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Cooperative Extension Service

# Midwest Tree Fruit Pest Management Handbook

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# Contents

# Preface

This tree fruit production guide is presented in an ongoing attempt to better serve midwestern fruit growers. Financial constraints make publication of fruit production circulars by each of the North Central states increasingly difficult. By pooling the resources and expertise of the various states, Extension specialists believe that this publication will be of better quality, with information adaptable over a wider range of climates, soil conditions, and orchard management schemes. This cooperation enables the authors to include more information at greater depth that should be of value to you, the grower.

This handbook contains information on pests, production practices, and pest management practices that should be useful over several years. Your state's spray guide, which lists pesticides for specific crops and problems, is published separately and is updated each year. This handbook should be used in conjunction with an up-to-date spray guide for your state and with the newsletters issued from your state's Cooperative Extension Service. Contact your state's Extension fruit specialist for information on newsletters.

This publication does not replace the many publications on fruit cultivars or management practices that are available from your Cooperative Extension Service. Other useful references are included in Appendix C.

### *Disclaimer Clause*

Reference to products in this publication is not intended to be an endorsement to the exclusion of others which may be similar. Any person using products listed in this publication assumes full responsibility for their use in accordance with current directions of the manufacturer.

### *Legal Responsibilities for Pesticide Use*

Pesticides suggested for use in this publication are registered by the Environmental Protection Agency, Pesticides Regulation Division, and are cleared for use as indicated on the individual labels. The legal limitations in the use of these pesticides should be strictly observed to prevent excessive residues in or on harvested fruit. Each grower is held responsible for the residues on fruit from his or her orchard and should follow directions carefully and observe cut-off dates and rates of application. Some of the pesticides listed may be on the EPA restricted-use list.

# Introduction

## Orchard Management

Economic production of high-quality fruit depends on the growers developing a system of crop management that is appropriate for each orchard. Decisions are made to manage practices such as planting, fertility, harvesting, and pruning as well as to manage the insect, disease, and weed problems that can reduce yield or quality. Diseases and insects affect fruit production throughout the Midwest, although the relative importance of the different diseases and insects varies from region to region. The information in this handbook should serve as an introduction to some of the common diseases and insects in the Midwest, but it is the responsibility of growers to know which pests are important in their orchards. Your state Cooperative Extension Service can help you identify diseases and insects and direct you to additional resources on specific problems. For current recommendations, refer to the *Commercial Tree Fruit Spray Guide*, available from your Cooperative Extension Service.

Effective management of an orchard pest problem depends on:

- Using appropriate cultural practices that will prevent or delay pests from reaching damaging levels,
- Early detection of pests and/or environmental conditions that regulate pests before serious losses occur,
- Correct diagnosis of the problem and correct identification of the pest causing it, and
- Evaluation of pest population densities to determine if economic damage is likely and if additional control measures are needed.

### Diseases

The diseases described in the following sections are caused by fungi and bacteria. However, several important diseases result from infection by viruses, phytoplasmas (formerly called mycoplasma-like organisms or MLOs), and nematodes. To keep your orchard free from virus and phytoplasma diseases, purchase trees that are certified "virus-free" from reputable nurseries. Where possible, eradicate wild alternate hosts of virus and phytoplasma diseases. For example, wild chokecherry is a common host for X-disease, an important phytoplasma disease of peaches, nectarines, and cherries. Control insects, especially aphids and leafhoppers, which are common vectors of viruses and phytoplasmas. Finally, if you do your own grafting, be aware that several diseases are graft transmissible.

### Integrated Pest Management (IPM) of Insects, Mites, and Diseases

Integrated pest management is a systematic way to use multiple techniques to manage orchard costs, avoid economic damage, and minimize environmental damage. It includes the use of *cultural and mechanical practices* to prevent pest outbreaks from developing; *biological control* to encourage the pest's natural enemies to survive and attack pests; and selective use of *chemical control* when cultural and biological controls are inadequate and a crop needs to be rescued from a damaging pest population. IPM maximizes applicator and environmental safety while minimizing pesticide usage and ensuring high fruit quality and yields. *Although the term "pest" means "insects" to many people, in IPM the term pest is used in a broader sense that includes disease-causing microorganisms and weeds, as well as insects, mites, birds, and mammals.*

The types of pests and their intensities vary among orchards in the Midwest. Orchards in warmer or drier climates may not have the same key pests of the same crop in a cooler or wetter climate. For that reason, IPM is not simply a "recipe" to follow. The grower must identify the important pests and deploy appropriate preventive cultural practices, monitoring, and control strategies that exploit knowledge about the pests' life cycles and their natural enemies. Additionally, as new IPM strategies are discovered, orchard IPM programs will continue to evolve by integrating new strategies into a unified program.

### Disease Management as a Component of IPM

Diseases must be considered in the larger framework of whole orchard management. Most practices that promote tree health—planting on favorable sites, adequate but not excessive fertilization, and proper pruning—will improve trees' resistance to diseases. Many diseases can be managed by planting resistant cultivars. Orchard sanitation (e.g., removing diseased and dead tissues) will reduce disease pressure.

Fungicide and bactericide use is consistent with IPM, if these pesticides are used judiciously. Overuse and misapplication of pesticides are not only economically and environmentally unsound, but could lead to the development of pathogens that are tolerant of or resistant to the pesticide. For example, resistance of the apple scab pathogen to the fungicides benomyl and dodine has been documented throughout the world. Likewise, the fire blight pathogen has developed resistance to streptomycin in the Pacific Northwest and regions of Michigan and Missouri. Specific information on currently available fungicides and bactericides is provided in Chapter 6.

The number and variety of pesticides available to manage diseases and other pests of fruit crops is finite. If a pathogen becomes resistant to a product, it is unlikely that an effective substitute or alternative will be available to manage the disease. We must take steps to ensure that the limited arsenal of pesticides will be functional until effective nonchemical means of control are practical in commercial orchards. To reduce the risk of resistance developing to a pesticide: 1) use pesticides only in the framework of an IPM program; 2) minimize the number of applications; 3) do not go below or above rates given on product labels; and 4) avoid exclusive, season-long use of a single product or products with similar modes of action.

## Strategies of Pest Management

Some of the strategies 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 summaries at the end of the disease and insect sections within each crop chapter.

### Cultural Controls

These are preventive and help to minimize infestations and infections.

When establishing a new orchard:

- Site selection,
- Variety and rootstock selection,
- Disease-free planting stock, and
- Tree density.

When maintaining an orchard:

- Pruning: remove infected or infested branches, improve tree architecture, allow quicker drying of leaves, and improve spray penetration;
- Fertility: provide plants with optimum nutrient levels;
- Timely sanitation of prunings, fruit mummies, and other orchard debris;
- Fruit thinning;
- Habitat modification: remove weeds and alternate hosts of pests; and
- Pest exclusion: use fences or nets to exclude wildlife.

### 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, traps, or poisoned feeding stimulants to prevent pest infestation.

## Chemical Controls

- Conventional synthetic pesticides,
- Inorganic pesticides,
- Botanical pesticides,
- Soaps and oils, and
- Insect growth regulators.

## Biological Control

### *Natural Enemies of Disease-causing Microorganisms*

Biological control of insect pests has a long and better-known history than biological control of disease-causing microorganisms, but research in both disciplines has been increasing recently. Beneficial microorganisms that have the potential for incorporation into IPM programs include some fungi that attack pathogenic nematodes and beneficial fungi, such as *Trichoderma,* that are antagonistic to fungal crop pathogens. Although commercial biological control products have great potential for the future, they play a relatively small role in current disease management programs in midwestern orchard systems.

### *Types of Natural Enemies Attacking Arthropods*

All insects and mites have natural enemies that attack them. Only a small percentage of the arthropod species typically found in an orchard are pests. In unmanaged orchards, it may be difficult to find some pests because they are kept under control by natural enemies. In managed orchards, natural enemies may be scarce because they are sensitive to pesticides. Natural enemies of arthropod pests in the orchard may be predators, parasitoids, or pathogens. For detailed information about natural enemies, see the publications by Mahr and Ridgeway (1993) and Henn and Weinzierl (1990) listed at Appendix C.

**Predators** are usually as big or larger than their prey. They consume several to many prey over the course of their development. Common predators include hover fly larvae (also called syrphid fly larvae), lacewing larvae, some lacewing adults, ground beetle adults and larvae, lady beetle adults and larvae, minute pirate bugs, damsel bugs, assassin bugs, some stink bugs, yellowjackets, and some thrips (Figure 1). Some species of mites such as *Neoseiulus (Amblyseius) fallacis* and *Zetzellia mali* are also predators.

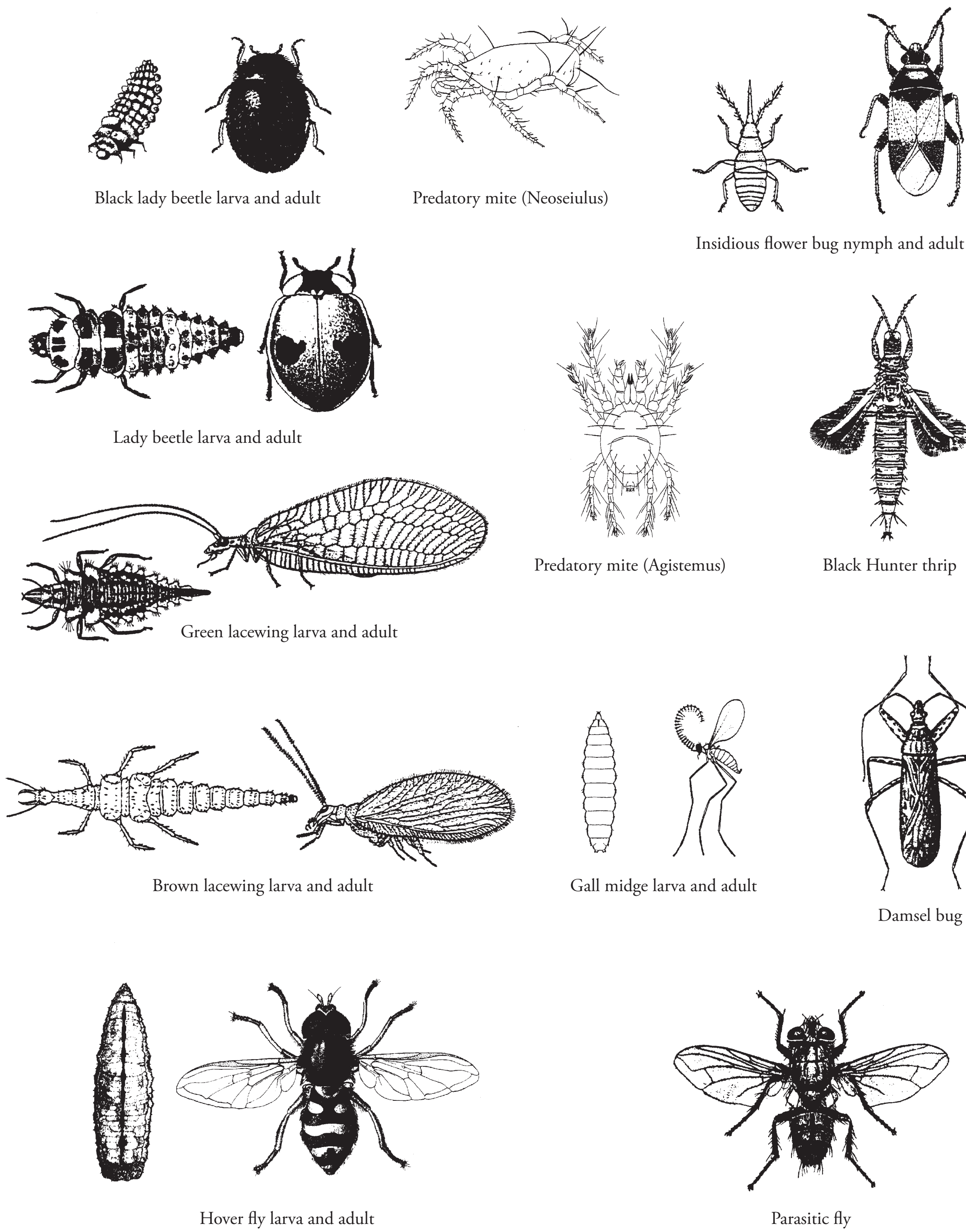
**Parasites** are usually smaller than their hosts. A parasite usually does not kill its host or consume large parts of its tissue. *Parasitoids* are similar to parasites, but they differ in important ways. Unlike true parasites that usually only weaken their host, parasitoid development always results in the death of the host. Parasitoids are usually about the same size as their host. Several types of wasps and flies are common parasitoids. The adult female lays eggs inside the body of the host pest, and the egg hatches into a larva that slowly consumes the body of the host. Parasitoids commonly attack soft-bodied insects, such as caterpillars, aphids, eggs, or pupae.

**Beneficial pathogens** are living microbial organisms that cause insects and mites to become sick and die. These include fungi, bacteria, viruses, protozoa, and nematodes. These pathogens occur naturally, particularly when the weather is warm and wet for prolonged periods. These are not the same pathogens that cause disease in plants. In fact, one advantage of beneficial pathogens is that toxicity to other organisms and humans is very low. A few commercially available microbial pesticides such as sprays contain the bacterium *Bacillus thuringiensis,* the fungus *Beauvaria bassiana,* and the nematode *Steinernema carpocapsae*.

### *Biological Control Methods*

Biological control involves conserving and encouraging naturally occurring enemies, or releasing natural enemies that have been purchased. The best way to encourage the survival of natural enemies in an orchard is to avoid exposing them to pesticides that are highly toxic to them. Some insecticides such as Guthion, Asana, Ambush, Pounce, and Sevin are toxic to a wide range of chewing and sucking insects. Some fungicides are also toxic to beneficial organisms. Natural enemies can also be conserved by choosing pesticides that are compatible with IPM, that is, that are toxic to target pests but relatively nontoxic to predators. Table 18 on page 87 shows the relative toxicity of several insecticides and miticides against predatory mites. It can also be done by using the spray strategy known as alternate row middle spraying, in which some unsprayed foliage is available as a refuge for predators.

**Figure 1.** Arthropod predators in midwestern orchards.



Some of the world's success stories of integrated biological and chemical control are from tree fruit, where naturally occurring predaceous lady beetles *(Stethorus punctum)* or predaceous mites *(Neoseiulus* [*Amblyseius*] *fallacis* and *Zetzellia mali)* have been important in keeping spider mites at tolerable levels. Likewise, some of agriculture's greatest disasters have resulted from the failure to use integrated management systems that rely on biological and cultural tactics as much as chemical control.

## Monitoring Insects and Mites to Make Control Decisions

**Action thresholds:** Many crops can tolerate a certain amount of pest damage without a reduction in yield or quality. 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 low levels (for example, plum curculio and apple maggot). A rescue treatment is not needed until the pest population reaches a critical density, usually referred to as a threshold or action threshold. An action threshold is the density of pests that signals the need for control if economic damage is to be avoided. Thresholds for different pests may be expressed as a number of pests per leaf or plant, per trap, 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, spotted tentiform leafminer control is suggested in some areas if the average number of mines per leaf is two or greater. Rosy apple aphid control is suggested in apples if 5 percent or more of the terminals or fruit clusters are infested. Codling moth control is suggested if pheromone traps catch an average of five or more moths per week. However, growers need to wait 250 degree-days after codling moth capture before applying an insecticide (see "Insect Development and Degree-days"). While action thresholds are available for pests of some orchard crops in the Midwest, particularly apples, thresholds for pests on many crops have not been determined.

### *Monitoring Pests*

Growers who practice IPM as part of their fruit production operation need to know how to monitor pests, especially insects and mites, because pest control decisions are based on the knowledge of *which pests* are present in their orchards, *how many* are present, *when* they are present, and how many are economically *tolerable*.

The two most common types of pest monitoring are *scouting* and *trapping*. Scouting and trapping each have their own merits. Scouting may be time consuming but can provide accurate information on the presence of the pest in its damaging 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 control decisions on the larval form. Both methods should be used, where appropriate, to provide information to make management decisions. Another method of predicting when pests are likely to appear is *weather monitoring*. Development of certain fungal and bacterial diseases can be predicted by monitoring temperature, duration of leaf wetness, and rainfall. Activity of some insects can be predicted by monitoring temperatures and calculating degree-days.

Scouting means walking through the orchard and looking for pests or symptoms of their presence. The purpose of scouting is to monitor the effectiveness of preventive actions and the possible need for a rescue treatment. A representative sample of each crop is examined to determine the average infestation or infection level. The number of plant parts to examine varies according to the crop, size of the orchard, and the time of 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. With a systematic sampling plan, orchards should be scouted on a regular basis, generally once a week. It is important to examine samples carefully for the presence of egg masses and small insects that may be present before the damage is evident.

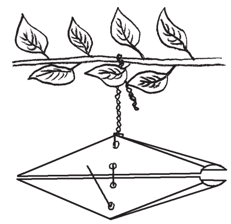
**Insect trapping.** Traps that have the ability to catch insects are useful in some cases to reduce insect densities through mechanical control, but are most often used as a monitoring tool. Insect traps are used to determine if an insect species is present as well as to estimate the insect's density and distribution. Insects can be attracted to traps by visual appearance or by odor. Odor traps attract certain insects by using scents associated with food or mates.

**Food attractant traps.** Traps that use the scent of a food source are commercially available for Japanese beetle, rose chafer, and apple maggot. While these may be used for mechanical control, they can also be used for monitoring purposes. The Japanese beetle bag trap uses a food attractant to lure both the 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 traps. The use of apple volatile lures greatly enhances the attractiveness of red sphere sticky traps to apple maggot flies.

**Visual traps.** The adult form of the apple maggot is a true fruit fly that is attracted to red spheres and yellow cards coated with sticky material. The effectiveness of these traps is enhanced when baited with apple volatile lures. Another example is white sticky traps used to monitor the tarnished plant bug.

**Pheromone traps.** The most common trapping method is the pheromone trap. Sex pheromones are natural scents produced by insects to attract mates. Most commercial pheromones are imitations of secretions from unfertilized adult female insects, which are used to attract male insects of the same species. The main advantage of pheromones is that they are specific to individual pest species; for example, the pheromone for the red-banded leafroller attracts only red-banded leafrollers and not the oblique-banded or fruit-tree leafrollers. Orchard pests that can be monitored with pheromone traps include codling moth, San Jose scale, red-banded leafroller, oblique-banded leafroller, fruit-tree leafroller, oriental fruit moth, peachtree borer, lesser peachtree borer, dogwood borer, American plum borer, and spotted tentiform leafminer.

Traps used with pheromone lures come in a variety of styles and materials. One of the most common types is a wing trap. A wing trap is made of a cardboard or plastic top and a sticky cardboard bottom, held together with a wire hanger. The pheromone is impregnated on a small rubber stopper which is placed in the middle of the sticky bottom or glued to the inside of the trap top. Another style is the bucket trap, such as a Unitrap or Multi-pher trap. Bucket traps have a funnel entry system for keeping the pest from escaping. This trap does not need a sticky coating. With pheromone traps, the lures need to be replaced periodically, typically every 4 weeks, or as recommended by the manufacturer.



