension Publications Office, The Ohio State University, 385 Kottman Hall, 2021 Coffey Road, Columbus, Ohio 43210-1044.

---



Keith L. Smith, Associate Vice President for Ag. Adm. and Director, OSU Extension.

TDD No. 800-589-8292 (Ohio only) or 614-292-1868

ohioline.ag.ohio-state.edu -- your Link to Information, News, and Education

# Ohio State University Extension Fact Sheet

## Plant Pathology

**2021 Coffey Road, Columbus, Ohio 43210-1087**

---

# Grape Black Rot

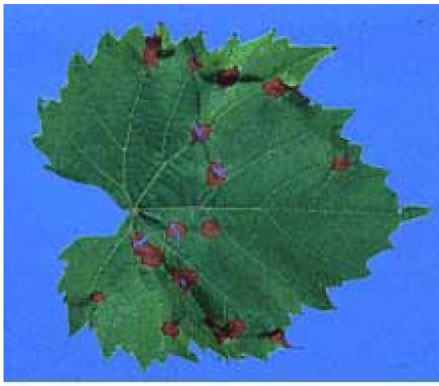
**HYG-3004-94**

**Michael A. Ellis**

Black rot is one of the most damaging grape diseases in Ohio. All cultivated varieties of grapes are susceptible to infection by the black rot fungus. If not controlled, some or all of the grapes within a cluster will be rotted. The disease is favored by warm, humid weather as is found during the summer throughout most of Ohio. Before good control measures were devised, vineyards along the Ohio River often were hard hit. Grape growers commonly lost most of their crop, and the grape industry was literally driven out of the area.

### Symptoms

Symptoms of black rot first appear as small yellowish spots on leaves. As the spots (lesions) enlarge, a dark border forms around the margins. The centers of the lesions become reddish brown. By the time the lesions reach 1/8 to 1/4 inch in diameter (approximately two weeks after infection), minute black dots appear. These are fungal fruiting bodies (pycnidia) and contain thousands of summer spores (conidia). Pycnidia are often arranged in a ring pattern, just inside the margin of the lesions. Lesions may also appear on young shoots, cluster stems, and tendrils. The lesions are purple to black, oval in outline, and sunken. Pycnidia also form in these lesions. Fruit symptoms often do not appear until the berries are about half grown. Small, round, light-brownish spots form on the fruit. The rotted tissue in the spot softens, and becomes sunken. The spot enlarges quickly, rotting the entire berry in a few days. The diseased fruit shrivels, becoming small, hard, black and wrinkled (mummies). Tiny black pycnidia are also formed on the fruit mummies. The mummies usually remain attached to the cluster.



Black rot lesion on grape leaf.

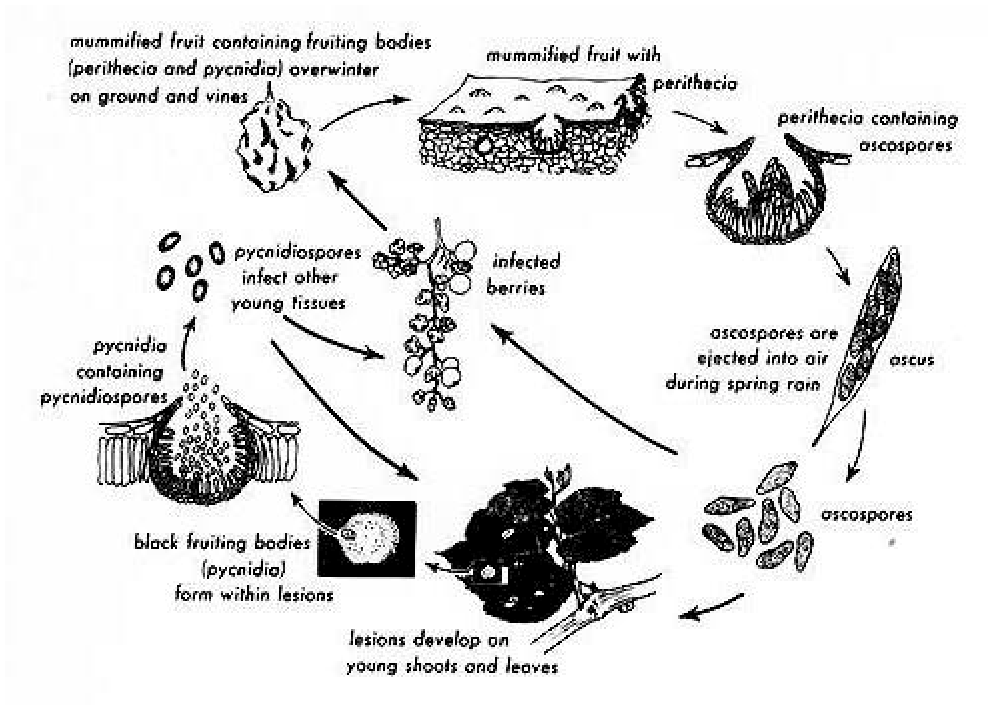
Close-up of black rot lesion on grape leaf. Note the tiny black dots (fungal fruiting bodies) in the lesion.