*Insect pheromone trapping guidelines:*

- Use a minimum of two traps for each pest species in representative locations.
- Monitor traps at least twice a week.
- Count and record the number of captured insects in each trap. Compare the appearance of the trapped insects with pictures or specimens of the intended target pest to be sure you are not counting other species. Remove captured insects during each visit with a wire or twig, wipe them on a paper towel or rag, and dispose of them away from the orchard.
- Record trap catches on each date in an IPM scouting log. It can help to keep a running graph of the information.
- Change trap liners (sticky cardboard bottoms) monthly, or more frequently when covered with debris. The trap often becomes less effective if too much dust or debris accumulates in the sticky layer.
- Change pheromone lures every 4 weeks (or according to manufacturer's directions). DO NOT dispose of old lures in the orchard; these will compete with the traps and cause lower trap catch numbers. It is useful to establish a pattern when changing lures, such as the first of every month.
- Store replacement lures in a freezer or refrigerator. It is best to only buy a 1-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 the oldest ones can be used first.

- If you are trapping for more than one species, change gloves or wash your hands when handling pheromones for different species to prevent cross-contamination. Minute traces of one pheromone on another can render the second completely ineffective to its target pest. Label each trap with the target pest name, and be sure to place the correct pheromone lure into the correct trap.

## *Weather Monitoring*

The weather conditions that determine the rate of 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 computer. The weather monitoring station should be located within the orchard in a location that is representative of the orchard. Weather data can then be pulled into equations or computer programs for disease development to determine management actions. Predictive models are available for apple scab and fire blight.

**Insect development and degree-days.** While scouting and trapping can provide information about which pest species are present at a given time, another monitoring tool of a more predictive nature is the use of temperature-based development models. Temperature plays a major role in determining the rate at which insects develop. Each insect species has a temperature range in which it feeds and develops. Below that temperature range, the insect will not develop, and above that temperature range, development will slow drastically or stop. Each insect also has an optimal temperature at which it will develop at its fastest rate. By using this relationship, you can predict 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 four things: the threshold temperature, the daily average temperature, the thermal constant, and the biofix date. Each insect species has a *threshold* temperature. Below this temperature no development of the insect occurs. The threshold temperature is 50°F for many insect species, 43°F for other species. A degree-day is the number of degrees above the threshold temperature over a 1-day (24-hour) period. For example, if the threshold temperature of an insect is 50°F and the average temperature for the day is 80°F, then 30 degree-days would have accumulated on this day
(80 – 50 = 30).

The accumulation of degree-days can be used to predict when insects will hatch, pupate, and emerge as adults. By using accumulated degree-days, growers can estimate when a pest will appear in their 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. This 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 start of degree-day accumulations varies by pest species but usually is based on either a fixed calendar date or a specific biological event (biofix). The calendar date is the same each year (often January 1), but often it is necessary to keep track of degree-day accumulations for several weeks before the insect appears. The biofix is often the initiation of adult flight or peak flight as indicated by pheromone trap catches. For example, with codling moth, the biofix is the date when the fifth moth is captured at the beginning of the season.

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°F, and the low temperature was 60°F, then the average temperature for the day would be:

75°F [(90 + 60) ÷ 2 = 150 ÷ 2 = 75)].

If the threshold temperature for an insect were 50°F, then 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, use the following rules:

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

   maximum daytime temperature = 45°F
   threshold temperature = 50°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 example:

   maximum daytime temperature = 70°F
   low daytime temperature = 45°F
   threshold temperature = 50°F.

   The threshold temperature of 50°F would be used instead of the actual low daytime temperature when calculating the average daily temperature. So the degree-day units accumulated on this day would be 10:

   [(70 + 50) ÷ 2 – 50 = 120 ÷ 2 – 50 = 60 – 50 = 10].

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 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°F
   optimum temperature = 95°F
   low daytime temperature = 75°F
   threshold temperature = 50°F.

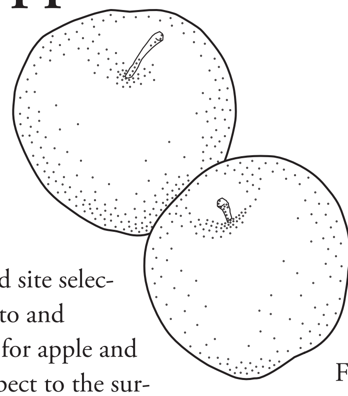
   The optimum temperature of 95°F would be used instead of the actual high temperature for the day when calculating the average temperature for that day. So the degree-day units accumulated on this day would be 35:

   [(95 + 75) ÷ 2] – 50 = (170 ÷ 2) – 50 = 85 – 50 = 35].

   Many of the insect pests that attack orchard crops in the Midwest have degree-day models developed to predict their development. Degree-day models are commonly used to improve the timing of insecticide applications for codling moth and San Jose scale (see Appendix A).

CHAPTER 1

# Apples and Pears



Successful production of apples and pears depends in large part on good site selection and paying meticulous attention to and following through on details. The site for apple and pear orchards should be high with respect to the surrounding area and have excellent air drainage to avoid late spring frost losses and to reduce disease pressure. Pears are more prone to spring frost injury because they bloom earlier than apples. Proximity to a good water source for irrigation and spray water is highly desirable.

Both crops perform best on deep, friable, fertile soils with good internal drainage. Deep soils are desirable because of their greater water-holding capability and capacity to continue sizing fruit under dry conditions. Pears will generally perform better on heavier soils than apples. Soils that remain wet for long periods or that have a high water table, impervious clay pans or hardpans close to the surface, or very heavy clay texture reduce chances of success. Wet soils promote Phytophthora root rot, particularly in apples on susceptible rootstocks. Some of these problems can be remedied by managing surface water through waterways and drainage ditches and by installing drainage tile.

One to two years before planting, adjust the soil pH, phosphorus, potassium, calcium, magnesium, and other minor element levels as recommended. Adjustment of the soil pH to between 6.5 and 7.0 and incorporation of organic matter or a green manure crop are highly recommended prior to establishment. Nitrogen, applied early in the season, should be the only element required for the first several years if proper soil adjustments are made initially. Nitrogen should be applied based on the inherent fertility of the soil and annual tree growth. Excessive nitrogen applications should be avoided because they make trees more susceptible to fire blight and reduce fruit color development and storage life. Nitrogen application rates are intentionally kept low on pears to reduce fire blight susceptibility.

Foliar nutrient applications are minimized in the Midwest because it is much cheaper and more efficient to apply fertilizers to the soil. Foliar applications are generally recommended to accomplish a "quick fix" when nutrient deficiencies are detected. However, calcium and boron foliar sprays are routinely applied in many orchards. Calcium sprays are used to reduce cork spot and bitter pit, since it is often difficult to get sufficient calcium into the fruit even when soil levels are at recommended levels. Some growers also apply foliar boron sprays annually where soil levels are low. Foliar magnesium is occasionally used where foliar symptoms are apparent.

A combination of soil testing and leaf tissue analysis (sampled in mid- to late July) is recommended for monitoring tree nutrient levels and is used to make fertility recommendations. Consult your state Cooperative Extension Service for leaf-testing procedures and processing instructions.

Weed pests will deprive trees of water and minerals. Although orchards will always have some weeds, noxious perennial weeds such as johnsongrass, vining milkweed, trumpet vine, poison ivy, and yellow nutsedge should be eliminated from the site prior to planting trees.

Many midwestern growers are adopting high-density planting systems such as the French axis for apples. These systems use dwarf rootstocks, have considerably higher per acre dollar inputs, and require a considerably higher level of grower expertise and cultural management. However, these systems crop much earlier and provide a much faster return on investment than less dense planting systems.

# Integrated Management of Apple and Pear Diseases

The objective of an integrated disease management program is to provide a commercially acceptable level of disease control from year to year while minimizing the cost of disease management. For each orchard, a program needs to be developed that integrates all available control tactics.

# Identifying and Understanding Major Apple and Pear Diseases

Accurate disease identification is critical in making smart disease management decisions. Growers should develop a basic understanding of the pathogen biology and disease life cycles for the major apple diseases. The more you know about a disease, the better equipped you will be to make sound and effective management decisions. The following literature contains colored photographs of disease symptoms on apples and pears, as well as information on pathogen biology and disease development.

*Compendium of Apple and Pear Diseases*
Published by the American Phytopathological Society, 3340 Pilot Knob Rd., St. Paul, Minnesota 55121. Phone: (612) 454-7250 or (800) 328-7560.

*Diseases of Tree Fruits in the East*
Published by Michigan State University Cooperative Extension Service, as Publication NCR 45. Your county Extension office may have this bulletin in stock, or call Michigan State University. Phone: (517) 355-0240.

## Apple Scab

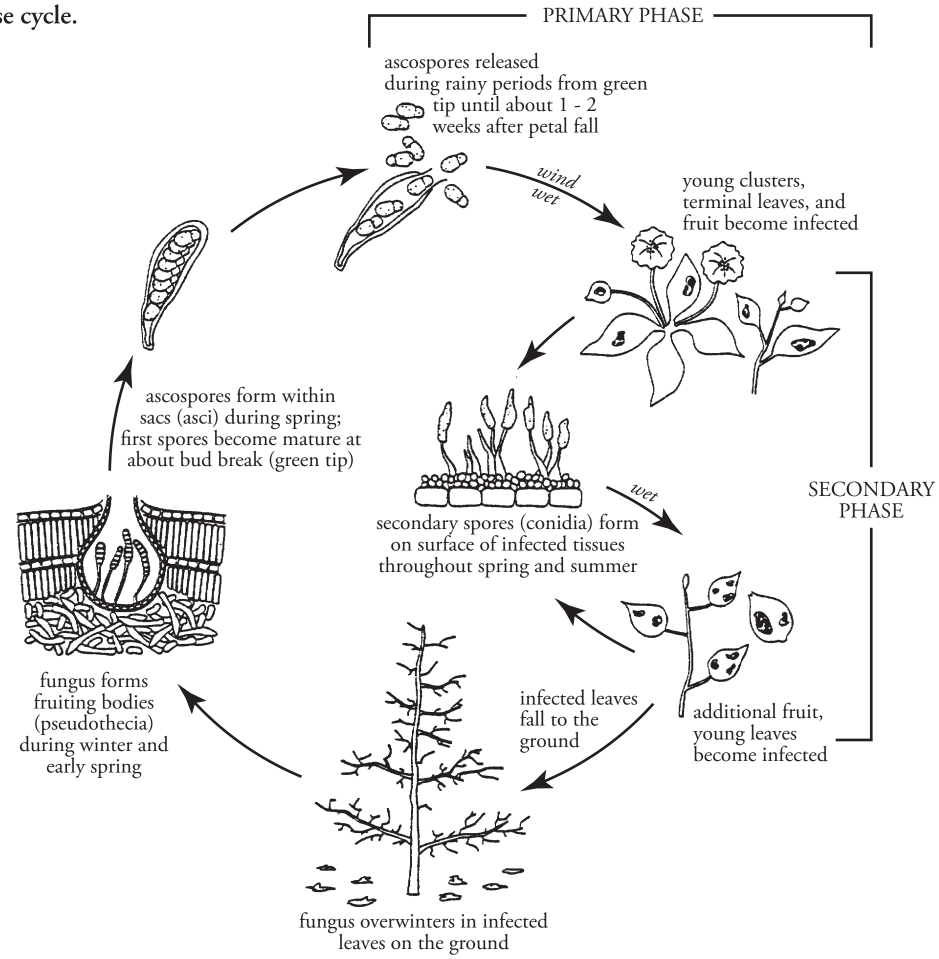
The most common disease of apple in the Midwest is apple scab, caused by the fungus *Venturia inaequalis*. Pear scab is caused by a related fungus, *Venturia pirina*, but is a minor problem compared to apple scab in the Midwest. Scab-resistant apple cultivars (Table 1) are recommended for growers who do not want to use fungicides. Contact your state Cooperative Extension Service for information on the cultivars best suited for your region. In the moist, temperate climate of the Midwest, managing orchards where scab-susceptible cultivars are grown depends on the judicious use of

**Table 1. Relative resistance of apple cultivars to apple diseases.**

| Cultivar | Apple scab | Cedar-apple rust | Fire blight | Powdery mildew |
|---|---|---|---|---|
| Ben Davis | 3 | 3 | 4 | 3 |
| Braeburn | - | - | 4 | - |
| Cortland | 4 | 3 | 3 | 4 |
| Delicious | 3 | 1 | 2 | 2 |
| Early McIntosh | 3 | 2 | 2 | - |
| Empire | 4 | 2 | 2 | 3 |
| Enterprise | 1 | 2 | 2 | 2 |
| Freedom | 1 | 1 | 3 | 2 |
| Fuji | 3 | - | 4 | - |
| Gala | 3 | - | 4 | - |
| Golden Delicious | 3 | 4 | 3 | 3 |
| Goldrush | 1 | 4 | 2 | 2 |
| Granny Smith | 3 | 2 | 4 | 4 |
| Idared | 3 | 3 | 4 | 3 |
| Jerseymac | 4 | 1 | 3 | - |
| Jonafree | 1 | 3 | 2 | 2 |
| Jonagold | 4 | 3 | 4 | - |
| Jonamac | 3 | 2 | 3 | 3 |
| Jonathan | 3 | 4 | 4 | 4 |
| Liberty | 1 | 1 | 2 | 2 |
| Lodi | 3 | 4 | 4 | 2 |
| Macfree | 1 | 3 | 2 | 3 |
| McIntosh | 4 | 1 | 3 | 3 |
| Mutsu (Crispin) | 4 | 3 | 4 | 4 |
| Northern Spy | 3 | 3 | 2 | 3 |
| Paulared | 3 | 2 | 4 | 3 |
| Prima | 1 | 3 | 2 | 2 |
| Priscilla | 1 | 2 | 2 | 2 |
| Pristine | 1 | 3 | - | 3 |
| Quinte | 3 | 3 | 3 | 3 |
| Redfree | 1 | 2 | 3 | 3 |
| Rome Beauty | 4 | 4 | 4 | 3 |
| Sir Prize | 1 | 4 | 4 | 2 |
| Smoothee | 3 | 3 | 2 | - |
| Spartan | 3 | 2 | 3 | 2 |
| Starkspur Earliblaze | 3 | 2 | 3 | - |
| Stayman | 4 | 3 | 2 | 3 |
| Tydeman's Red | 3 | 1 | 3 | 2 |
| Williams Pride | 1 | 1 | 2 | 2 |
| Williams Red | 3 | 2 | 2 | - |
| Winesap | 4 | 3 | 2 | 3 |
| Yellow Transparent | 3 | 3 | 4 | 2 |

Resistance rating determined in New York by Cornell University Extension personnel; reports of T. van der Zwet and S. Beer, USDA Bulletin 631; D. Rosenberger, Northeast LISA Apple Project; and T. Sutton, *A Grower's Guide to Apple Insects and Diseases in the Southwest*. Several cultivars have been added to this table based on midwestern observations. Rating system; 1 = very resistant (No chemical control needed), 2 = resistant (Chemical control needed only under high disease pressure), 3 = susceptible (Chemical control usually needed where disease is prevalent), 4 = very susceptible (Chemical control needed where disease is prevalent. These cultivars should receive first priority when control is called for).

**Figure 2. Apple scab disease cycle.**




fungicides. Knowing the apple scab disease cycle (Figure 2), the weather conditions that favor infection (Tables 2 and 3), and the basics of how fungicides work (Table 4 and Chapter 6) will help you decide which fungicides to use and when to use them.

**Disease Development:** During winter and early spring, the scab fungus develops in fallen leaves that were infected the previous season. The development of fruiting bodies is favored by alternating dry and wet periods. Primary scab spores (ascospores) mature in early spring about the time that leaves start to emerge. When leaves on the orchard floor have been wetted by at least 0.01 inches of rain for at least 30 minutes, ascospores are released and carried by air currents to newly emerging leaves and blossoms. The maximum rate of spore discharge is reached after 2 to 3 hours of wetness; after 6 hours, 75 percent of the ascospores that are mature during that wetness period will have been discharged. In general, maximum ascospore discharge and maximum susceptibility of leaves and fruit occur between tight cluster and 10 days after petal fall. Discharge of ascospores may continue up to 2 weeks after petal fall, but the majority are released by first cover.

The time required for infection depends on the temperature and duration of the "wetting period," the period during which leaves on the tree are continuously wet from rain or dew (Tables 2 and 3). When the infection process is not inhibited by a fungicide, primary scab lesions appear 9 to 17 days after infection depending on the temperature. Various forms of the "Mills Table" (Tables 2 and 3) are valuable for determining when conditions are favorable for infection and for deciding when fungicides with "after-infection" activity should be used. The Mills Table as modified by A. L. Jones in the 1980s (Table 2) has been validated in the field over several years and locations. The most recent modifications to the Mills Table (Table 3) have not been as widely validated but may be highly relevant to the Midwest. The newer table suggests that infection can happen in much less time at low temperatures than previous tables pre-

**Table 2. Approximate minimum number of hours of leaf wetting required for primary apple scab infection at various temperatures.**[a]

| | Degree of Infection | | | Lesion |
|---|---|---|---|---|
| Average Temp.(°F) | Light (hr)[b] | Moderate (hr) | Heavy (hr) | Appearance (Days)[c] |
| 78 | 13 | 17 | 26 | - |
| 77 | 11 | 14 | 21 | - |
| 76 | 9 ½ | 12 | 19 | - |
| 63 to 75 | 9 | 12 | 18 | 9 |
| 62 | 9 | 12 | 19 | 10 |
| 61 | 9 | 13 | 20 | 10 |
| 60 | 9½ | 13 | 20 | 11 |
| 59 | 10 | 13 | 21 | 12 |
| 58 | 10 | 14 | 21 | 12 |
| 57 | 10 | 14 | 22 | 13 |
| 56 | 11 | 15 | 22 | 13 |
| 55 | 11 | 16 | 24 | 14 |
| 54 | 11½ | 16 | 24 | 14 |
| 53 | 12 | 17 | 25 | 15 |
| 52 | 12 | 18 | 26 | 15 |
| 51 | 13 | 18 | 27 | 16 |
| 50 | 14 | 19 | 29 | 16 |
| 49 | 14½ | 20 | 30 | 17 |
| 48 | 15 | 20 | 30 | 17 |
| 47 | 17 | 23 | 35 | 17 |
| 46 | 19 | 25 | 38 | 17 |
| 45 | 20 | 27 | 41 | 17 |
| 44 | 22 | 30 | 45 | 17 |
| 43 | 25 | 34 | 51 | 17 |
| 42 | 30 | 40 | 60 | 17 |

a From W. D. Mills, Cornell University as modified by A. L. Jones, Michigan State University.
b The infection period is considered to start at the beginning of the rain.
c Number of days required for lesions to appear after infection has been initiated.

dicted. For example, according to Table 3, infection can take place if leaves are wet for 18 hours at 43°F, which is 7 fewer hours than predicted in Table 2. During especially wet springs when inoculum is high, one might be conservative and use data from Table 3. However, Table 2 has served many growers in many regions successfully over several years.

Within each primary scab lesion (which was caused by one ascospore), thousands of secondary spores (conidia) are produced, each of which is capable of causing a new infection. Conidia are spread by splashing rain and by wind. Germination and infection by conidia occur under about the same conditions as for ascospores. Additional conidia are produced all season long from established scab lesions. Although fruit become more resistant as they mature, secondary infection of fruit can occur in the fall but not show up until several weeks in storage. Scab can also develop on leaves, especially their lower surfaces, after harvest. This late-season scab may be from new infections, from infections that occurred several weeks earlier, or a combination of the two. In any case, late-season scab on leaves means that disease pressure will be high the following spring even though scab was managed during the growing season.

**Control of Apple Scab:** The key to successful apple scab control is to *prevent primary infection by ascospores*. Infections by ascospores occurring prior to tight cluster can cause significant losses because conidia are produced just as leaves and fruit reach maximum susceptibility. If ascospores are prevented from establishing infections early in the season, no further scab control is needed after ascospores are depleted. However, if scab is established early in the season, a grower must fight secondary infections throughout the summer. The number of conidia produced by just a few scab lesions is greater than the total number of ascospores produced in an entire acre of leaf litter in most commercial orchards.

Fungicides vary in their properties of retention, redistribution, protection, and after-infection activity (Table 4). In general, a program aimed at controlling scab will control other diseases (e.g., powdery mildew and rust) that are important early in the season. However, if you have a particular problem with other diseases, you may have to modify or bolster your scab control program. Four general approaches to primary scab control are:

**1. Standard Protectant Program (7-day interval)**
Protectant fungicides must be applied at approximately 7-day intervals during primary scab "season" because growing clusters and terminals are continually producing new tissues that need protection. The old rule-of-thumb is "Repeat protectant sprays after 7 days of new growth or one inch of rain." *In extremely wet growing seasons, intervals of less than 7 days may be required.* Also, the less effective protectants (e.g., ferbam, sulfur, thiram, and ziram) probably need to be

**Table 3. A proposed revision for the minimum number of hours of leaf wetness required to produce apple scab infections.[a]**

| Average temperature (°F) | Hours |
|---|---|
| 34 | 41 |
| 36 | 35 |
| 37 | 30 |
| 39 | 28 |
| 41 | 21 |
| 43 | 18 |
| 45 | 15 |
| 46 | 13 |
| 48 | 12 |
| 50 | 11 |
| 52 | 9 |
| 54-56 | 8 |
| 57-59 | 7 |
| 61-75 | 6 |
| 77 | 8 |
| 79 | 11 |

a Data of W. MacHardy and D. Gadoury; and A. Stensvand, et al., Cornell University.

applied more frequently than every 7 days. In practice the 7-day protectant program can be modified to take advantage of weather predictions. For example, if a protectant fungicide is used and no rain is predicted on days 7, 8, and 9 after the last application, the next application can be made just before the next rain. Unfortunately, springtime weather throughout the Midwest is unpredictable, and a grower assumes risk in stretching spray intervals beyond 7 days.

**2. Extended Sterol Inhibitor/Protectant Program (10-day interval not to exceed 14 days)**

This combination program utilizes both the protectant and after-infection activities of the different scab fungicides (Table 4 and Chapter 6) and should result in fewer sprays than the standard protectant program. The first scab spray of the season is a protectant fungicide applied between green tip and half-inch green. Sterol-inhibiting (SI) fungicides are not recommended in the first spray because there is not enough leaf tissue exposed to take up the systemic fungicide. At tight cluster, scab pressure is high, and the first SI/protectant combination spray is made. The SI/protectant combination provides approximately 5 to 6 days of protection and 3 to 4 days of curative activity, which means the spray interval can be extended to 10 days. This program can also be modified to take advantage of information on infection periods that are determined from environmental monitoring (Tables 2 and 3). For example, the interval can be extended 1 day for each day without infection on days 6 through 9 after the last application. When using SI/protectant combinations, *the interval should never exceed 14 days* because some scab lesions partially inactivated by the SI fungicides may not be completely controlled without a second spray.

*In extremely wet growing seasons, intervals of less than 10 days may be required*. For example, a 7- to 10-day interval using fungicides at their higher recommended rates is recommended if an infection period occurred greater than 2 days prior to the previous SI/protectant spray. The reasoning is as follows: The first SI/protectant spray will reach back 3 to 4 days, but will be most effective at halting scab development if applied within 2 days of an infection period. The purpose of the second spray is to inactivate any fungal growth that might have survived the first spray. Thus, the longer you wait after infection has occurred to apply the first spray, the more important it is to apply the second spray after only 7 to 10 days. If the second spray is not made, then the fungus may resume activity and produce lesions with conidia.

**3. Post-infection Program**

This program can significantly reduce the number of fungicide applications, but it should be used only by growers who are accurately monitoring infection periods. It is *not* recommended in orchards with high levels of scab inoculum from the previous year. This program is designed for orchards that had less than 2 percent fruit scab the previous year and did not have late-season scab on leaves. In the post-infection program, an SI/protectant combination should be applied within 72 to 96 hours after the start of an infection period. The sooner the spray is applied after the infection period, the more effective it will be. *Fungicides applied in a post-infection program should be used at their full recommended rates*. Post-infection sprays should be followed with a second application of the SI/protectant 7 to 10 days later (7 is better than 10) to make sure that scab lesions are inactivated. A

**Table 4. Properties of fungicides for apple scab control.**

| Trade Names[a] | Common Names | Rate/100 gallons | Retention[b] | Redistribution[c] | After-infection activity[d] (hr) | Protection[e] |
|---|---|---|---|---|---|---|
| Benlate 50WP | benomyl | 3.0 oz | Good | Good | 18-24 | Fair |
| Captan 50WP | captan | 2.0 lb | Good | Good | 18-24 | Very Good |
| Carbamate 76WP | ferbam | 2.0 lb | Good | Good | None | Good |
| Dithane M-45 80WP | mancozeb | 2.0 lb | Good | Good | 18-24 | Very Good |
| Manzate 200 80WP | mancozeb | 2.0 lb | Good | Good | 18-24 | Very Good |
| Nova 40% WP | myclobutanil | 2.0 oz | Fair | Fair | 72-96 | Fair |
| Penncozeb | mancozeb | 2.0 lb | Good | Good | 18-24 | Very Good |
| Polyram 80WP | metiram | 2.0 lb | Good | Good | 18-24 | Very Good |
| Procure 50WS | triflumizole | 4.0 oz | - | - | 48-72 | - |
| Rubigan 1E | fenarimol | 3.0 fl oz | Poor | Poor | 72-96 | Fair |
| Sulfur 95% | sulfur | 5.0 lb | Fair | Good | None | Fair |
| Syllit 65WP | dodine | 0.5 lb | Good | Good | 30-36 | Very Good |
| Thiram 65% WP | thiram | 2.0 lb | Fair | Fair | 15-20 | Fair |
| Topsin-M 70WP | thiophanate-methyl | 3.0 oz | Good | Good | 18-24 | Fair |
| Ziram 76DF | ziram | 2.0 lb | Good | Good | 18-24 | Good |

a No discrimination or endorsement is implied by the Cooperative Extension Service. Not a complete list. Also see Chapter 6 of this handbook for information on attributes of different fungicides.
b Retention is the ability of the fungicide to stick to the leaf surface.
c Redistribution is the ability of a fungicide to move to unsprayed areas and onto new growth during rains and weathering.
d After-infection activity is the ability to inhibit infection that has started. Use the start of a rain as the start of infection. At average temperatures below 50°F, use the longer time; at average temperatures above 50°F, use the shorter time.
e Protection is the ability of a fungicide to protect tissue from new infections after the material is applied.

potential problem with this spray program is that extended rainy periods can interfere with post-infection applications that must be made within 72 to 96 hours after the start of an infection period. Indeed, extended periods of rain are a problem with any fungicide program.

**4. New York IPM (Integrated Reduced Spray) Program**

This is a minimal spray program. As is the case for the post-infection program, it is *not* recommended in orchards that had greater than 2 percent fruit scab the previous year or late-season scab on leaves. The first fungicide application is delayed 1 to 3 weeks; a total of four applications of an SI fungicide (e.g., fenarimol, myclobutanil) is made: 1) tight cluster (with oil); 2) pink (with insecticide); 3) petal fall (with insecticide); and 4) first cover (with insecticide). Optimal protection is achieved by mixing a protectant (e.g., captan, mancozeb, or metiram) with the SI fungicide, especially at petal fall and first cover when young fruit are highly susceptible to infection. Including a protectant with the SI should also delay development of resistance to the SI. Because this is a minimal spray program, spray coverage must be nearly perfect. Thus, the program is not suited to blocks of large trees where near-perfect coverage is impossible. The timing of the four applications is dictated by the weather (spraying when conditions will allow optimal coverage) and timing of insect and mite control rather than by infection periods. However, if intervals greater than 10 days occur (e.g., from pink until petal fall), and weather conditions have been favorable for infection, it may be necessary to compensate by increasing the sterol inhibitor to the highest rate permitted on the product label.

**Monitoring for Scab:** Losses from scab often occur when conidia, formed in primary infections, infect young, developing fruit. Therefore, orchard blocks should be monitored for scab lesions starting at petal fall and continuing through first cover. Examine both surfaces of spur leaves and fruit. If scab is detected, the safest recommendation is to apply an SI *at the full recommended rate* plus a protectant through second cover to suppress further development of lesions and to protect susceptible fruit. In orchards where dodine has not been used extensively, and therefore resistance to dodine is unlikely, this fungicide may help "burn out" existing lesions. However, dodine applied after bloom can cause russeting. Another option is to not make "burning out" lesions the primary goal, but rather to focus on protecting fruit with the full rate of captan or an EBDC fungicide (e.g., mancozeb, maneb, or metiram). Note that after pre-bloom, the EBDCs may not be used at rates greater than 3 lb per acre.

## Powdery Mildew

Powdery mildew, caused by the fungus *Podosphaera leucotricha*, can seriously reduce the vigor and productivity of apple trees. Powdery mildew is usually not as severe a problem as scab in the Midwest, but on highly susceptible varieties (Table 1) the mildew fungus may deform, stunt, or kill twigs, leaves, blossoms, and fruit. Infected fruits may become severely russeted. Gray to white felt-like patches occur on the leaves and on 1-year-old twigs. Leaves are narrow, crinkled, and folded lengthwise, and they become thickened.

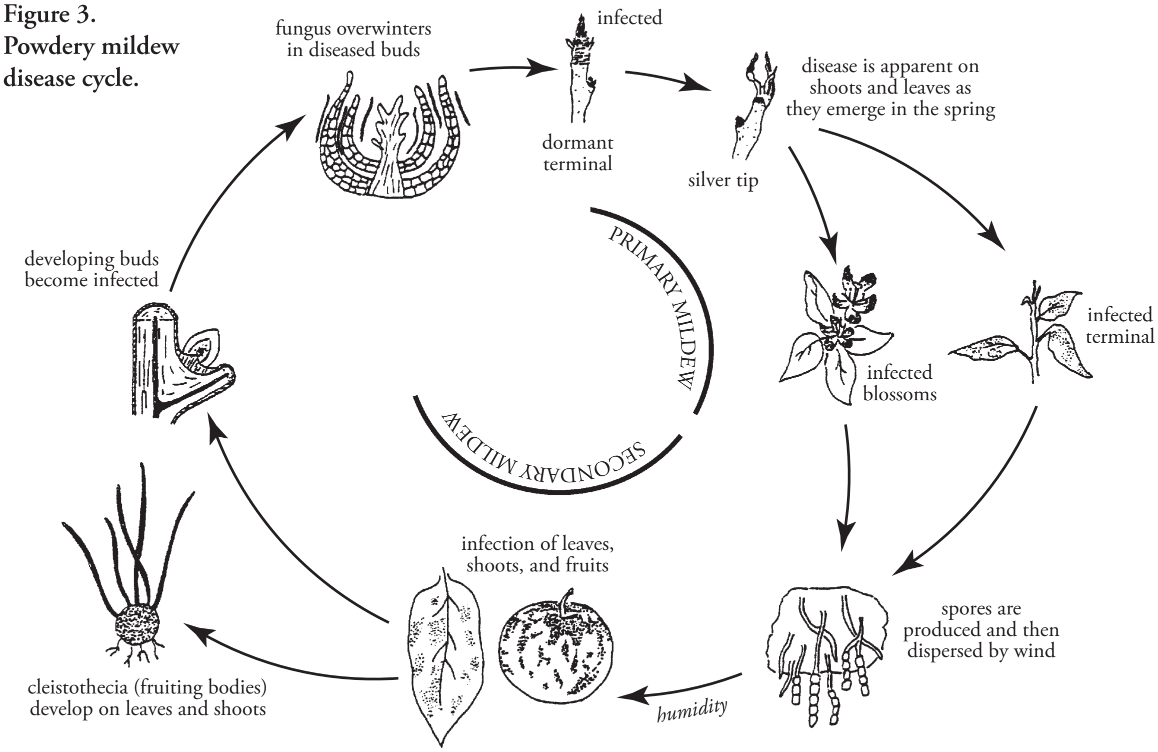
**Disease Development:** The powdery mildew fungus overwinters in vegetative or fruit buds infected the previous season (Figure 3). Infected terminals may have a silvery gray color, stunted growth, and a misshapen appearance and are more susceptible to winter injury than are noninfected terminals. Temperatures near –18°F kill a majority of mildew-infected buds and the fungus within them. Thus, disease pressure from powdery mildew is usually greater in growing seasons following mild winters.

As buds break dormancy, the powdery mildew fungus resumes growth and colonizes developing shoots, causing primary infections. Primary mildew infections may occur on vegetative shoots and blossoms and thereby cause a reduction in yield. The powdery white appearance on infected shoots consists of many thousands of spores, which are responsible for secondary infections. Secondary infections usually develop on leaves and buds prior to terminal bud set in midsummer and may reduce the vigor of the tree. Young fruit may become infected from about the pink stage of flower bud development up to 1 to 3 weeks after bloom. Fruit infection results in a weblike russeting on the mature fruit. Infected buds are the primary means of overwintering for the fungus. The powdery mildew fungus produces masses of small black fruiting bodies called cleistothecia on infected leaves and terminals in the late summer and fall. Although cleistothecia contain ascospores, their role in the disease cycle is not clearly understood.

The conditions required for infection by the powdery mildew fungus are very different from those required by the scab fungus. Unlike the apple scab fungus, the powdery mildew fungus does not require leaf wetness for infection. In fact, powdery mildew spores will not germinate if immersed in water. Rather, powdery mildew infections occur when the relative humidity is greater than 90 percent and the temperature is between 50° and 77°F. The optimal temperature range for the fungus is 66° to 72°F. The high relative humidity that often occurs before and after wetting periods is conducive to powdery mildew development. Under optimal conditions, powdery mildew will be obvious to the naked eye 48 hours after infection. About 5 days after infection, a new crop of spores is produced. Non-germinated powdery mildew spores can tolerate hot, dry conditions and may persist in the orchard until conditions are favorable for germination and infection.

**Control of Powdery Mildew:** Apple cultivars vary in relative resistance to powdery mildew (Table 1). Because powdery mildew does not need a wetting period to develop, control measures may be needed even during dry weather. The critical period for powdery mildew control is from about tight cluster to pink through first or second cover. The SI fungicides that are used to control apple scab (e.g., Nova, Procure, and Rubigan) are also effective against powdery mildew. Another SI fungicide, Bayleton (triadimefon), is a good mildewcide but is less effective in controlling scab. Wettable sulfur (95% WP) is a good mildewcide but is relatively weak against scab and can be phytotoxic at temperatures greater than 80°F. Thorough spray coverage, including the tops of trees, is essential for control of powdery mildew with fungicides.

**Figure 3.
Powdery mildew
disease cycle.**




## Rust Diseases

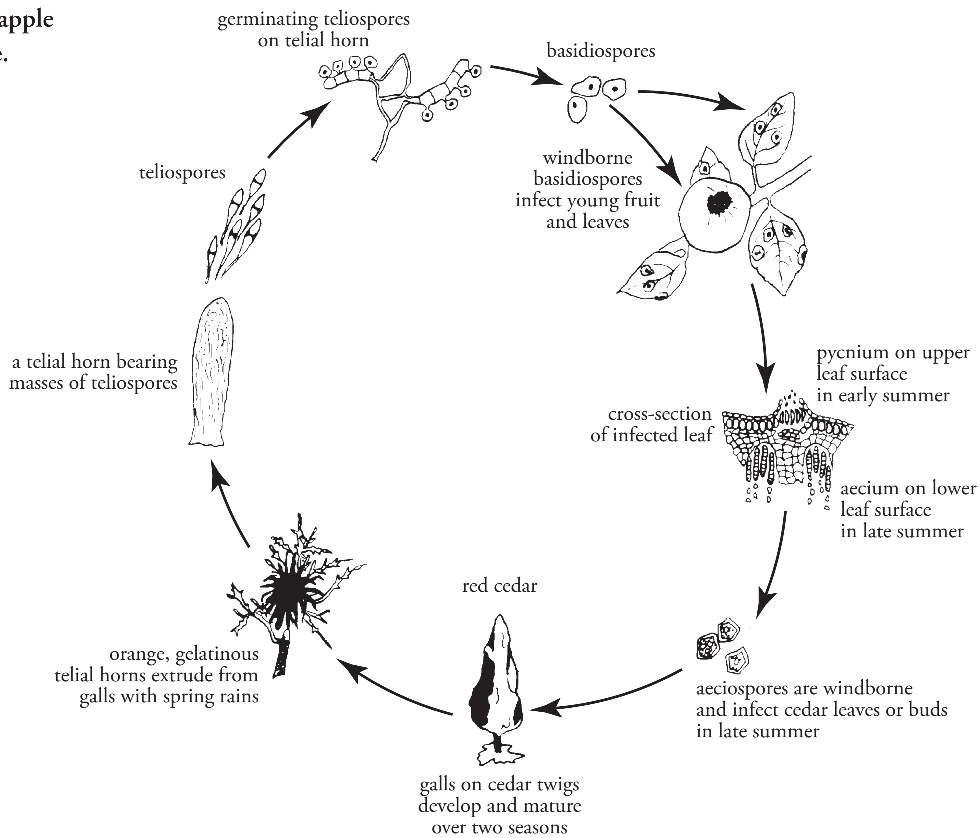
Three rust diseases commonly infect apples in the Midwest: cedar-apple rust (*Gymnosporangium juniperi-virginianae*), quince rust (*G. clavipes*), and hawthorn rust (*G. globosum*). Pears are susceptible to quince rust and hawthorn rust but not to cedar-apple rust. All three rust fungi require infection of eastern red cedar or related species of *Juniperus* to complete their life cycles. The rust diseases are usually kept in check by fungicides aimed at scab. Where fungicide use is minimal (e.g., on scab-resistant cultivars or in organic orchards), rust diseases, especially cedar-apple rust, can severely spot leaves and mar fruit. Quince rust causes fruit lesions but rarely affects leaves of apple. Hawthorn rust causes leaf lesions but rarely affects apple fruit.

Cedar-apple rust leaf spots initially develop on the upper leaf surfaces shortly after bloom. Lesions are pale yellow, but as they expand, they turn orange, which distinguishes them from other types of leaf spots. Later, small black dots (fungal fruiting structures called pycnia) appear in the orange rust spots. By late summer, tiny fungal tubes (aecia) emerge from the lower leaf surfaces. Extensive leaf infection may cause early defoliation, which in turn weakens the tree.

Fruit infection by cedar-apple rust is most common near the blossom end. The yellowish orange lesions are similar to but much larger than those on leaves. The lesions have a dark green border and are up to 1/16-inch deep; the tissue beneath the lesions is unaffected. Quince rust lesions on fruit are dark green, 3/4 to 1 1/2 inches in diameter, and become puckered at the blossom end. The tissue beneath the lesions is brown and spongy, and necrosis can extend to the core.