Close-up of grape black rot mummies.

Grape berries infected with black rot. Note the shriveled mummies.

## Causal Organism

Grape black rot is caused by the fungus, *Guignardia bidwellii*. Black rot survives the winter in cane and tendril lesions and fruit mummies. In the spring during wet weather, the pycnidia on infected tissues absorb water and conidia are squeezed out. Conidia are splashed about randomly by rain and can infect any young tissue in less than 12 hours at temperatures between 60-90 degrees F. A film of water on the vine surface is necessary for infection (Table 1). A second type of spore, an ascospore, may also be produced in overwintered fruit mummies. Ascospores are forcibly discharged into the air and can travel considerable distances. Research has shown that ascospores are an important source of primary infections in the spring.




**Disease cycle of grape black rot.**

## Control

1. Sanitation is important. Destroy mummies, remove diseased tendrils from the wires, and select fruiting canes without lesions. It is very important not to leave mummies attached to the vine. Research has shown that mummies on the ground release most or all of their ascospores before the end of bloom. Mummies left up in the trellis can produce ascospores and conidia throughout the growing season, thus making control of this disease much more difficult. If only a few leaf lesions appear in the spring, remove these infected leaves.
2. Plant grapes in sunny open areas that allow good air movement. Proper row orientation to prevailing winds and good weed control beneath the vines also enable plants to dry more quickly during wet weather.
3. A good fungicide spray program is extremely important. Early season control (bud break through bloom) must be emphasized. If controlled early, the need for late season (post bloom) applications of fungicide is greatly reduced. For the most current spray recommendations, commercial growers are referred to Bulletin 506-B2 "Ohio Commercial Small Fruit Spray Guide," and backyard growers are referred to Bulletin 780 "Controlling Diseases and Insects in Home Fruit Plantings." These publications can be obtained from your county Extension agent or the Extension Publications Office, The Ohio State University, 385 Kottman Hall, 2021 Coffey Road, Columbus, Ohio 43210-1044.

**Table 1. Leaf wetness duration and**

| temperature necessary for infection by the black rot fungus. | |
|---|---|
| **Temperature (degrees F)** | **Hours of leaf wetness required for infection** |
| | |
| 45 | No infection |
| 50 | 24 |
| 55 | 12 |
| 60 | 9 |
| 65 | 8 |
| 70 | 7 |
| 75 | 7 |
| 80 | 6 |
| 85 | 9 |
| 90 | 12 |

---

ohioline.ag.ohio-state.edu -- your Link to Information, News, and Education

THE OHIO STATE UNIVERSITY FactSheet Extension

# Ohio State University Extension Fact Sheet

## Plant Pathology

**2021 Coffey Road, Columbus, Ohio 43210-1087**

---

# Red Stele Root Rot of Strawberry

**HYG-3014-95**

**Michael A. Ellis**

Many commercial strawberry cultivars are susceptible to the red stele fungus. This root rot disease has become a serious problem facing strawberry production in the northern two-thirds of the United States. The disease is most destructive in heavy clay soils that are saturated with water during cool weather when the fungus is most active. The red stele fungus can survive in soil for up to 13 years or longer once it becomes established in the field or garden.

Normally, the disease is prevalent only in the lower or poorly drained areas of the planting; however, it may become fairly well distributed over the entire patch, especially during a cool, wet spring.

Strawberry field affected with red stele root rot. Susceptible variety on left, and resistant variety on right.

Strawberry root system affected by red stele.

## Symptoms

When plants start wilting and dying in the lower portions of the strawberry planting, the cause is very likely to be red stele. Infected plants are stunted, lose their shiny-green luster, and produce few runners. Younger leaves often have a metallic, blueish-green cast. Older leaves turn prematurely yellow or red. With the first hot, dry weather of early summer, diseased plants wilt rapidly and die. Diseased plants have very few new roots, when compared with the roots of healthy plants that have thick and bushy roots with many secondary feeding roots. Infected strawberry roots usually appear gray, while the new roots of a healthy plant are yellowish-white.