**Disease Development:** The disease cycles of the three rust fungi are similar and relatively complex. Cedar-apple rust involves two hosts, three types of fruiting structures (telia, pycnia, and aecia), and requires 2 years to complete its disease cycle (Figure 4). The fungus overwinters in reddish brown galls on cedar trees. When wet in the spring, orange, gelatinous tendrils, or “horns,” containing teliospores emerge. The teliospores germinate to form basidiospores which are car-

**Figure 4. Cedar-apple rust disease cycle.**




ried by wind to apple trees. Basidiospores germinate if temperature and wetting requirements have been met (Table 5). No infection occurs below 43°F because basidiospores are not produced. Fruit are most susceptible for 2 to 3 weeks starting at bloom; leaves are most susceptible when 4 to 8 days old. Once release of basidiospores from cedar trees has ceased (generally by second or third cover), there is no further infection of apple tissues. Unlike apple scab, cedar-apple rust lesions on apple leaves will not produce spores that reinfect apple leaves and fruit. Instead, fungal mating occurs in rust lesions which result in the formation of aecia. Aecia release aeciospores which are carried by wind to cedar trees where they infect and complete the disease cycle. Galls start to develop on cedar shortly after infection but do not exude telial horns until the second spring after infection.

**Control of Rust Diseases:** Some apple cultivars are resistant to cedar-apple rust (Table 1). Removing cedars within a 2-mile radius of an orchard will disrupt the disease cycle, and fungicides may not be needed. Many of the fungicides directed at scab will also control rust, although captan, dodine, and benomyl do not control rust diseases. The basidiospores that infect apples are produced and released from cedar galls starting at about the pink stage of flower bud development through first or second cover; this is the most critical time for control with fungicides.

## Fire Blight

Fire blight, caused by the bacterium *Erwinia amylovora*, is a serious disease of apples, pears, and related ornamental plants. Incidence and severity are influenced by cultivar and rootstock susceptibility (Tables 1 and 6), the weather, and the amount of succulent tissue present. Managing fire blight requires an integrated approach that relies primarily on cultural practices and is supported by the judicious use of bactericides.

**Table 5. Approximate minimum number of hours of leaf wetness required for cedar-apple rust infections on leaves of susceptible cultivars.**

| Degree of Infection[a] | | |
|---|---|---|
| Average Temperature (°F) | Light (Hours) | Heavy (Hours) |
| 36 | 24 | - |
| 40 | 12 | 24 |
| 43 | 8 | 10 |
| 46 | 6 | 7 |
| 50 | 5 | 6 |
| 54 | 4 | 5 |
| 58 | 3 | 5 |
| 61 | 3 | 4 |
| 64 | 3 | 4 |
| 68 to 76 | 2 | 4 |
| 79+ | - | - |

a Based on the data of Aldwinckle, Pearson, and Seem, Cornell University. Assumes that cedar-apple rust inoculum (orange, swollen galls bearing teliospores with basidiospores on cedar trees) is available at the start of the rain. If inoculum is not already present (dry period prior to the rain), add 4 hours at temperatures above 50°F and 6 hours at temperatures of 46° to 50°F. Infection is unlikely at temperatures below 43°F if inoculum is not already present.

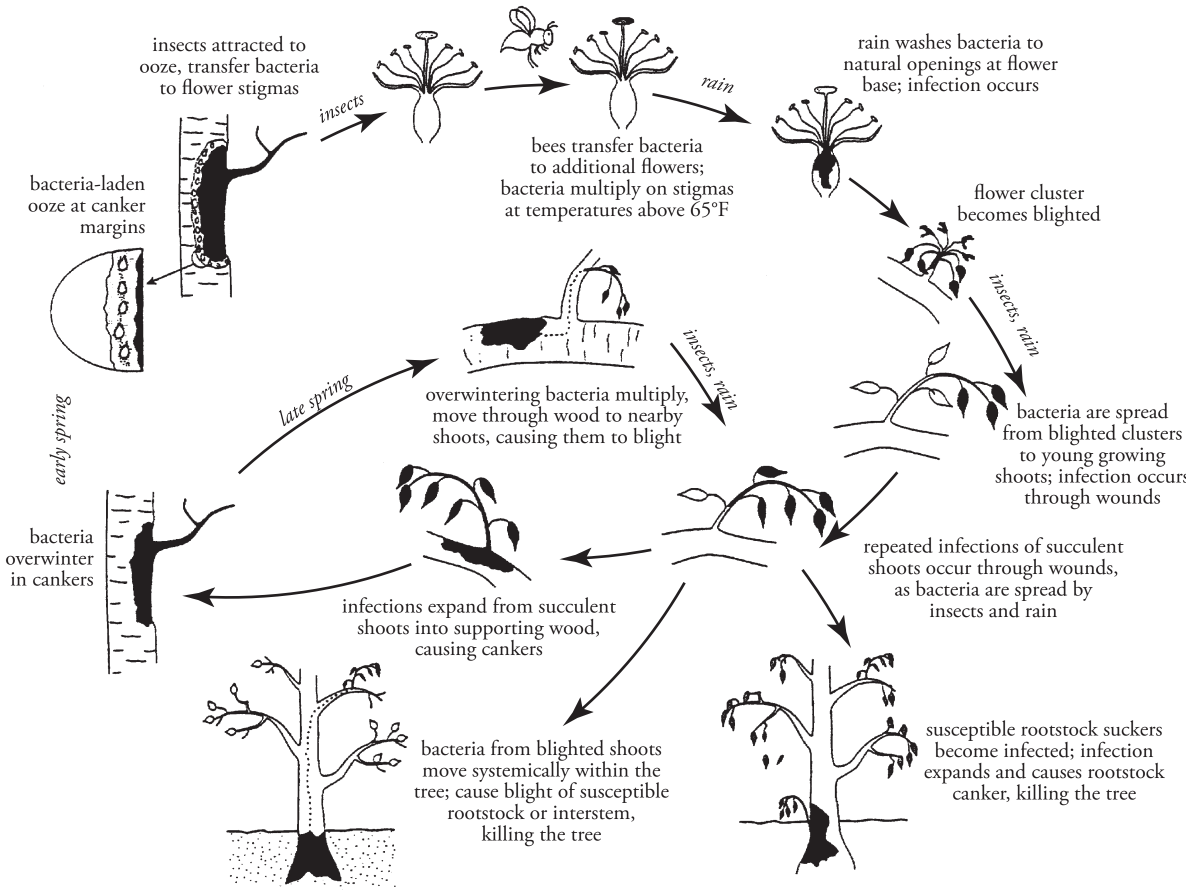
**Table 6. Relative resistance of apple rootstocks, pear varieties, and pear rootstocks to fire blight.**

| **Apple Rootstocks** | | |
|---|---|---|
| **Resistant** | **Moderately resistant** | **Susceptible** |
| Geneva 11 | Bemali | Alnarp |
| Geneva 30 | Bud.118 | Bud.9 |
| Geneva 65 | Bud.490 | M.9 |
| M.7 | MM.106 | M.26 |
| Novole | MM.111 | M.27 |
| Robusta 5 | | Mark |
| | | Ottawa 3 |
| | | P.2 |
| | | P.16 |
| | | P.22 |
| **Pear and Asian Pear Varieties** | | |
| **Resistant** | **Moderately resistant** | **Susceptible** |
| Ayers | Dawn | Aurora |
| Harrow Delight | Douglas | Bartlett |
| Harrow Sweet | Garber | Bosc |
| Honeysweet | Harvest Queen | Clapp's Favorite |
| Kieffer | Lincoln | d'Anjou |
| Magness | Luscious | DeVoe |
| Maxine | Rogue Red | Earlibrite |
| Monterey | Seckel | Flemish Beauty |
| Moonglow | Spartlett | Highland |
| Potomac | Worden Seckel | Sierra |
| Tyson | Chojuro | Starkrimson |
| | Shinseiki (New Century) | Hosui |
| | | Nijisseiki (20th Century) |
| **Pear and Asian Pear Rootstocks** | | |
| **Resistant** | **Moderately resistant** | **Susceptible** |
| Old Home (OH) | *P. betulaefolia* seedlings | Bartlett seedlings |
| OH x Farmingdale (OHF) (except OHF 51) | | Provence quince |
| *P. calleryana* | | Winter Nelis seedlings |

Adapted from *Fire Blight–Its Nature, Prevention, and Control* by T. van der Zwet and S. V. Beer, USDA Agriculture Information Bulletin No. 631.

**Disease Development:** The fire blight bacterium overwinters in cankers on branches and trunks (Figure 5). In the spring, bacteria-laden ooze is exuded from the canker margins. Splashing rain and insects carry the pathogen to blossoms, and bees further spread the pathogen as they pollinate. If the weather is warm and rainy or humid, populations of *E. amylovora* double every few hours, and more than a million bacterial cells can colonize a single floral stigma. Rain or dew then washes the bacteria into openings at the base of the blossom. The pathogen can apparently move systemically within the plant to shoot tips and rootstocks. This may explain why trees sometimes are severely damaged or killed by shoot and rootstock infections even when blossom infection was minimal or absent. Sudden or "explosive" outbreaks of fire blight often appear about 1 to 2 weeks following a storm with strong winds or hail that damage succulent tissue. Apparently several simultaneous inoculations occur during the storm, and bacteria multiply rapidly in succulent shoots; this leads to the sudden appearance of symptoms throughout a block of trees.

**Figure 5. Fire blight disease cycle.**




**Control of Fire Blight:** Methods for consistent and reliable control of fire blight are not available. Relatively resistant cultivars and rootstocks (Tables 1 and 6) should be planted whenever possible. Highly susceptible combinations (e.g., Gala on M.26) should be avoided. Fertilization, especially nitrogen application, should be adequate for tree health without promoting rapid growth and prolonged succulence. Susceptible varieties should be pruned to improve tree shape and promote rapid drying of foliage but should not be pruned aggressively.

Pruning fire blight strikes during the growing season is a controversial issue. Removing sources of the pathogen is desirable, but pruning can actually make fire blight worse by increasing the amount of succulent tissue and by spreading the pathogen on tools. If fire blight strikes are so numerous that is not practical to remove them all, then wait until the dormant season. If fire blight strikes are few, it may be practical to remove them. They should be removed by making cuts at least 12 inches below visible symptoms. The computer program MARYBLYT, available from pest management suppliers (see Appendix B), is useful for predicting the onset of symptoms. With this knowledge, growers with small trees and adequate labor can scout for and remove the first infected tissues before symptoms become widespread. This will not eliminate further symptoms but may reduce the spread of fire blight. Missed strikes and cankers should be pruned during the dormant season.

Chemical control of fire blight is effective during the spring when the pathogen is at the surface of cankers and on flowers. After the bacterium has invaded tissues, it is beyond the reach of chemicals. Sprays of copper sulfate when cankers are active but before leaves have emerged, and fixed copper at 1/4-inch green tip, may reduce populations of the fire blight bacterium. Be aware, however, that if little rain (less than 2 inches) falls between an early copper application and petal fall, the copper residues could be great enough to damage fruit finish.

Streptomycin applied during bloom will reduce blossom infections unless streptomycin-resistant strains of *E. amylovora* are present. The MARYBLYT program is useful for accurately timing streptomycin applications. Without information from MARYBLYT, applications should be made every 3 to 4 days during bloom if the average temperature is 65°F or greater and there is rain or relative humidity of 60 percent or greater. Streptomycin works best when *not* tank-mixed with fungicides and when applied at night or when drying conditions are slow. Streptomycin applications made after bloom are generally ineffective at controlling shoot infections. The number of streptomycin applications should be kept to a minimum to reduce the risk of selecting streptomycin-resistant strains of the pathogen. Streptomycin resistance is a serious problem in commercial orchards in southwestern Michigan, parts of Missouri, and the western states.

## Collar and Crown Rot

Root, crown, and collar rot, caused by the soil-borne fungus *Phytophthora cactorum* and other species of *Phytophthora*, is a perennial problem in midwestern apple orchards. *Phytophthora* belongs to a group of fungi known as the "water molds" because water is critical for many stages of its life cycle. Although *Phytophthora* species are common in agricultural soils, disease is most frequently found in areas with heavy, poorly drained soil and is especially severe on MM.106 and M.26 rootstocks. The pathogen attacks the lower trunk just at or below the soil surface. Cankers may extend up the trunk to the rootstock-scion union or beyond if the scion is susceptible to *Phytophthora*. Cankers at the base of the tree have dark, sunken bark; infected tissue beneath the bark appears reddish brown to dark brown. Leaves on affected trees may be small and pale during the summer and turn reddish in late summer. With relatively recent infections, a sharp line often delimits healthy from infected tissue. However, Phytophthora rots are easily confused with fire blight infections of rootstocks. Distinguishing the two diseases requires evaluation of host susceptibility, site conditions, disease history, and often culturing of the pathogen(s) from infected tissue in the laboratory.

**Control of Collar and Crown Rot:** Good water management and site selection are the most important factors for control of *Phytophthora* diseases. Orchard soils should be well drained and leveled *before* planting. For trees that are already planted, drainage should be improved in the vicinity of the trunk, making sure water is not allowed to pool around the base of the trunk. If subsurface drainage is a problem, the only solution may be to install drainage tile—a task more easily done before trees are planted. Relatively resistant rootstocks include M.9, Mark, Bud.118, and Bud.9. However, some of these rootstocks are highly susceptible to fire blight (Table 6).

In areas of orchards historically affected by root, crown, or collar rot, fungicides may be needed to minimize damage. Fungicides will not be effective if the cultural practices discussed above are not followed, and they will not revitalize trees showing moderate to severe rot symptoms. See the current *Commercial Tree Fruit Spray Guide* and the product label for details on using fungicides to manage root, crown, and collar rot.

## Summer Diseases

Bitter rot, black rot, and white rot (bot rot) are the most common summer rot diseases of apple. Flyspeck and sooty blotch cause superficial blemishes which detract from the appearance of apple and pear fruit. The summer diseases have the potential to cause serious losses, especially in the more southern regions of the Midwest and on trees not sprayed with fungicides. In the northern regions of the midwest, some fruit rot fungi invade winter-injured tissue and are associated with branch cankers. Any condition that reduces tree vigor will increase susceptibility to branch and trunk infections. Flyspeck and sooty blotch fungi, and some of the fruit rot fungi, survive on a wide range of woody plants. The fruit rot fungi are similar in many respects:

- they survive in dead or weakened tissue, including fire blight cankers and mummified fruit;
- they produce enormous numbers of spores which are readily disseminated by rain and wind; and
- the diseases they cause are favored by warm, humid weather.

## Bitter Rot

Symptoms vary slightly, depending on which spore type (ascospore of *Glomerella cingulata* or conidium of *Colletotrichum gloeosporioides* or *C. acutatum*) causes the infection. Lesions incited by conidia are sunken, light brown, and often marked with concentric circles of spore masses that appear creamy and salmon- to pink-colored under humid conditions. Lesions incited by ascospores are usually not sunken and are darker than those caused by conidia. Spore-producing bodies are scattered over the lesion in dark brown to black clusters. Bitter rot decay extends in a cone shape toward the core, which helps distinguish bitter rot from other fruit rots. The rotten spots are soft but firmer than white rot lesions.

## Black Rot

In addition to affecting fruit, the black rot fungus, *Botryosphaeria obtusa*, causes leaf spots (frog-eye leaf spot) and branch cankers. The optimal temperature for fruit infection is 68° to 75°F with 9 hours of wetting. Fruit symptoms often start at the blossom end. Dark brown lesions expand and eventually can encompass the entire fruit. Lesions are often marked by concentric alternating brown and black rings. The rotted area is firm, leathery, and dotted with dark fungal fruiting bodies. Fruit infection can occur throughout the growing season; however, rot symptoms generally appear as fruit reach maturity.

The optimal temperature for leaf infection is 80°F with 4 1/2 hours of wetting. Leaf spots first appear about 1 to 3 weeks after petal fall as purple flecks that expand to about 1/4-inch in diameter. The margins of spots remain purple, while the centers turn tan to brown so that the spots resemble a “frog's eye.” Spots can enlarge and become irregular in shape as they are invaded by other fungi later in the season. The leaf spot phase is not economically important unless it results in significant defoliation.

Branch cankers initially appear as slightly sunken reddish brown areas on the bark. Fire blight cankers and winter-injured tissue are frequent sites for black rot canker initiation. Cankers can expand to several feet in length and girdle limbs. Branches are weakened and sometimes killed.

## White Rot (Bot Rot)

White rot (*Botryosphaeria dothidea*) lesions begin on fruit as small, circular, tan spots that are sometimes surrounded by a red halo. Duchess, Golden Delicious, Grimes Golden, Gallia Beauty, Rome, and Yellow Transparent varieties are all highly susceptible to white rot. Jonathan and Red Delicious are generally less affected. The rot extends in a cylindrical shape toward and surrounding the core. Eventually the entire fruit becomes soft, watery, and light tan. Under cooler conditions the rot may be darker and closely resemble black rot. Branch infections start out as reddish brown bark lesions that expand and sometimes exude fluid. Cankers are more severe if trees are stressed by drought.

## Flyspeck and Sooty Blotch

Flyspeck and sooty blotch are two separate diseases that frequently occur together on the same fruit. Flyspeck appears as clusters of tiny, black dots. Sooty blotch appears as dark, sooty smudges. The fungi that cause flyspeck (*Zygophiala jamaicensis*) and sooty blotch (*Peltaster fructicola*, *Gastrumia polystigmatis*, *Leptodontium elatius*, and others) overwinter on the twigs of many woody plants, especially brambles. Spores of sooty blotch fungi are spread during rain. The flyspeck fungus is spread as airborne ascospores which are released during rain or as airborne or waterborne conidia. Fruit infection can occur any time after petal fall but is most prevalent during mid- to late summer. Both diseases are favored by temperatures between 65° to 80°F and by high relative humidity at the fruit surface (greater than 90 percent for sooty blotch and greater than 95 percent for flyspeck). Conditions such as these are most frequent when nighttime temperatures remain near 65° to 70°F or during extended warm rainy periods. The diseases flourish in orchards subject to heavy dews or fog. Under ideal conditions, sooty blotch and flyspeck symptoms can develop within 14 days of infection, but symptom development is arrested by high temperatures and low relative humidity. Thus, the period between infection and symptom development ranges from 25 to more than 60 days in the Northeast and may be similar in the Midwest. Sooty blotch and flyspeck infections not yet visible at harvest can develop during storage.

### *Control of Summer Diseases*

A combination of annual pruning, adequate fruit thinning, orchard sanitation, and protective fungicides is the key to controlling summer diseases.

**Pruning and Thinning:** Pruning systems that open the tree canopy to light should also improve air movement and thereby reduce relative humidity and the time that leaves and fruit are wet. For example, summer pruning, as opposed to dormant pruning, reduced the incidence of flyspeck on apple fruit by 50 percent in research conducted in Massachusetts. Keeping the orchard mowed should also promote air movement, enhance rapid drying, and in turn, reduce summer diseases. Thinning of fruit is important to improve spray coverage and drying. Clustered fruit often have flyspeck on their inner faces even when an adequate fungicide program has been used.

**Sanitation:** Dead or weakened wood in or near an orchard can serve as a reservoir for the fungi that cause summer diseases. Therefore, removal and destruction of dead and dying plant material, including the current year's fire blight strikes, is necessary to keep the level of summer disease fungi to a minimum. Removing unwanted vegetation that might be a reservoir for pathogens, particularly wild brambles, should also reduce disease pressure in the orchard.