The most reliable symptom of red stele is found within the roots and may be observed by gently digging up a few plants that are just beginning to wilt, taking care to preserve the root system. Plants with red stele usually have few fine lateral roots so the main fleshy roots have a "rat-tail" appearance (Figure 1). During intermediate stages of disease development, these fleshy roots will be white near the crown of the plant but will show a dark rot progressing upward from the tips. When the white outer portion of the root just above this rotten zone is peeled off or sliced through, the root core (or stele) will appear to be dark red (Figure 2). It may be necessary to examine several rotting roots before finding a red stele, but this symptom is very distinctive and is diagnostic for the disease. Reddened steles are relatively difficult to find after harvest because most infected roots have died and begun to decay by then.

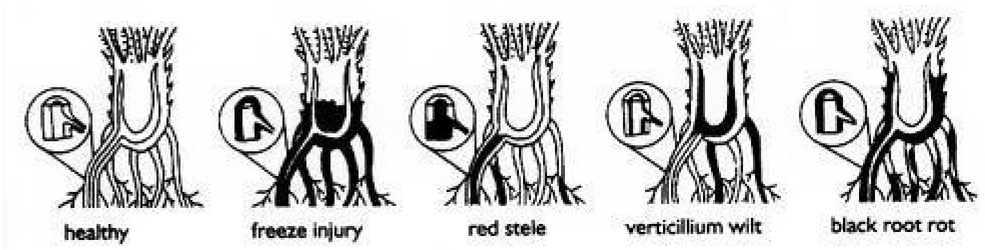
Section of an infected strawberry root (left) showing discoloration from red stele disease. Healthy root on right.

## Causal Organism and Disease Cycle

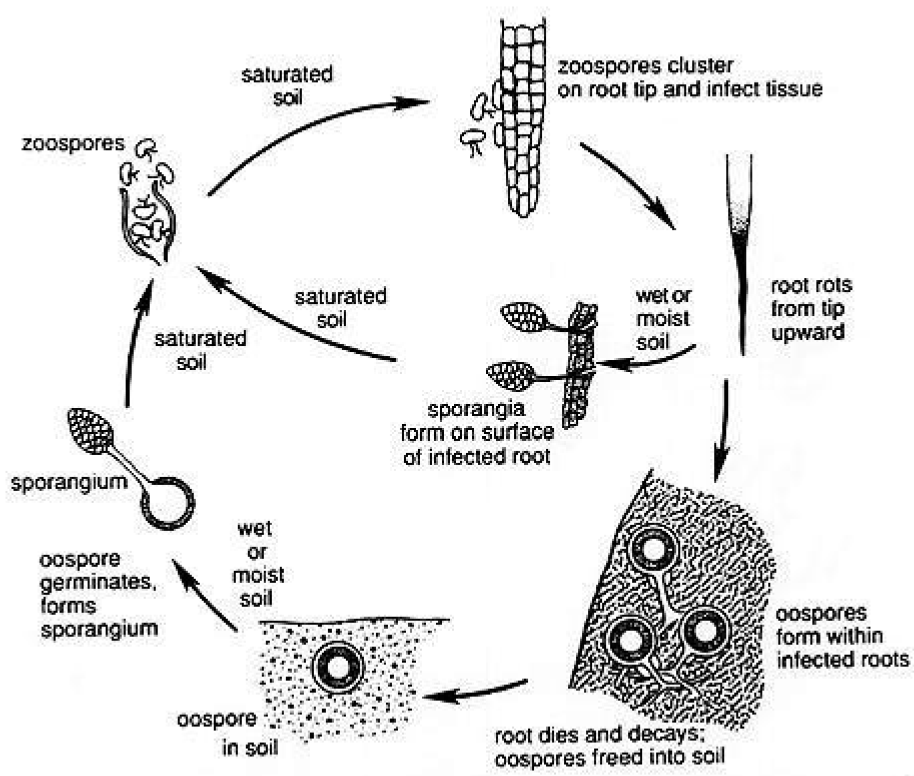
Red stele is caused by the soilborne fungus *Phytophthora fragariae*. This fungus is not a natural inhabitant of most agricultural soils but probably is introduced on nursery stock or by the movement of infested soil and runoff water from fields in which the disease occurred previously. *P. fragariae* is very persistent and can survive in a field for many years once it has become established, even if no strawberries are grown during that time. The organism that causes red stele of strawberry is not known to cause disease on any other crop, with the possible exception of loganberry.

*P. fragariae* persists in the soil as thick-walled resting spores (oospores). When the soil is moist or wet, some of the oospores germinate and form structures called sporangia, which are filled with the infectious spores of the fungus (zoospores). These microscopic zoospores are released into the soil when it becomes completely saturated with water (flooded or puddled) and use tail-like structures to swim short distances through water-filled soil pores to the tips of strawberry roots, to which they are chemically attracted. Zoospores also may swim to the soil surface, where surface runoff water may carry them relatively long distances. Zoospore activity may occur at soil temperatures ranging from about 38 to 77 degrees F (4 to 25 degrees C), but is most significant from 44 to 59 degrees F (7 to 15 degrees C). Thus infection is most likely in the spring and fall.

Once zoospores have infected the root tip, the fungus begins to grow up into other parts of the root, causing the characteristic dark rot and red stele symptoms. New sporangia are formed along the outside of infected root issue and release additional zoospores whenever the soil is saturated, thereby continuing to spread the disease. The fungus produces oospores within infected roots as they begin to rot and die, and these oospores are released into the soil when the roots decay, thus completing the disease cycle.




Some common strawberry root problems and typical symptoms.




Disease cycle of Red stele on strawberry.

## Control

Since significant production and movement of infective zoospores occurs only during periods when the soil is completely saturated, the key to control is drainage. Strawberries should not be planted in low-lying or heavy soils where water accumulates or is slow to drain. On marginal soils, planting strawberries on beds raised at least 10 inches high will bring much of the root system above the zone of greatest pathogen activity and the severity of red stele root rot should be significantly reduced.

Strawberry varieties highly resistant to red stele should be seriously considered for planting in a marginally drained site or a field in which red stele has been suspected of occurring in the past. Only resistant varieties should be planted in a field where red stele is known to have caused losses within the last 5 to 10 years. The following junebearing varieties are reported to be resistant to Red Stele: Allstar; Delite; Earliglow; Guardian; Lester; Midway; Redchief; Scott; Sparkle; Sunrise and Surecrop. The everbearing varieties are also reported to be resistant. All "resistant" varieties, however, are resistant only to certain common races of the red stele fungus and can become diseased if exposed to other races of the pathogen.

It is important to minimize the chance of introducing the red stele fungus into a field where it does not already exist. Buy nursery stock only from a reputable supplier, and take care not to transfer soil on farm implements from an infested field into a clean one. New fungicides active against red stele also help in controlling this disease but are most effective when used in combination with good soil water management practices.

For the most current spray recommendations, commercial growers are referred to Bulletin 506-B2 "*Ohio Commercial Small Fruit Spray Guide*," and backyard growers are referred to Bulletin 780 "*Controlling Diseases and Insects in Home Fruit Plantings*." These publications can be obtained from your county extension agent or the Extension Publications Office, The Ohio State University, 385 Kottman Hall, 2021 Coffey Road, Columbus, Ohio 43210-1044.

---



---

ohioline.ag.ohio-state.edu -- your Link to Information, News, and Education

FactSheet Extension

# Ohio State University Extension Fact Sheet

## Plant Pathology

**2021 Coffey Road, Columbus, Ohio 43210-1087**

---

# Botrytis Fruit Rot "Gray Mold" of Strawberry, Raspberry and Blackberry

**HYG-3017-94**

**Michael A. Ellis**

Early stages of gray mold on strawberry fruit.

Many fungi are capable of rotting mature or near-mature fruits of strawberry, raspberry, and blackberry. Under favorable environmental conditions for disease development, serious losses can occur. One of the most serious and common fruit rot diseases is gray mold. The gray mold fungus can affect petals, flower stalks (pedicels), fruit caps, and fruit. In wet, warm seasons, probably no other disease causes a greater loss of flowers and fruit. The disease is most severe during years with prolonged rainy and cloudy periods during bloom or during harvest.