**Fungicides:** Different fungicides are recommended for the different summer diseases. In general, protectant fungicides (e.g., captan, ziram) that are permitted later in the season are used alone or mixed with benomyl (Benlate) or thiophanate-methyl (Topsin-M). See the current *Commercial Tree Fruit Spray Guide* for specific recommendations.

# Insect and Mite Pests of Apples and Pears

Control of the major insect pests of apples in commercial production involves timely insecticide applications. Unlike some crop pests, pests of apples can be very elusive, and damage can often occur without individual pests being seen. To maintain healthy, productive trees and fruit, producers should recognize what pests to look for, understand pest biology, use appropriate preventive measures, and apply timely controls when needed.

## Identifying and Understanding Major Apple and Pear Pests

It is important for growers to recognize all stages of the insects and mites that attack apples and pears. Proper identification is critical to making the correct management decisions. In addition, growers should develop a basic understanding of the pest. The more you know about the pest, the better equipped you will be to make sound and effective management decisions. The following literature contains color photographs of pests of apples and pears, as well as information on their biology.

*Common Tree Fruit Pests*
Authored by Angus Howitt and published as North Central Regional Extension Publication #63 by Michigan State University Cooperative Extension Service. Phone: (517) 355-0240.

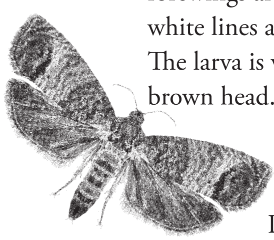
*Mid-Atlantic Orchard Monitoring Guide*
Edited by Henry Hogmire and published as NRAES 75 by the Northeast Region Agricultural Engineering Service, Cooperative Extension Service.
Phone: (607) 255-7654.

## Codling Moth

(*Cydia pomonella*; order Lepidoptera, family Tortricidae)

**Damage:** Codling moth is a serious pest of apples and pears. Larvae damage apples and pears by chewing their way into the center of the fruit. "Frass," or fecal material, is pushed out through the side of the fruit skin or the calyx end. Wounds caused by codling moth larvae promote the development of fruit rots. Most of the damage is caused by second- and third-generation larvae.

**Appearance:** The adult moth is about 3/8-inch long and blends in well with the bark. The adult moth's forewings are gray-brown crossed with light gray and white lines and with deep gold or bronze wing tips. The larva is white, often tinged with pink, and has a brown head.



*codling moth*

**Life Cycle and Habits:** The fully developed larva is the overwintering stage. Pupation occurs in spring beginning about the same time as bloom, with adults first active in late April or early May. Female moths lay the scale-like eggs singly on developing fruit or adjacent leaves or stems just after sundown each night. Upon hatching, the larva enters into the calyx end or side of the fruit, then tunnels to the center where it feeds and develops. Brown frass is often noticed near the calyx end of the developing fruit. Larval development is completed in 3 to 5 weeks. Larvae exit the fruit to pupate in a thick silken cocoon on the bark or other protected areas. In the Midwest, there are two generations and sometimes a partial third one.

**Monitoring and Thresholds:** Management of codling moth in commercial orchards relies on regular examination of the fruit, pheromone trapping, and the use of degree-day models. Pheromone traps for this pest need to be monitored from pink through harvest. Typically, the first moth catch is at bloom, and two or three generations should be expected throughout the year. Traps help determine timing of sprays; sprays should target larvae emerging from eggs.

The biofix for the codling moth is the starting date of the first sustained flight of male moths captured in pheromone traps. Generally, this is when the fifth moth has been captured in the trap. A few moths often emerge very early in the spring ahead of the rest. Using the fifth moth as the biofix better represents when the majority of the codling moths begin to emerge. This usually occurs just after petal fall. Sprays should be applied when 250 degree-days (50°F threshold) have accumulated after the cumulative capture of five moths per trap. Typically, 1,000 degree-days are needed to complete each generation. Growers should use an action threshold of an average of five or more moths per week throughout the season. An insecticide application should be made 250 degree-days later if the number of moths exceed this threshold.

For one season, a grower will need a minimum of two wing traps (two plastic trap tops, two wire hangers), ten to 25 wing trap bottoms (sticky cardboard), and ten pheromone lures. Hang codling moth pheromone traps in the southeast quadrant of the tree, 6 feet off the ground. Avoid hanging traps in outside rows.

**Mating Disruption:** Isomate C-plus and CheckMate CM are registered for the control of codling moth. They dispense the sex attractant of the codling moth and are designed to prevent male moths from locating females for mating. This strategy, termed mating disruption, is most likely to succeed in blocks of at least 5 acres and where initial populations of codling moth are low. If mating disruption is used for codling moth control in smaller blocks, or where infestations are greater, border sprays or at least one or two cover sprays will also be necessary. Controlling codling moth by mating disruption will not control other insect pests that are controlled by cover sprays (plum curculio and apple maggots, for example). Isomate C-plus has performed better than CheckMate CM in most studies.

**Chemical Control:** Control of codling moth later in the season is assisted by good control of the first generation.

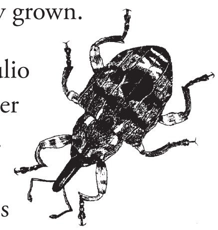
*plum curculio larva*

## Plum Curculio

(*Conotrachelus nenuphar*; order Coleoptera, family Curculionidae)

**Damage:** Plum curculio attacks apples and pears. Surface feeding and egg laying by overwintering adults can scar or misshape the fruit by harvest, and feeding by larvae may cause some premature fruit drop. Newly emerging adults in the summer feed on apples for a short time, causing round feeding scars that penetrate the fruit about 1/4-inch.

**Appearance:** The adult is a typical snout beetle, 1/4-inch long, dark brown with patches of white or gray. There are four prominent humps on the wing covers. The snout is one-quarter the length of the body, with mouth parts located at the end. The larva is a legless, grayish white grub with a brown head. Its length is about 1/3-inch when fully grown.



*plum curculio adult*

**Life Cycle and Habits:** Plum curculio overwinters as adults in ground litter or soil, usually outside the orchard. Adults migrate into the orchards each spring. Typically, the first signs of damage coincide with the onset of 60°F nighttime temperatures. Eggs are laid on crescent-shaped flaps cut in the skin of young fruit. Often border rows near woods are the first to show injury. Apples and pears attacked by plum curculio will drop from the tree early in the season, along with poorly pollinated fruit. When larvae are fully developed, they leave the fruit, drop to the ground, and pupate 1 to 2 inches below the surface. Adults emerge in midsummer and may feed on the fruit before leaving the orchard to find overwintering sites. There is one generation per year.

**Monitoring and Thresholds:** Currently there are no methods to accurately predict when plum curculio damage will occur. However, plum curculio pyramid traps are currently being tested in several midwestern states.

**Chemical Control:** Plum curculio is usually controlled with petal-fall and first-cover insecticide sprays directed at the adult before egg laying. Considerable egg-laying damage can occur over a short period of time. Where plum curculio has been a problem in the past, use preventive sprays at petal fall and first cover to reduce damage. Cool weather during petal fall may delay the immigration of the adults into the orchard. Under these conditions, a first-cover and possibly a second-cover spray may be needed to control plum curculio.

## Apple Maggot

(*Rhagoletis pomonella*; order Diptera, family Tephritidae)

**Damage:** Apple maggot mainly attacks apples. Egg punctures and larval feeding cause fruit to be dimpled, and if it is soft, the fruit will soon rot.

**Appearance:** Adult apple maggot flies have dark bands on their wings and white bands around the abdomen. There is a large white spot on the thorax. The larva, when fully grown, is about 1/3-inch long, cream colored, and legless.

**Life Cycle and Habits:** Apple maggot passes winter as a pupa, and adults emerge from June to September, with most adults emerging in June and July. They puncture the skin of an apple and insert an egg into it. The maggots hatch and feed by tunneling throughout the apple flesh, leaving tiny brown trails. Apple maggots are common in northern Illinois, Indiana, and Ohio and absent in the southern parts of these states. They seldom cause damage south of U.S. Highway 40. There is one generation per year (maybe two in southern range). Check with local Extension personnel for apple maggot incidence in your area.

*apple maggot*

**Monitoring and Thresholds:** Traps are used to monitor for apple maggot flies from early June through mid-August. Use yellow sticky traps or red spheres baited with fruit volatile lures. Place along edges of blocks nearest an abandoned orchard or woodlot; if these are not present, then along the southern edge of blocks. If traps are not used in every block, put them in the earliest-maturing variety or blocks closest to abandoned orchards. Place the trap in the outer part of the midcanopy (eye-height) of the tree in a relatively exposed spot; prune back any clusters or shoots within 6 to 12 inches of the trap.

Compare the appearance of the trapped flies with pictures of the apple maggot to be sure you are not counting a non-target species; pay particular attention to the dark patterns in the wings, which differ in the apple maggot fly and the cherry fruit flies. First trap captures usually occur in early to mid-June. Growers should spray when five apple maggot flies are trapped per ball (note: or one fly per trap if fruit volatile lure is *not* used). Season trapping needs include three red ball traps and three hangers, three fruit volatile lures (note: not a pheromone), and one tube or can of Tanglefoot. The fruit volatile lure lasts all season and does not need to be replaced periodically.

**Chemical Control:** Control of the apple maggot needs to be directed at the adult flies before egg laying occurs. Additional sprays may be needed if traps' catch counts remain above five flies. Often in commercial orchards, sprays applied to the first several border rows are sufficient to control apple maggot flies entering the orchard.

## Pear Psylla

(*Cacopsylla pyricola*; order Homoptera, family Psyllidae)

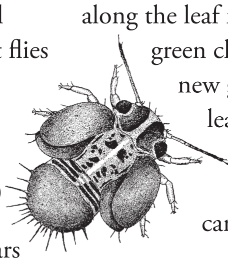
**Damage:** The most troublesome insect pest of pears is usually the pear psylla. It sucks plant sap and injects a toxin into leaves as it feeds, causing wilting and leaf drop. It may take the tree several years to recover from the reduction in vigor. Psylla excretes honeydew on leaves, which can kill leaf tissue and lead to a condition known as psylla scorch. Black sooty mold can grow on honeydew, which can further affect the appearance and vigor of pears.

**Appearance:** The pear psylla is a small insect, only 1/10-inch when fully grown. The adult has a stout body with a wide head and thorax, red eyes, and wings longer than the body. The clear wings are held roof-like over the sides of the body. It looks like a miniature cicada. Eggs are yellowish orange and may be seen with the aid of a magnifier. Newly hatched nymphs are yellowish, 1/80-inch. Late-stage nymphs are hard shelled, and wing pads are apparent.

*pear psylla adult*

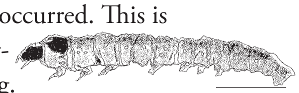
**Life Cycle and Habits:** Adults overwinter on the trees in bark crevices. Adults emerge, mate, and begin laying eggs when temperatures reach 50° to 60°F. Eggs are deposited in crevices in the bark and near the terminal buds. Most eggs hatch by petal fall. Nymphs move to the axils of leaf petioles and young fruit to feed. Five nymphal stages are passed before the adults appear. Females of the later generations deposit most of the eggs along the leaf midribs. There are three to four generations per year.

**Monitoring and Thresholds:** Look for adults on spurs and branches on warm days just before bud burst, and on the tender new shoots the remainder of the season. Eggs in late dormant to bud burst are found singly or in rows on spurs and twigs or around bud scales. Through the remainder of the season, look on the undersides of tender new growth for rows of eggs along the leaf midribs. Small nymphs are found from green cluster throughout the season on tender new growth; larger nymphs are found on leaves that are hardening off. Nymphs and adults can be monitored with beat cloths and adults with yellow sticky cards.



*pear psylla nymph*

**Chemical Control:** Pear psylla is difficult to control and has become resistant to many insecticides. A delayed dormant oil should be applied as adults are emerging, but before egg laying has occurred. This is green tip in most years, but monitoring will determine more exact timing. The most important times to treat for pear psylla are at the pre-bloom (white bud) and petal fall stages.



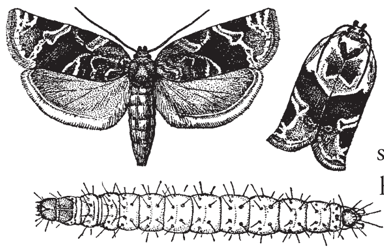
*fruit-tree leafroller larva*

## Leafrollers

(order Lepidoptera, family Tortricidae)
Red-banded Leafroller (*Argyrotaenia velutinana)*
Oblique-banded Leafroller (*Choristoneura rosaceana*)
Fruit-tree Leafroller (*Archips argyrospila*)

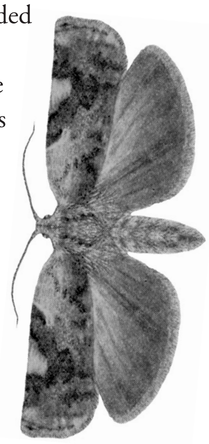
**Damage:** *Red-banded leafroller* larvae feed on apple foliage and fruit, with the last generation of the season doing the most serious damage. The larva attaches a leaf to the fruit surface with silk and feeds on apple skin and flesh. Some other species of leafrollers that can be found in the Midwest include the *oblique-banded leafroller* and *fruit-tree leafroller.*

**Appearance:** The red-banded leafroller is brown, about the size of the codling moth, and has broad



*red-banded leafroller*

reddish bands on each forewing. Larvae are green and slender with a light brown head; they reach a length of about 2/3-inch. The oblique-banded leafroller is brown with three dark bands on the front wings. Wing spread is about 1 inch. Larvae are small and green with black heads. The fruit-tree leafroller is a brown moth slightly larger than the codling moth. Thin light markings appear in various patterns across the front wings. The larva is a slender, pale green worm. The head is black with a black spot just behind the head. The larva reach about 3/4-inch in length.



*fruit tree leafroller adult*

**Life Cycle and Habits:** The red-banded leafroller overwinters as a pupa in debris on the ground. Adults emerge in early spring and lay eggs in masses on undersides of larger limbs. Eggs hatch at about bloom. Newly hatched larvae fold or roll leaves together with webbing and feed on foliage. There are second, third, and fourth generations in southern areas of the Midwest.

The fruit-tree leafroller overwinters in the egg stage on twigs. Hatch occurs about the time buds begin to open. Larvae feed on buds, blooms, leaves, and fruits. In June, fully grown larvae pupate inside folded or rolled-up leaves. Moths appear 2 weeks later, lay their eggs, and die. Only one generation occurs each year.

Overwintering of the oblique-banded leafroller occurs as partially grown larvae inside tightly woven cases on the host trees. During spring, larvae emerge and feed until late May. Pupation occurs, and adults emerge in June. One or two generations may occur each year. Damage is done by young larvae mining the leaves, with larger larvae feeding inside rolled-up leaves.

**Monitoring and Thresholds:** Leafroller populations can be sampled by both tree examination and pheromone traps. Because these species have wide host ranges, pheromone trap catch numbers are of limited value in determining economic thresholds and the need to spray. Pheromone trap catches will indicate when to monitor carefully for the larvae. Pheromone traps should be in place by the green tip for red-banded leafroller, pink for fruit-tree leafroller, and mid-May for oblique-banded leafroller and maintained through September. Monitor for larvae by examining the number of larvae per 100 expanding leaf terminals or fruit clusters. Use an average of four larvae per 100 expanding leaf terminals or fruit clusters for making management decisions.

*oblique-banded leafroller*

**Chemical Control:** In the Midwest, cover sprays for codling moths and other orchard pests usually control leafrollers as well. Egg hatch of the red-banded leafroller often coincides with petal fall, so sprays applied at this time will control it. In some areas, the oblique-banded leafroller has become resistant to organophosphate insecticides, so chemicals with different modes of action may be required.

## Tufted Apple Budmoth

(*Platynota idaeusalis*; order Lepidoptera, family Tortricidae)

**Damage:** Young larvae of tufted apple budmoth feed along midribs of leaves, then bite into the petiole to make a characteristic notch. Like other leafrollers, older larvae of the tufted apple budmoth use webbing to attach a leaf to a fruit, then they chew on the surface of the fruit underneath the leaf. Fruit damage is similar to that of red-banded leafroller, but the budmoth-damaged patches are usually smaller and more separated than the more continuous patches of feeding damage caused by red-banded leafroller. Characteristic fruit damage by tufted apple budmoth is the same as that of the variegated leafroller (*Platynota flavedana*), which is the major leafroller in central Virginia and parts of West Virginia. Tufted apple budmoth is the major leafroller in Pennsylvania and other mid-Atlantic states. It is present in the Midwest but is not as serious a pest as it is in Pennsylvania.

**Appearance:** Fully grown larvae are 3/4-inch long, light grayish brown with a dark stripe down the back, and they have a chestnut brown head capsule and a dark brown plate just behind the head. Egg masses are flat, dime-sized, and contain about 150 eggs; eggs are green when freshly laid and bronze when close to hatching. Adults are small moths that are mottled grayish brown, lighter at the wing base, and darker at wing tips. There are tufts of scales on the top of the middle of the forewings.

**Life Cycle and Habits:** Tufted apple budmoth overwinters as larvae in rolled leaves beneath fruit trees. Adults emerge in early May and lay eggs on the upper surface of leaves. Eggs hatch in 10 to 14 days. First generation eggs hatch in June. Second generation eggs hatch in August. There are two generations per year.

**Cultural Control:** Remove apple suckers and suppress the groundcover under apple trees to eliminate the early spring habitat of tufted apple budmoth.

**Monitoring and Thresholds:** A sex pheromone trap is available to monitor adult males of this species. Use one trap per block if less than 5 acres, or two traps per block if more than 5 acres. Set up traps by the first of May. Attach the trap to a limb in the outer third of the tree canopy, at a 5- to 6-foot height. Fruit damage is usually negligible if there are fewer than 50 moths per trap during the 3-week period after the first moth is caught. If the number of moths per trap during the 3-week period after the first moth is caught is 100, then about 3 percent of fruit is likely to be damaged at harvest; if 200 moths are trapped, then about 9 percent fruit damage is predicted at harvest.

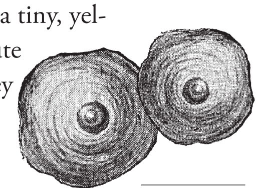
**Chemical Control:** Insecticide is effective if used when eggs are hatching and larvae are small, before they are protected within rolled leaves. The best time to spray to control the first brood is when 10 percent of eggs have hatched, which is 530 degree-days (base 45°F) after the first moth was caught in a pheromone trap, and spray again after 60 percent of eggs have hatched, which is 805 degree-days after the first moth was trapped. The best time to spray to control the second brood is at 10 percent egg hatch, which is 2,280 degree-days (base 45°F) after the first moth was caught, and spray again after 60 percent egg hatch, which is 2,665 degree-days after the first moth was trapped. Control is improved if spray volume is at least 100 gallons per acre.

## San Jose Scale

(*Quadraspidiotus pericosus*; order Homoptera, family Diaspididae)

**Damage:** San Jose scale can infest apples, pears, peaches, and plums. The young crawlers feed on limbs, leaves, and fruit, causing red, spotted areas. Infested leaves usually drop, and limbs lose vigor and die. Fruit will have an undesirable finish because of the red, spotted appearance caused by scale feeding and the presence of the scale.

**Appearance:** The yellow female is underneath a gray, round, and flattened scale-like cap. When mature, the scale is about 1/20-inch in size. The male is a tiny, yellow, two-winged, gnat-like insect. The minute crawlers are orange-yellow and oval, and they have six legs.



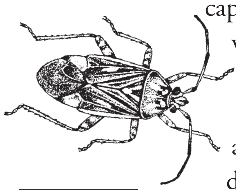
*San Jose scale*

**Life Cycle and Habits:** San Jose scale overwinters as a nymph under a scale on tree limbs and resumes feeding when sap begins to flow in the tree. In the spring, adult males emerge about mid-May and seek out wingless females. Mating occurs and crawlers emerge about 1 month later. These tiny yellow insects move around on bark, foliage, and fruit until they locate a suitable site to settle down permanently. Once settled, the crawler sticks its mouthparts into the tree and secretes a waxy shell over its body. There are two or more generations per year.

**Monitoring and Thresholds:** Scale should be monitored by two methods: 1) adult traps about 2 months in early spring and 2) the appearance of the crawler stage. Assemble traps and hang in scale-infested trees by April 1. At least twice per week, remove each trap from the tree and examine the surface with a hand lens (magnifier) for adult scales. Once adult scales have been captured, begin calculating degree-day accumulation (see "Chemical Control"). Crawlers can be detected easily by wrapping a small amount of black electrical tape with the sticky side out around an infested limb. Pay particular attention to the edge of the tape. Crawlers also can be detected with a hand lens and a straight pin to probe or "flip" over mature scales and look for tiny, orange-yellow crawlers.

The presence of reddish blemishes on fruit at harvest indicates damaging numbers on the trees. If such damage is noted, inspect bark of trees for scale, especially 1-year-old wood. During pruning operations, look for purplish red halos on young bark that are indications of scale infestation. Often this very small insect goes unnoticed until large populations have developed. Growers should be on the lookout for scale on the fruit at harvest and evidence of scale on new wood during pruning.

**Chemical Control:** Because this insect spends much of its life cycle under a protective cover or scale, timing of insecticide applications is very important. Sprays should be applied when crawlers are observed or 400 degree-days (base 51°F) after adults are captured. Insecticidal control is most effective when used in conjunction with a well-applied dormant oil and a good pruning and training program. Usually, dormant oil applications are more effective against scale than delayed-dormant applications.



*tarnished plant bug adult*

## Tarnished Plant Bug

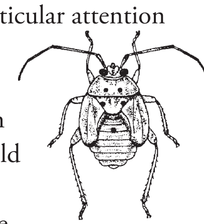
(*Lygus lineolaris*; order Heteroptera, family Miridae)

**Damage:** Their feeding with piercing, sucking mouthparts on fruit when it is very small causes deep depressions or dimples in apples and pears that are noticeable at harvest time. Several species of *Lygus* can cause similar damage to apples.

**Appearance:** Adults are 1/4-inch long, mottled brown insects with wings folded over the abdomen. A yellow-tipped triangle is present in the middle of their backs. Nymphs are small and greenish and resemble the adult without wings. Both nymphs and adults have a beak used for sucking plant juices. They move rapidly when disturbed.

**Life Cycle and Habits:** Adult tarnished plant bugs overwinter under bark, in leaf litter, and in other such protected places. The adult feeds on opening buds or flowers in early spring, and later on developing fruit. They lay eggs in the plant tissue of their many hosts. Nymphs emerge about 1 week later and feed for about 3 weeks before reaching adulthood. Several generations of this insect occur each year. They are often abundant on pigweed and other flowering weeds.

**Monitoring and Thresholds:** Pay particular attention to plant bugs before bloom. Adults are difficult to find in trees and will fly when disturbed. Hold a beat cloth under a scaffold, and strike the scaffold sharply once or twice with the mallet. Sample five scaffold limbs per tree. Examine 100 fruit clusters for tarnished plant bugs; the threshold is five nymphs or adults per 100 fruit clusters.



*tarnished plant bug nymph*

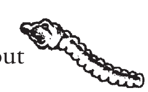
**Cultural Control:** Tarnished plant bugs overwinter in, feed on, and may build up in number on ground-cover plants. Cover crop management is important to prevent tarnished plant bugs from moving into fruit trees. Because tarnished plant bug is attracted to flowering broadleaf weeds, management of annual weeds through regular mowing is an important practice for this pest.

**Chemical Control:** Control is most effective at the pink stage. This insect also damages young peach buds, causing deformed fruit at harvest. Sprays at the pink stage to peaches are effective for its control.

## Spotted Tentiform Leafminer

(*Phyllonorycter blancardella*; order Lepidoptera, family Gracillariidae)

**Damage:** The larva of this moth is a leafminer that feeds inside the leaf between the upper and lower surfaces. At first, the new mines are visible only on the bottom surface of the leaves as a pale blotch. As the leafminer grows, the mine can be seen on the top of the leaf; it looks like a circle of speckles about 1/2-inch in diameter. High populations can cause severe defoliation, leading to reduced fruit and terminal growth, early leaf drop, and reduced fruit set the following season.

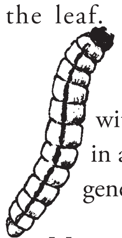


*spotted tentiform leafminer young larva*

*spotted tentiform leafminer adult*

**Appearance:** Adults are 1/8-inch long, golden brown moths with white spots or bands. The eggs are small, flat, elliptical, and laid singly on the undersides of leaves. Eggs are transparent early, but soon turn creamy to yellow. Small larvae are extremely flat and legless; they live in the small space between leaf surfaces. Larger larvae have visible legs and a head capsule and thus more closely resemble caterpillars than the small larvae.

**Life Cycle and Habits:** This insect overwinters as pupae in leaf litter. Small eggs are laid singly on the undersides of leaves. Small larvae begin to appear around bloom. These larvae feed in a "U" shape pattern which delineates the area that will be the mine. This is normally only visible from the underside of the leaf. Larger, tissue-feeding larvae feed on both the upper and lower leaf surfaces. After about a month of feeding, larvae pupate within the mine, and adults begin to appear in about another month. This insect has three generations per year.



*spotted tentiform leafminer larva*

**Monitoring and Thresholds:** Pheromone traps can be used to monitor adult activity from green tip through harvest. The first catch usually occurs at green tip with the first generation peak at early pink and the second generation peak in late June. Scout for eggs at pink or for larvae at petal fall and in July.

Scout for eggs of spotted tentiform leafminer at pink stage. Use a hand lens to see the small, round, translucent eggs. Examine three fruit clusters each from at least three trees, and count the number of eggs on the undersides of the second, third, and fourth leaves in each cluster (start counting leaves from the bottom of the bud). If an average of nine or more eggs per fruit cluster is detected at pink, then use an insecticide for leafminer larvae at petal fall. If fewer than nine eggs per fruit cluster are detected at pink, then an insecticide for leafminer larvae will probably not be needed at petal fall, but scout for early mines at petal fall to help make the final decision.

Scout at petal fall for early mines of the first generation. Early mines are visible only on the underside of the leaf, not on the top. Examine three fruit clusters from each of at least three trees, and count the number of early mines on the undersides of the second, third, and fourth leaves in each cluster. If four or more new mines per fruit cluster are detected, then use an insecticide for leafminer larvae at petal fall.

Scout in early to midsummer for early mines of the second generation of spotted tentiform leafminer. The ideal time to scout can be determined by using a pheromone trap and degree-day counts; scouting should be done 500 to 700 degree-days, base 43°F, (about 3 weeks) after the number of leafminer moths begins to sharply increase in pheromone traps. To scout in midsummer, examine five mature terminal leaves per tree from at least five trees, and count the number of new mines on the undersides of these leaves. If 2 1/2 or more new mines per leaf are detected, apply an insecticide effective against sap-feeding leafminer larvae.

**Chemical Control:** If leafminers have been a persistent problem in previous years, apply an insecticide spray targeted at adults at peak emergence. If leafminer has not been a persistent problem, then do not spray for adults, but scout for eggs at pink and for young larvae at petal fall and in July.

This insect has developed resistance to Guthion, Imidan, and other commonly used cover sprays. Grower experience has shown that Provado or Agri-Mek applied at petal fall provides satisfactory season-long control and does not harm beneficial mites and insects. A pyrethroid (Asana, Ambush, Pounce) or carbamate (Lannate) can be used, but these may lead to mite outbreaks later in the season due to their toxicity to predatory mites.

## White Apple, Rose, and Potato Leafhoppers

(order Homoptera, family Cicadellidae)
White Apple Leafhopper (Typhlocyba pomaria)
Rose Leafhopper (Edwardsiana rosae)
Potato Leafhopper *(Empoasca fabae)*

**Damage:** Whitish spots or stippling on upper leaf surface are evidence of white apple leafhopper and rose leafhopper feeding. Sticky honeydew secretions from leafhopper feeding frequently cover lower fruits and are called "tar spotting." Damage is caused by nymphs and adults removing chlorophyll and sap from the lower leaf surface which can affect fruit development and bud formation. Adults can be a nuisance if they are abundant at harvest as they can be inhaled by pickers. The potential for rose leafhopper is largely dependent on the density and proximity to orchards of the primary overwintering host, floribunda rose.

Damage by potato leafhopper is less common and is characterized by yellowing and necrotic leaf margins. While these damaged areas are typically V-shaped, intense feeding can cause the entire leaf margin to be affected. The bronzed, dried appearance of leaf tips is referred to as "hopper burn." Leaf margins on injured leaves often curl downward. 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, nonbearing fruit trees and young, tender foliage.

**Appearance:** White apple leafhopper and rose leafhopper adults are very similar in appearance. The long, slender adults are wedge-shaped, with a convex back. The body is a light yellow, and the head is slightly darker. Juveniles are generally pale white and wingless; they scurry around when disturbed. While white apple leafhopper nymphs are without noticeable markings, older rose leafhopper nymphs have a few small black spots on the back of the thorax and wingpads.

*white apple leafhopper adult*

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 backward, while potato leafhopper walks sideways as well as forward and backward.

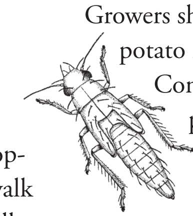
**Life Cycle and Habit:** White apple leafhopper overwintering eggs begin hatching at pink, and hatching is usually complete by petal fall. The nymphs move to the undersides of the leaves to feed. First-generation adults begin to appear in June. There are two generations of white apple leafhopper per year. The second generation adults are often noticeable during harvest.

Rose leafhopper overwinters as eggs on wild roses and brambles. Nymphs emerge in the spring and feed on the wild hosts. In June, adults disperse and move to apples. The second and third generations feed on apples.

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 depends on the jet stream and weather patterns.

**Monitoring and Thresholds:** Scout from bloom through petal fall for nymphs of the white apple leafhopper. Examine a leaf from the middle of a fruit cluster on 25 clusters on each of five trees. If an average of three or more nymphs per leaf is detected, then use an insecticide specifically targeted for leafhopper in addition to your cover spray insecticide at petal fall. With the rose leafhopper, and the second generation of white apple leafhopper, examine 25 leaves per tree and treat with an insecticide if there is an average of three or more nymphs per leaf.

Growers should monitor young apple plantings for potato leafhopper and initial signs of damage. Consider treatment of young blocks when potato leafhoppers first appear, particularly where they have been a problem in the past.



*white apple leafhopper nymph*

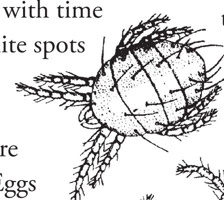
**Chemical Control:** The white apple leafhopper has become resistant to commonly used cover spray insecticides, such as Guthion and Imidan. Provado is very effective against this insect, and it is less disruptive on mite management. In orchards where leafhoppers have become troublesome, it is important to include an effective leafhopper control in the first cover spray. Young leafhoppers are easier to control than adults. The first brood is an easier target than the second brood because the hatch is more synchronous.

## European Red Mite

(*Panonychus ulmi*; order Acari, family Tetranychidae)

**Damage:** European red mites feed by withdrawing juices and chlorophyll from leaves and can build up to the point where leaf bronzing is visible by mid- to late July. Under such conditions, mites can cause serious injury to the current year's crop. Injury will be expressed on fruit as poor color or a reduction in size and quality. If damage is both heavy and early enough in early to midsummer, the next year's crop can be affected by a reduction in the number of fruit buds. The earlier mites build up in the growing season, the more serious the potential injury.

**Appearance:** This mite is red, with newly emerging females being bright velvety red, changing with time to brick red. There are often noticeable white spots at the base of six to eight hairs on its back. Males are dull green to yellowish brown. Females are more globular shaped; males are narrower with a more pointed abdomen. Eggs are of two forms. Overwintering eggs are red-orange and globular and somewhat flattened (onion shaped) with a slender stalk on top. Eggs produced during the growing season are yellowish orange and spherical without the stalk. The first mite stage (instar) has six legs and succeeding instars have eight legs.

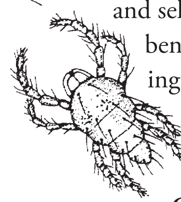


*European red mite female*

**Life Cycle and Habits:** Overwintering occurs as eggs laid in roughened bark around the bases of buds and spurs. Egg hatch in the spring begins around tight cluster stage. Newly hatched mite larvae crawl onto the unfolding leaves and begin feeding. The life stages are egg, larva, protonymph, duetonymph, and adult, with a resting stage between each active stage. Development from egg to adult may take from 1 to 3 weeks and is very temperature dependent. There can be six to eight overlapping generations per season. Summer eggs are laid on the undersides of leaves, unlike winter eggs that are laid on twigs and branches.

**Monitoring and Thresholds:** Scout for European red mite each week from petal fall to August. Start by taking four leaves from each of five trees, examine them for the presence or absence of mites (do not count the number of mites per leaf, just rate each as infested or not infested). Then refer to the mite sampling charts (Figure 6) that correspond to the appropriate time: early season, mid-season, or late-season. On the chart, plot a point that shows how many infested leaves you found in your 20-leaf sample. The point will fall in one of three decision zones: treat with a miticide, do not treat, or take additional samples. If the point on the chart falls in a "continue" zone, then collect leaves from additional trees until you reach a decision. The maximum number of leaves to examine is 100 per block.

**Biological Control:** European red mite is rarely a serious pest in backyard and unmanaged orchards. Predatory mites, lady beetles, and the banded thrips help to maintain European red mite at below damaging levels. This mite is considered a secondary pest; it typically builds to damaging levels only after its natural enemies have been depleted by insecticide applications used to control codling moth or other pests. Minimizing insecticide usage and selecting insecticides that are least toxic to beneficial organisms—in particular, avoiding the use of pyrethroid insecticides—will help to minimize problems with this mite.



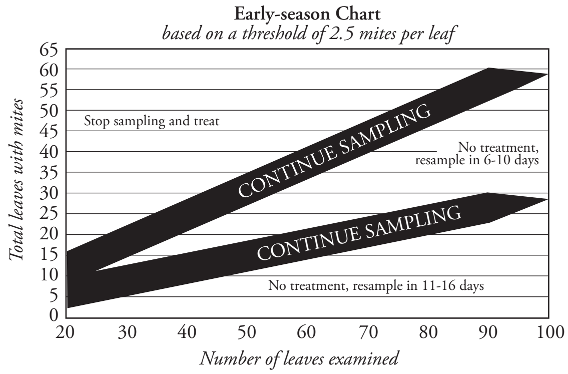
*European red mite male*

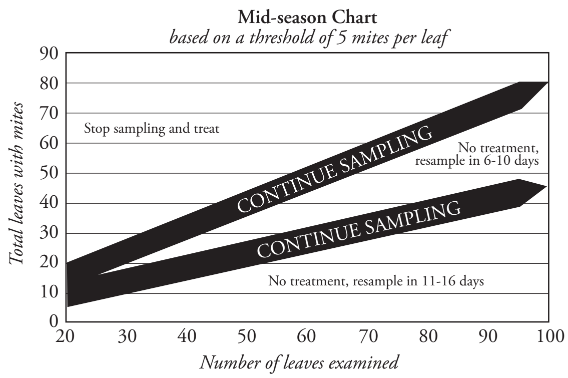
**Control with Oil:** Over the years, a superior oil application applied close to the time mites hatch has proven to be one of the best control practices. The oil coats the eggshell, thereby suffocating the developing mite embryo by blocking respiration. In recent years, a number of orchards had mites that showed various degrees of resistance to miticides. Because of this problem, a good oil application becomes even more important during the dormant to delayed dormant period.

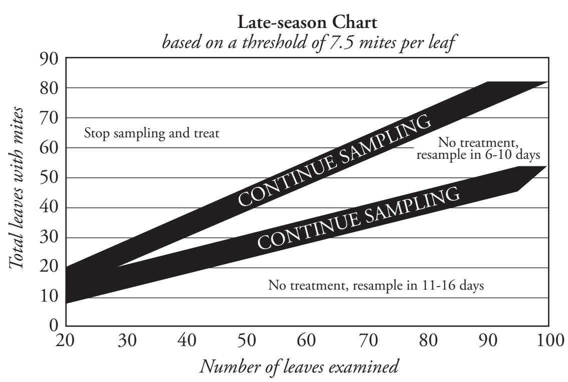
**Chemical Control:** Recent work has shown that tight cluster (Apollo), pink (Savey), or petal-fall miticide (Agri-Mek) sprays significantly help season-long mite control, provided mite predators are conserved. The use of early miticides will often delay mite buildup, so that by late June or early July, very low populations are present in the field. Because this coincides with the establishment of mite predators, early control measures often increase the likelihood of good predator-to-prey ratios, permitting the predator to keep mites below treatment levels.

**Figure 6. European red mite sampling charts.**

**Procedure:** Collect four leaves from each of five trees, examine them for presence or absence of mites, then plot the number on the chart. If the point falls in the *continue* zone, then collect leaves from additional trees until a decision is reached.



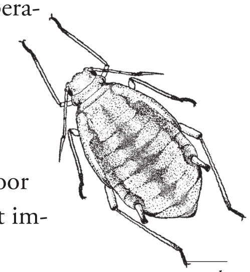




**Source:** Cornell Cooperative Extension Service, *1992 Pest Management Recommendations for Commercial Tree-Fruit Production.*

Growers routinely using early-season mite sprays on their mite-prone varieties should develop a plan to manage the development of mite resistance to these sprays. Apollo and Savey have very similar modes of action. Because of this, alternating Apollo and Savey is a poor resistance management strategy.

During midsummer, Carzol, Pyramite, Kelthane, and summer oils are rescue treatments that may be used against established mite populations. Carzol, Kelthane, and Pyramite are highly toxic to mite predators. In the summer, it may be necessary to make two summer oil applications 7 to 10 days apart to reduce established populations. Carzol provides control of adults only and would have to be applied repeatedly to reduce mite populations. Kelthane givessome control of mites in cool and warm temperatures, but it should only be applied as a back-to-back application to the same generation of mites to prevent the buildup of resistance. Vendex provides a long-residual control, but control is poor to fair. Pyramite is most effective against immature motile stages.