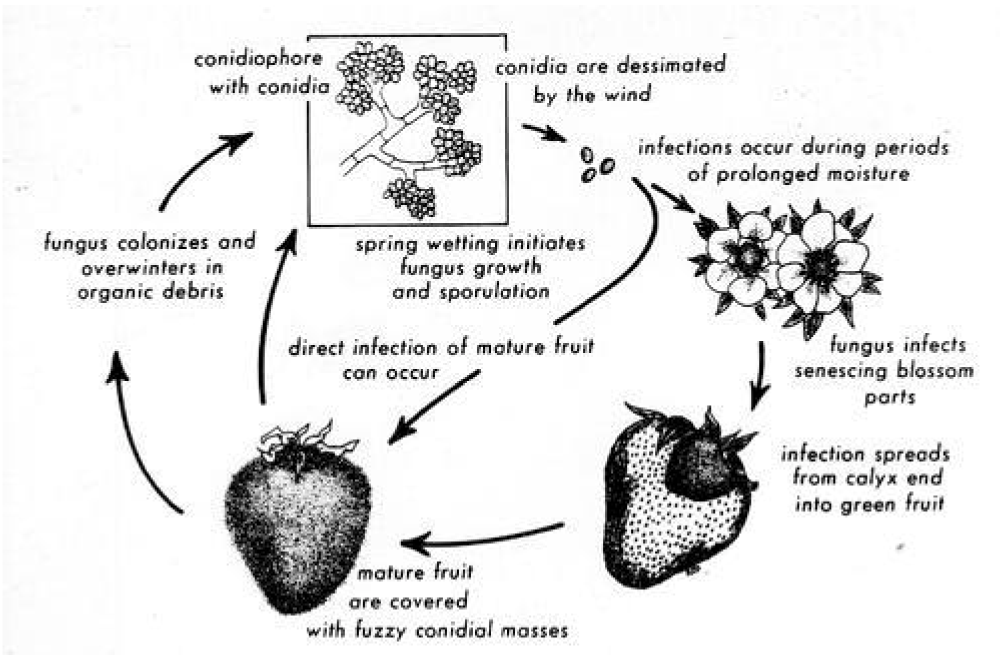
### Symptoms

Young blossoms are usually very susceptible to infection. One or several blossoms in a cluster may show blasting (browning and drying) that may extend down the pedicel. Fruit infections usually appear as soft, light brown, rapidly enlarging areas on the fruit. If infected fruits remain on the plant, the berry usually dries up, "mummifies," and becomes covered with a gray, dusty powder, which gives the disease its name "gray mold." Fruit infection is most severe in well-protected areas of the plant, where the humidity is high and air movement is poor. On strawberry, berries resting on soil or touching another decayed berry or a dead leaf in dense foliage are most commonly affected. The disease may develop on young green fruits, but fruits become more susceptible as they mature. Usually, the disease is not detected until fruits are mature at harvest time. After picking, mature fruits are extremely susceptible to gray mold, especially if bruised. During picking, the handling of infected fruit will spread the fungus to healthy ones. Under favorable conditions for disease development, healthy berries may become a rotted mass within 48 hours after picking.

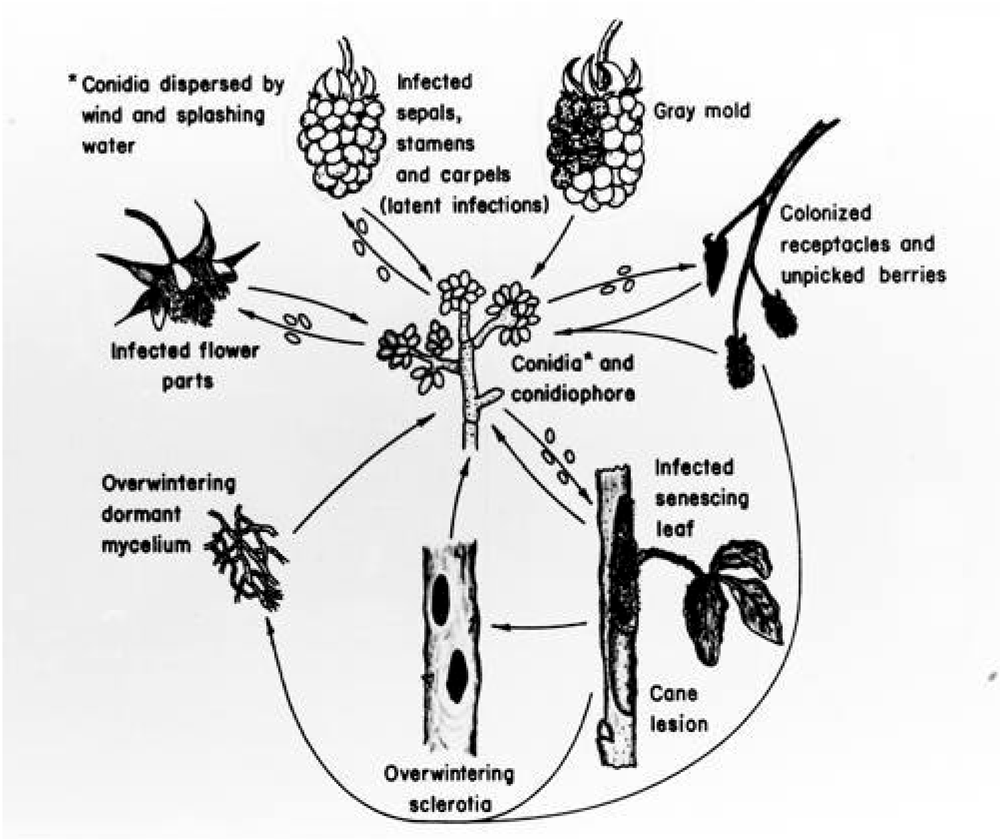
## Causal Organism


Later stages of gray mold on strawberry fruit.

Gray mold is caused by the fungus *Botrytis cinerea*. The fungus is capable of infecting a great number of different plants. The disease cycle is very similar for both strawberries and brambles. The fungus overwinters as minute, black, fungus bodies (sclerotia) or as mycelium in plant debris, such as dead strawberry or raspberry leaves. Recent research has shown that nearly all of the overwintering inoculum in strawberry plantings comes from mycelium in dead strawberry leaves within the row or planting. In early spring, the mycelium becomes active and produces large numbers of microscopic spores (conidia) on the surface of old plant (leaf) debris in the row. Spores are spread by wind throughout the planting where they are deposited on blossoms and fruits. They germinate when a film of moisture is present and infection can occur within a few hours. Temperatures between 70 and 80 degrees F (20 to 27 degrees C) and free moisture on the foliage from rain, dew, fog, or irrigation water are ideal conditions for disease development. The disease can develop at lower temperatures if foliage remains wet for long periods. Strawberries and raspberries are susceptible to Botrytis during bloom and again as fruits ripen. Recent research indicates that most fruit infection actually occurs during bloom; however, symptoms usually do not develop until close to harvest. During bloom, the fungus colonizes healthy or senescing flower parts, often turning the blossoms brown. These blossom infections establish the fungus within the receptacle of the young fruit as a "latent" or "quiescent" infection. The fungus generally remains latent in developing (green) fruit until the fruit starts to mature, at which time the fungus becomes active and symptoms (rot) appear. Thus, the most critical period for applying fungicides to control gray mold is during bloom. This is an important point to remember when considering fungicide applications for controlling this disease.




**Disease cycle of gray mold on strawberry.**




**Botrytis gray mold on raspberry fruit.**

Gray mold fruit rot on raspberry.

## Control

Select a planting site with good soil drainage and air circulation. Plants should be exposed to direct sunlight. Plant rows with the direction of the prevailing wind to promote faster drying of foliage and fruit.

A good layer of straw mulch (or other material) between the rows or around the plants aids greatly in controlling fruit rots. The mulch acts as a barrier that reduces fruit contact with the soil.

Proper spacing of plants and timing of fertilizer applications are also important. Excessive applications of nitrogen fertilizer, especially in the spring before harvest, can produce excessive amounts of dense foliage. Shading of berries by thick foliage prevents rapid drying of the fruit during wet periods and creates ideal conditions for disease development.

Good weed control is very important. Weeds prevent air movement in the plant canopy. This slows drying time of flowers and fruits and increases the chances for infection. Pick fruit frequently and early in the day as soon as plants are dry. Cull out all diseased berries but do not leave them in the field. Handle berries with care to avoid bruising. Refrigerate fruit promptly at 32 to 50 degrees F (0 to 10 degrees C) to check gray mold.

Fungicides are an important disease management tool in commercial plantings, but are generally not effective unless they are timed properly and used in conjunction with the above mentioned cultural practices. Homeowners are encouraged to emphasize the use of cultural practices in order to avoid the use of fungicides. For the most current fungicide recommendations and spray schedules, commercial growers are referred to Bulletin 506-B2 "*Ohio Commercial Small Fruit Spray Guide*," and backyard growers are referred to Bulletin 780 "*Controlling Diseases and Insects in Home Fruit Plantings*."

---