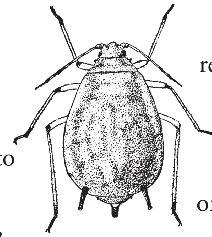


*apple grain aphid*

## Aphids

(order Homoptera, family Aphididae)
Rosy Apple Aphid (*Dysaphis plantaginea*)
Green Apple Aphid (*Aphis pomi*)
Apple Grain Aphid (*Rhopalosiphum fitchii*)
Woolly Apple Aphid (*Eriosoma lanigerum*)

**Damage:** Generally three species of aphids, the green apple aphid, rosy apple aphid, and apple grain aphid, attack apple foliage in the Midwest. However, the rosy apple aphid causes the most severe damage and is the most difficult of the three to control. Large numbers of any type of aphid can stunt new growth and cause sooty mold to develop on fruit and leaves, but the rosy apple aphid injects a toxin with its saliva that causes the leaf to curl and the fruit to abort or to be small or distorted. Relatively low numbers of rosy apple aphids can cause considerable damage. Problems usually begin to appear at pink and into early summer before the aphids move to alternate hosts. Feeding by the woolly apple aphid on roots results in knots and stubby, gnarled root growth. Young trees are often severely injured by this pest. Although woolly apple aphids feed above ground, the feeding on the roots produces the greatest damage.



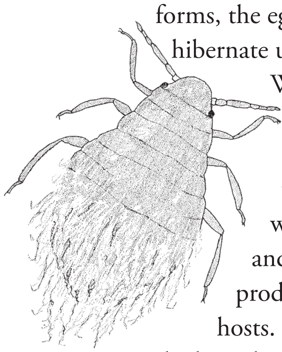
*green apple aphid*

**Appearance:** Apple aphids are small pear- to teardrop-shaped insects. Color varies from purple to gray to rosy for rosy apple aphid, and to light green for green apple aphid and apple grain aphid. Generally a pair of projections (cornicles) will be present on the fifth or sixth segment. Mouthparts are piercing-sucking.

Woolly apple aphid colonies appear as a cottony mass clustered in wounds of the trunk and branches of the tree. The aphids themselves are purplish, but are covered with waxy white threads.

**Life Cycle and Habits:** The life cycle of these aphids begins with the overwintering egg stage. Overwintering eggs are found on twigs, around buds, or in crevices in the bark. Eggs begin hatching in early spring about green-tip stage. The first generation of nymphs are all wingless females, called stem mothers. These females give birth to live young, and a generation is completed about every 14 days. In early summer, some winged young are produced; these fly to new host plants and start new colonies. During late summer and early fall, both male and female forms are produced, which mate and lay overwintering eggs. These eggs are green when first laid, but soon turn shiny black as they mature.

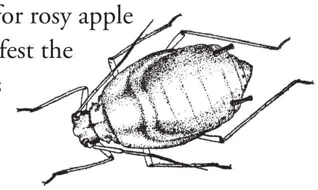
The woolly apple aphid passes the winter in two forms, the egg and the immature nymph. Nymphs hibernate underground on roots of apple trees. Wherever apples and elms are close together, overwintering eggs are deposited in cracks or protected places on the elm. During spring, eggs hatch into wingless nymphs which feed on elm buds and leaves. In early June, a winged form is produced which migrates to apples and other hosts. These individuals feed on wounds in the branches and trunk, and many work their way down to the roots and trunk below ground surface. During the summer, repeated generations of wingless individuals will be produced. In the fall, winged individuals are produced which fly back to the elm and lay overwintering eggs, while some wingless forms remain on the apple tree on both aboveground and belowground parts throughout the winter. Now that elms are relatively uncommon, this aphid generally spends its entire life cycle only on apples.



*woolly apple aphid*

**Cultural Control:** Although all apple varieties are attacked by rosy apple aphid, 'Cortland,' 'Ida Red,' and 'Golden Delicious' are particularly susceptible. Rootstocks vary in susceptibility to woolly apple aphid injury. Use MM.111 or MM.106 if woolly apple aphid is a serious problem.

**Monitoring and Thresholds:** Apple growers should monitor their trees carefully at pink for rosy apple aphids. A few colonies can rapidly infest the entire tree. Examine ten fruit clusters from the inner canopy of each of ten trees. If *any* rosy apple aphids are found in this sample, then use an insecticide for aphid control at pink. If rosy aphid is not detected at pink, do not use an insecticide at pink unless the block has a history of economic injury from plant bugs. After petal fall, treat for rosy apple aphid if 5 percent of the terminals or fruit clusters have live colonies. A number of predators often control rosy apple aphid, so distorted leaves should be opened to determine if the aphids or predators are still present before making control decisions.



*rosy apple aphid*

Monitor for green apple aphid from petal fall until new growth hardens off (usually by mid-July). Examine five terminals on each of five trees. Look for aphids and natural enemies, particularly the gall midge larva (an orange maggot) that commonly preys on apple aphids. Treatment is suggested if 30 percent of the terminals are infested and natural enemies are not present.

Careful examination of woolly apple aphid colonies is necessary to determine if live aphids or predators are present. Predators can completely destroy an aphid colony, but leave the waxy residue.

**Chemical Control:** Because rosy apple aphid infestations will curl the leaves, early control is important. Once the leaves are tightly curled, adequate spray coverage and control are more difficult. For that reason, rosy apple aphids are best controlled at the pink stage of bud development while they are still exposed and before the serious leaf curl has occurred. The cover sprays for codling moth may control light infestations of woolly apple aphid.

## Dogwood Borer

(*Synanthedon scitula*; order Lepidoptera, family Sesiidae)

**Damage:** On young apple trees, dogwood borer can cause serious damage, possibly girdling trees. The larvae feed primarily in burrknot tissue on clonal rootstocks. All commercial dwarfing and semi-dwarfing rootstocks have a tendency to develop burrknots. As the burrknot tissue is consumed, the larvae move outward and begin to feed on the cambium adjacent to the burrknot.

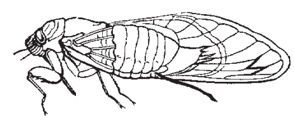
**Appearance:** The adult dogwood borer is a wasp-like, black and yellow, clearwing moth. With a wing span of 3/4-inch, it is smaller than the peach borers. The female has a wide yellow band on the fourth abdominal segment; the male has a narrow yellow band on the same segment. The larvae are white to pink, have a brown head capsule, and are 1/2-inch when fully grown.

**Life Cycle and Habits:** The dogwood borer lays eggs in burrknot tissue or in graft unions on clonal rootstocks such as M.7, M.26, etc., or interstems; the larvae tunnel throughout the burrknot tissue and adjacent cambial tissue. There is one generation per year.

**Monitoring and Thresholds:** Pheromone traps can be used from petal fall through harvest to monitor for adult dogwood borers. The first trap catch usually occurs in late May or early June and peaks in early July. Control by trunk application at peak egg hatch, 8 to 9 days after peak flight.

**Cultural Control:** White latex paint brushed on the exposed portion of the rootstock before egg laying begins can prevent new infestations and also protect against southwest injury to the bark. Minimize the use of plastic trunk guards, which create humid conditions on the trunk that are favorable to borer development.

**Chemical Control:** Infestations of dogwood borer are uncommon, and routine trunk sprays are not recommended. But in orchards where dogwood borer is a problem, new infestations can be controlled by applying an insecticide to the trunk at the time of peak egg hatch.



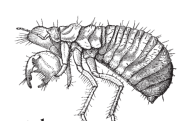
*periodical cicada adult*

## Cicadas

(order Homoptera, family Cicadidae)
Periodical Cicada (*Magicicada septendecim*)
Annual Cicada (several species)

**Damage:** While periodical cicadas emerge at 13- or 17-year intervals, annual cicadas may be seen each year. The worst damage results from egg laying when females slit the bark on twigs and lay their eggs in the wounds. These small branches can turn brown and die, sometimes breaking off. On young fruit trees, newly developed trunk or scaffold branches can be so severely damaged that new branches must be grown. Damage can be severe in newly planted orchards or new plantings of shade trees or shrubs. Juvenile feeding on roots causes the most long-term damage. Once nymphs have burrowed into the ground and reached the roots, no control method is available. During years one through five of an infestation, damage probably will not be noticeable. However, for years 6 to 13 (or 17), juvenile cicadas may be extremely destructive to plants. Serious damage by annual cicadas is uncommon, and their activity in orchards is generally limited to feeding.

**Appearance:** The periodical cicada and the annual cicada are confused because of superficial similarities. The periodical cicada is 1 1/2-inches long, with red eyes, a black body, and clearwings with orange veins; it appears from April to June. In contrast, the annual cicada is 2- to 2 1/2-inches long, with green eyes, a green to black body, and light green wings with dark green veins; it appears from July to September.



*periodical cicada nymph*

**Life Cycle and Habits:** After emergence and mating in late April through June, female periodical cicadas lay eggs in rows in pockets they cut in small branches and twigs of trees with their knifelike egg layers. Females prefer grapevines and oak, hickory, apple, pear, and peach trees for egg laying. Eggs hatch in 6 to 8 weeks. Nymphs fall to the ground and burrow down to the root system where they stay for the next 13 (or 17) years. Damage occurs as they use their piercing-sucking mouthparts to feed on the roots.

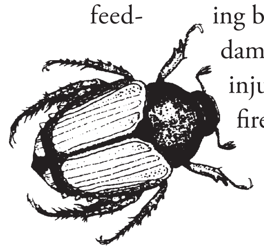
**Cultural Control:** Small trees can be covered with a protective netting like cheesecloth secured at the bottom around the trunk. This covering will need to stay on for 4 to 6 weeks or until egg laying is complete. Since the trees are growing rapidly at this time, care must be taken to keep the netting from deforming the scaffold branches. With older trees, damaged branches can be removed during winter pruning operations.

**Chemical Control:** Trees can also be sprayed. Orchards under a routine spray schedule may adjust this schedule to coincide with the time when large numbers of cicadas are present. Spray requirements will vary depending on the severity of the outbreak.

## Japanese Beetle

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

**Damage:** The adult beetles feed on leaves of a wide variety of trees and shrubs. Adults feed on the upper surface of foliage, chewing tissue between the veins and leaving a lace-like skeleton of the leaf. They usually feed in groups, starting at the top of a plant and working downward. The beetles are most active on warm, sunny days and prefer plants that are in direct sunlight. A single beetle does not eat much; it is group feeding by many beetles that results in severe damage. Trees that have been severely injured appear to have been scorched by fire. Japanese beetles will feed on fruits that have been damaged by other insects.



*Japanese beetle*

**Appearance:** Adult Japanese beetles are 3/8-inch-long, metallic green beetles with copper-brown wing covers. A row of white tufts of hair project from under the wing covers on each side of the body.

**Life Cycle and Habits:** Japanese beetles overwinter underground in the grub stage and pupate near the soil surface in the spring. Grubs spend 10 months in the soil where they feed on roots of grasses and can be serious pests of turf. Adults emerge from the ground and begin feeding on various plants in June. Activity is most intense over a 4- to 6-week period beginning in late June. By mid-July, numbers of beetles gradually diminish. Individual beetles live about 30 to 45 days. There is a single generation per year. Orchard trees that may be severely attacked include apple, cherry, black cherry, peach, and plum.

**Monitoring and Thresholds:** There are few threshold guidelines relative to when apples need to be treated for Japanese beetles. However, the first Japanese beetle colonizers in the early summer will attract others into the orchard, so early control can reduce later infestations.

Japanese beetle traps are available that lure both male and female beetles into the trap. This trap is so effective at attracting beetles that it can actually increase both the number of beetles in the vicinity of the trap and the damage they cause. Despite the bad reputation the trap has earned because of its super-attractiveness, the trap is still effectively used if it is placed at some distance away from the orchard.

**Chemical Control: Carbaryl is the most effective insecticide used in managing Japanese beetles. However, because carbaryl can greatly increase problems with European red mites, other insecticides are recommended to manage low to moderate Japanese beetle populations in apples. Repeated insecticide applications may be necessary at 7- to 10-day intervals to prevent reinfestation during the adult flight period or after heavy rains. Use of a spreader/sticker in the spray mix can increase the duration of effectiveness.**

# Summary of Insect and Mite Pest Management Procedures on Apples and Pears

**Cultural controls when establishing a new orchard:**

- Choose a planting site with suitable soil and good water drainage.
- Remove alternate hosts for codling moth and plum curculio.
- Remove alternate hosts, especially brambles for flyspeck and sooty blotch, and cedars for rust.
- Purchase certified virus-free stock from a reputable nursery.
- Avoid rootstocks that are highly susceptible to woolly apple aphid.
- Avoid cultivars that are highly susceptible to rosy apple aphid.
- Avoid fire blight-susceptible rootstock/cultivar combinations.

**Cultural controls while maintaining an orchard:**

- Prune trees to ensure adequate spray coverage in all parts of the trees.
- Provide adequate but not excessive nitrogen fertilizer, especially to fire blight-susceptible trees and to avoid flushes of growth attractive to aphids.
- Destroy fruit that falls in early to midsummer.
- Prune to ensure good air circulation and adequate spray coverage in all parts of the trees and to remove fire blight infections.
- Keep broadleaf groundcover under trees to enhance predatory mites.
- Keep orchard mowed to discourage tarnished plant bug.

**Monitoring for pests:**

*Insect traps*

- Hang pheromone traps for leafrollers and spotted tentiform leafminers in trees at green tip and examine twice per week.
- Hang pheromone traps for San Jose scale at pink and examine twice per week through May, or use sticky tape to monitor for crawlers from mid-May through early June.
- Hang pheromone traps for codling moth at pink and examine twice a week through harvest.
- In the northern Midwest, hang canary-yellow sticky traps and red spheres in early June to monitor for apple maggot and maintain them through mid-August.
- Use degree-day forecasting to time spray applications for San Jose scale and codling moth, in conjunction with pheromone traps.

*Disease prediction*

- Use a commercial scab predictor or temperature and leaf wetness measurements to monitor scab infection periods.
- Use the MARYBLYT computer program to monitor development of fire blight and predict the onset of symptoms.

*Scouting*

- Pruning: look for scale injury to new wood.
- Tight cluster through pink: look for plant bugs and rosy apple aphid.
- Tight cluster through first cover: look for aphids.
- Petal fall through second cover: look for plum curculio damage and leafhoppers.
- Early June: begin looking for European red mite and Japanese beetle.
- Harvest: evaluate for San Jose scale, codling moth, plum curculio, and leafroller control. Also, examine leaves, especially the undersides, for late-season scab.

**Applying insecticides and miticides:**

- To minimize the emergence of pests that are resistant to pesticides, avoid repeated application or season-long use of pesticides with the same mode of action.
- Use a delayed dormant oil application to control European red mite and San Jose scale.
- Use broad-spectrum insecticide only against codling moth, plum curculio, and leafrollers.
- Use narrow-spectrum insecticides if problems are detected with aphids, leafhoppers, leafminers, and San Jose scale.
- Avoid using products known to be highly toxic to predatory mites or predaceous insects.

**Consider using mating disruption for codling moth management.**

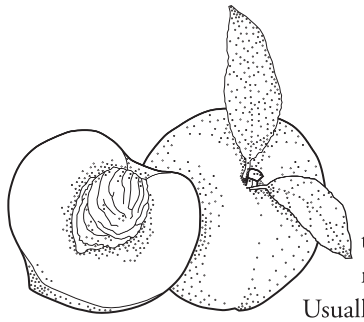
**Apple Orchard Management Calendar**

| | Pre-season | Dormant | Silver tip | Green tip | Half -inch green | Tight cluster | Pink | Bloom | Petal fall | First cover | Second cover | Third cover | Summer cover | July | August | September | Harvest | October | November | December |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dormant Pruning, Brush Removal, Leaf Chopping | X | X | X | X | | | | | | | | | | | | | | | | |
| Ridomil for Collar Rot | | X | | | | | | | | | | | | | | | | | X | |
| Fertilization | X | | | | | | | | | | | | | | | | | | | |
| Pre-emergence Herbicides | X | X | | | | | | | | | | | | | | | | | | |
| San Jose Scale | | X | | | | | ● | | | X | X | X | | | | | | | | |
| European Red Mites | | | | X | X | X | X | | X | X | X | X | X | X | X | X | X | | | |
| Spotted Tentiform Leafminer | | | | ● | X | | X | | X | | | | X | X | X | X | X | | | |
| Scab Infection | | | | ● | X | X | X | X | X | X | X | X | X | X | X | X | X | | | |
| Rosy Apple Aphid | | | | | X | | X | | | | | | | | | | | | | |
| Green Apple Aphid | | | | | | | X | | X | X | X | X | X | | | | | | | |
| Powdery Mildew | | | | | | X | X | X | X | X | X | | | | | | | | | |
| Rust Infections | | | | | | | X | X | X | X | X | | | | | | | | | |
| Tarnished Plant Bug | | | | | | | X | | | | | | | | | | | | | |
| Foliar Boron and Nitrogen | | | | | | | X | | X | | | | | | | | | | | |
| Fire Blight Infections | | | | ● | | | | X | X | X | X | | | | | | | | | |
| Codling Moth | | | | | | | ● | | X | X | X | X | X | X | X | X | X | | | |
| Plum Curculio | | | | | | | | | X | X | X | | | | | | | | | |
| Red-banded Leafroller | | | | | | | | | X | X | X | X | X | X | X | X | X | | | |
| Chemical Thinning | | | | | | | | | X | X | X | | | | | | | | | |
| White Apple Leafhopper | | | | | | | | | X | | | X | X | X | X | X | X | | | |
| Fruit Rots | | | | | | | | | | X | X | X | X | X | X | X | X | | | |
| Blister Spot | | | | | | | | | X | X | | | | | | | | | | |
| Cork Spot and Bitter Pit | | | | | | | | | X | X | X | X | X | X | X | X | X | | | |
| Flyspeck and Sooty Blotch | | | | | | | | | | | X | X | X | X | X | X | X | | | |
| Apple Maggot | | | | | | | | | | | X | X | X | X | X | X | X | | | |
| Oblique Banded Leafrollers | | | | | | | | | | | X | X | X | X | X | X | X | | | |
| Japanese Beetle | | | | | | | | | | | X | X | X | | | | | | | |
| Post-emergence Herbicides | | | | | | | | | | | X | X | X | X | X | X | X | | | |
| Irrigation | | | | | | | | | | | X | X | X | X | X | X | X | | | |
| Watersprout and Sucker Removal | | | | | | | | | | | | X | X | | | | | | | |
| Foliar Analysis | | | | | | | | | | | | | X | | | | | | | |
| Put out Rodent Bait. | X | | | | | | | | | | | | | | | | | X | X | X |
| Trunk Borers | | | | | | | | | | | | | | | | | | | | |

● Put pheromone traps in place or begin taking environmental data.for pest prediction

CHAPTER 2

# Stone Fruits



A healthy stone fruit planting is relatively tolerant of pests. There are many environmental and cultural practices that directly influence pest pressure, pest management, and overall tree health. For example, stone fruit trees do not tolerate "wet feet." Because of their relatively early blooming, stone fruit trees are susceptible to late spring frosts. The success of stone fruit trees is highly dependent on a site with excellent air and water drainage. Air drainage is enhanced if the site is higher than the surrounding terrain. Also, the temperature moderation on the lee side by a large body of water reduces the risk of frost damage. Soil drainage can be enhanced by tiling or by planting trees on wide, raised beds. Sites should be in a rotation program so stone fruits will not directly follow stone fruits. Site selection and improvement should begin 1 to 2 years prior to planting. This includes draining low spots, eliminating undesirable weed species, improving soil fertility, and adjusting the soil pH to the levels recommended by the local Cooperative Extension Service educator.

Scion and rootstock choice also greatly influence pest management as both vary in their resistance to many pests as well as in their suitability to the intended site. Contact local Extension educators to determine which cultivars and rootstocks are best suited for the conditions. Always obtain the nursery stock from a reputable nursery which certifies trees to be virus-free. To obtain the desired scion-rootstock combination, order nursery stock well in advance of planting. Planting recommendations vary from planting in spring and fall in southern locations to spring planting in more northern climes.

Cultural care to maintain a healthy planting includes providing proper nutrition, assuring adequate moisture, and removing weeds that compete for water and nutrients. Nutrient needs are best determined by a combination of soil tests and foliar analysis. The nutrient application must be timed in a manner that allows the plant to harden off in the fall to reduce the chance of winter injury. Usually this means that fertilization is either in the dormant season or early to midsummer.

Proper pruning is a crucial part of pest management for stone fruits. There are a number of pruning systems, depending on the species and spacing. Remember:

- Stone fruits produce fruit blossoms on last year's growth.
- Time of pruning greatly affects susceptibility to pruning injury. Summer pruning should be completed by midsummer, and dormant pruning should not start until late winter and may continue through petal fall.
- Prunings should be removed from the orchard and destroyed to prevent re-infestation of the orchard.

Care of the fruit during harvest and storage greatly influences fruit quality and the development of post-harvest disorders. Fruit should be harvested at the appropriate stage of maturity for its intended use. Fruit intended for shipping is harvested firmer than fruit for local distribution. Care must be taken to harvest only fruit of proper maturity. Avoid bruising, and cool the fruit quickly to remove field heat. Stone fruit stores best at 32°F and 85 percent humidity. However, peaches cannot be left at temperatures below 50°F until they ripen, or they may become dry and mealy.

Winter injury shortens the life of the planting, reduces vigor, and makes the planting more susceptible to other disorders. The cultural and pest control methods used to produce a healthy tree also reduce the tree's susceptibility to winter injury. The susceptibility to winter injury is further reduced by:

- Avoiding late or excessive nitrogen fertilization;
- Using fall cover crops or allowing weeds to grow to harden the trees by competing for water and nutrients;
- Painting the trunk with white latex paint; and
- Pruning after late winter or at first bloom.

# Integrated Management of Stone Fruit Diseases

The objective of an integrated disease management program is to provide a commercially acceptable level of disease control from year to year while minimizing the cost of disease management. For each orchard, develop a program that integrates all available control tactics.

## Identifying and Understanding Major Stone Fruit Diseases

Accurate disease identification is critical in making smart disease management decisions. Growers should develop a basic understanding of the pathogen biology and disease life cycles for the major stone fruit diseases. The more you know about a disease, the better equipped you will be to make sound and effective management decisions. The following literature contains colored photographs of disease symptoms on stone fruits, as well as information on pathogen biology and disease development.

*Compendium of Stone Fruit Diseases*
Published by the American Phytopathological Society, 3340 Pilot Knob Rd., St. Paul, Minnesota 55121.
Phone: (612) 454-7250 or (800) 328-7560.

*Diseases of Tree Fruits in the East*
Published by Michigan State University Cooperative Extension Service as publication number NCR 45. Your county Extension office may have this bulletin in stock, or phone Michigan State University.
Phone: (517) 355-0240.

### Brown Rot

Brown rot, caused by the fungus *Monilinia fructicola*, is the most destructive disease of stone fruits in the Midwest. European brown rot, caused by *M. laxa*, affects sour cherry in some northern regions of the Midwest, but is not as widespread as *M. fructicola*.

Brown rot affects blossoms, fruit, spurs, and small branches. Infected blossoms wilt, dry, and persist into the summer. One to several small, light brown, soft spots develop on fruit. During warm, humid weather the lesions quickly expand, and tan to gray spore tufts break through the fruit skin. Rotted fruit persist as mummies on the tree or fall to the ground.

**Disease Development:** The brown rot fungus overwinters in mummies on the ground or in the tree and in other infected tissue (Figure 7). In the spring, spores are released and carried by wind and splashing rain to susceptible tissue. Blossom infection can occur after 5 hours of wetting at 77°F but requires 18 hours of wetting at 50°F. The fungus develops slowly below 55°F and above 80°F. Susceptibility of fruit increases with maturity. The fungus can penetrate unbroken fruit but also takes advantage of wounds caused by hail, insects, or cracking.

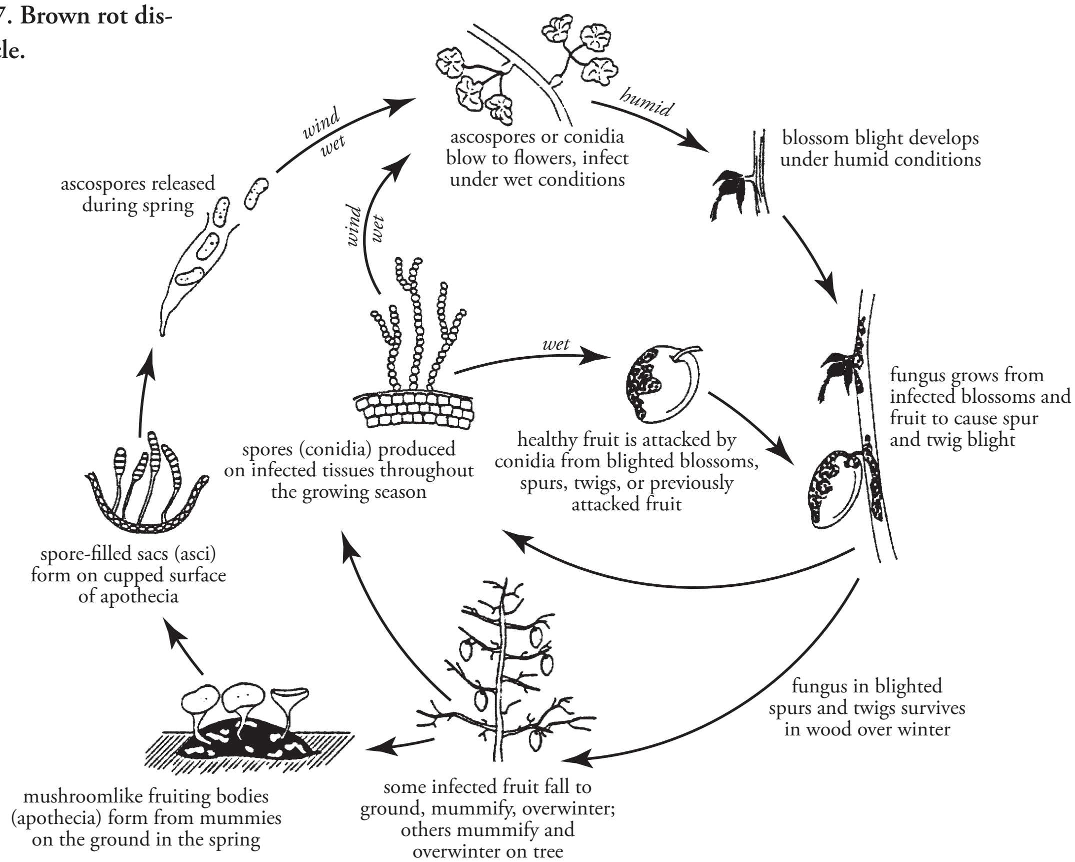
**Control of Brown Rot:** Brown rot is controlled by a combination of orchard sanitation (removal of mummies and infected tissues) to reduce the population of the pathogen and well-timed applications of protective fungicides. Two sprays during bloom and two to three sprays before harvest are usually needed if the weather is wet or humid. *Monilinia* species are prone to becoming resistant to fungicides. Therefore, fungicides should be used in a manner that will delay the onset of resistance (see “Disease Management as a Component of IPM,” p. 11). Insect control during fruit maturation is important to minimize fruit injury. Handling fruit carefully and removing field heat with refrigeration will reduce post-harvest decay by brown rot. Sweet cherries are more susceptible than sour cherries, nectarines are more susceptible than peaches, and apricots are highly susceptible. Specific cultivars of stone fruit trees with significant resistance to brown rot are not known.

### Cherry Leaf Spot

Cherry leaf spot, caused by the fungus *Blumeriella jaapii*, is a potentially devastating disease of sour and sweet cherries and plums. Besides a direct loss in yield and quality of fruit, premature defoliation weakens trees and makes them less winter-hardy.

During late spring, small purple spots develop on the upper surfaces of leaves. The spots enlarge, turn reddish brown, and sometimes coalesce to form large, irregular lesions. White to pink masses of spores (conidia)

**Figure 7. Brown rot disease cycle.**




are visible on the undersides of leaves during wet weather. On plums and sometimes on cherries, the centers of the spots become dry and fall out, producing "shot-holes." Infected leaves eventually turn yellow and drop.

**Disease Development:** The cherry leaf spot fungus overwinters in fallen leaves. At about the time of petal fall, ascospores and sometimes conidia are ejected from leaves on the orchard floor. Infection occurs through stomata (pores for gas exchange) on the undersides of leaves. After leaves have unfolded, they are susceptible throughout the season; however, they become less susceptible with age. Conidia are spread by wind and splashing rain to other leaves where additional infections occur. Optimal conditions for disease are temperatures of 60° to 68°F with rainfall (Table 7). Spread of conidia and subsequent infections continue throughout the season.

**Control of Cherry Leaf Spot:** Fungicides are the primary means of controlling cherry leaf spot. Because the fungus infects through stomata on leaves, and stomata are not open until leaves have unfolded, sprays can be delayed until petal fall. Sprays need to be repeated every 7 to 10 days until harvest and followed up with one or two post-harvest applications to reduce the amount of fungus that will overwinter. Removing leaf litter in the fall or early spring should reduce the number of primary infections. During dry years or where disease pressure is low, using fungicides only after an infection has occurred (Table 7) might provide adequate control, although it is riskier than a 7- to 10-day protectant schedule. Cultivars with resistance to cherry leaf spot have not been identified.

## Peach Leaf Curl

Peach leaf curl, caused by the fungus *Taphrina deformans*, can result in severe defoliation that in turn reduces fruit quality, yield, and tree vigor. A related disease, plum pockets, occurs on plums but is generally not a threat in commercial orchards.

**Disease Development:** Symptoms are first seen about a month after bloom. Leaves are initially red and become distorted, thickened, and curled before eventually turning brown and dropping. Infected fruit are distorted and off-color. Spores of the fungus are produced on the surface of diseased leaves and are spread by wind and splashing rain. Spores that become lodged under bud scales and rough bark overwinter in those sites. In the spring, spores germinate and infect young leaves *while still in the bud*. Leaf curl is more severe when extended cool and rainy weather occurs at bud burst; apparently, cool weather retards leaf maturation and prolongs the period that leaves are susceptible. Infection is greatest at temperatures of 50° to 70°F and minimal below 45°F and above 86°F.

**Peach Leaf Curl Control:** No peach or nectarine cultivars are immune to leaf curl, but Redhaven and its derivatives are more resistant than Redskin and its derivatives. A single fungicide spray applied in the fall after leaves drop or in the spring *while trees are still dormant* will control leaf curl. By bud burst, most infection has already occurred, and fungicide sprays are relatively ineffective.

**Table 7. Approximate minimum number of hours of leaf wetness at various temperatures required for leaf spot infections caused by conidia on sour cherry.[a]**

| Average temperature (°F) | Wetness (Hours)[b] |
|---|---|
| 46 | 28 |
| 47 | 25 |
| 48 | 23 |
| 49 | 20 |
| 50 | 19 |
| 51 | 17 |
| 52 | 15 |
| 53 | 14 |
| 54 | 12 |
| 55 | 11 |
| 56 | 10 |
| 57 | 9 |
| 58 | 8 |
| 59 to 60 | 7 |
| 61 to 62 | 6 |
| 63 to 68 | 5 |
| 69 to 70 | 6 |
| 71 to 72 | 7 |
| 73 | 8 |
| 74 | 9 |
| 75 | 11 |
| 76 | 12 |
| 77 | 14 |
| 78 | 16 |
| 79 | 18 |
| 80 | 21 |
| 81 | 28 |

a Requirements for primary (ascospore) infections are presumed to be similar.
b Hours of wetness from the beginning of the rain. Data of S. Eisensmith and A. Jones (Michigan State University).

## Bacterial Spot

Bacterial spot, caused by the bacterium *Xanthomonas campestris* pv. *pruni*, is a sporadic but potentially devastating disease of apricots, nectarines, peaches, plums, and prunes. Diseases caused by bacteria are nearly impossible to manage when conditions favor bacterial growth, and bacterial spot on stone fruits is no exception. Entire crops can be lost in years with long periods of warm, wet weather.

Small, angular, gray, water-soaked lesions appear on the undersides of leaves, especially along the midvein, tip, or margins. As lesions expand, they turn brown or black, and the centers of spots can fall out, giving the leaf a tattered appearance. Heavily infected leaves turn yellow and drop. Infected fruit is marred by brown to black pits and cracks. Elliptical cankers develop on current-year or 1-year-old stems.

**Disease Development:** The bacterial spot pathogen overwinters on twigs and in buds either with or without symptoms. In the spring, bacterial populations multiply, and infection occurs during wet conditions. Water congestion of plant tissue is important for disease development, and outbreaks are especially severe following storms with wind-driven rain. Abrasion by wind-borne sand injures tissue and leads to further infection. Warm, rainy weather throughout the season is conducive to secondary infections.

**Control of Bacterial Spot:** Peach varieties vary in their susceptibility to bacterial spot (Table 8). Chemical control is unreliable, so the best way to manage bacterial spot is by planting the most resistant cultivars. Fertilization should be adequate for tree health but not excessive; succulent tissues are very susceptible to bacterial spot. Sand abrasion can be minimized by planting a cover crop. Windbreaks will reduce wind speeds and should result in less tissue injury and spread of the pathogen. Dormant applications of fixed copper may reduce bacterial populations. The antibiotic oxytetracycline (Mycoshield), applied at shuck-split and continued at 7- to 10-day intervals until 3 weeks before harvest, has been used with varying degrees of success.

**Table 8. Relative resistance of peach cultivars to bacterial spot.**

| Resistant | Tolerant | Least resistant |
|---|---|---|
| Candor | Biscoe | Autumnglo |
| Cresthaven | Earlirio | Blake |
| Earliglo | Garnet Beauty | Harmony (Canadian) |
| Encore | Glohaven | Jerseyland |
| Harbelle | Jerseyqueen | Redcrest |
| Harbinger | Loring | Redhaven |
| Harbrite | Rio-Oso-Gem | Sweet Sue |
| Harken | Sentinel | Suncrest |
| Jerseydawn | Springold | Sunhigh |
| Norman | Summerglo | Triogem |
| Pekin | Sunqueen | Tyler |
| Ranger | Sunshine | Velvet |
| Redkist | Surecrop | Washington |
| Redskin | Topaz | |

Adapted from Rutgers University *Commercial Tree Fruit Production Guide*.

## Perennial Canker (Leucostoma canker, Valsa canker) of Peaches

Canker in peaches can be caused by either of two closely related fungi, *Leucostoma cincta* and *L. persoonii*. The disease is common on peaches throughout the Midwest, especially in northern growing regions; it is sporadic and less important on other stone fruits. Perennial canker is most destructive in young orchards where large oval or elliptical cankers form on the trunk or scaffold limbs. Cankers can continue to expand each year, eventually girdling the branch or trunk. Cankers often are covered with wet gum, but this symptom is not diagnostic for the disease.

**Disease Development:** The pathogens overwinter as fruiting bodies in the bark of cankers or in dead branches. Spores are extruded from the fruiting bodies and are spread by wind-driven rain. Low-temperature injury, pruning wounds, hail damage, insect wounds, and leaf scars are potential infection sites. Optimal temperatures for growth of *L. cincta* and *L. persoonii* are 68° and 86°F, respectively.

**Control of Perennial Canker:** Control of canker diseases in stone fruit trees requires integrating cultural practices that promote winter hardiness and rapid wound healing with orchard sanitation. Canker diseases in general are exacerbated if trees are stressed. Trees should be planted in sites with well-drained soil and good air circulation. Trees should be trained to avoid narrow crotch angles, which are generally prone to injury. Adequate hardening-off before winter can be achieved by fertilizing early in the season and planting a cover crop by early July. Clean cultivation by disking is not recommended as this can damage roots. Trickle irrigation during dry periods will increase resistance to canker diseases. Applying white latex paint to the southwest side of trunks and lower scaffold branches helps prevent low-temperature injury on cold, sunny winter days. Rapid healing is enhanced by delaying pruning until growth resumes in the spring. Avoid leaving stubs when pruning; these heal poorly and are likely sites for infection. Cankers and dead wood should be removed and destroyed by burning or burying. In addition to cultural practices aimed at reducing stress, the lesser peach tree borer must be controlled to minimize perennial canker. This insect lays its eggs on and in cankers. As the larvae tunnel, they carry the fungus into healthy bark and wood.

## Peach Scab

Peach scab, caused by the fungus *Cladosporium carpophilum*, occurs throughout the Midwest but is most important in the southern regions. The disease causes an unsightly spotting of fruit and sometimes creates entry points for the brown rot fungus, *Monilinia fructicola*.

**Disease Development:** The fungus overwinters in infected twigs. Spore production begins at shuck-split and peaks about 2 to 6 weeks later. Sporulation is greatest during humid periods. Spores are carried by wind and splashing rain to fruit. Infections remain latent (no symptoms) for 40 to 70 days. After the latent period, scab lesions appear as small, round, greenish black, velvety spots on fruit. Lesions tend to develop near the stem end of the fruit. Severely infected fruit may be stunted, misshapen, or cracked.

**Control of Peach Scab:** Peach scab is controlled by fungicide applications and by pruning so that leaves and fruit dry quickly and fungicides can penetrate the canopy. Fungicides are especially important at shuck fall and should be continued every 7 to 10 days until 40 days before harvest or as labels permit. Good canopy penetration by the fungicide will enhance coverage of fruit and result in less disease.

## Black Knot of Plums

Black knot of plums and prunes is caused by the fungus *Apiosporina morbosa* (formerly *Dibotryon morbosum*). Wild plums and cherries are also hosts and are common reservoirs for the pathogen. The elongated, corky swellings, or "black knots," stunt growth and eventually girdle and kill branches.

**Disease Development:** New stem growth becomes infected starting at about pink bud, and infections continue for about 2 weeks. Moisture is required for infection, and disease development is greatest at temperatures of 55° to 77°F. Several months are required for the knots to develop. Some knots are visible the same year as infection, but others are not visible until the following growing season. Newly forming knots are soft, greenish swellings that grow along the length of branches or twigs. As knots age, they become dry, hard, black, and are parasitized by other fungi, which often give the knots a pink or cream-colored appearance.

**Control of Black Knot:** Cultivars of plums vary in susceptibility to black knot. Stanley, Bluefre, Damson, and Shropshire are most susceptible; Fellenburg, Methley, Milton, Bradshaw, and Early Italian are moderately susceptible; Formosa, Shiro, and Santa Rosa are slightly susceptible; and President is resistant. Wild plums and cherries should be removed from woodlots near plum orchards. New plantings should be established in sites away from infected trees. Knots should be removed by making cuts 6 inches below the knot and then destroyed by burning or burying the prunings. Fungicides applied from white bud through first cover will help control black knot but are not a substitute for good orchard sanitation.

# Insect and Mite Pests of Stone Fruits

## Identifying and Understanding Major Stone Fruit Pests

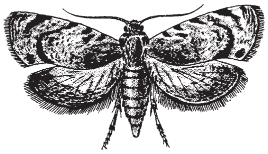
It is important for growers to recognize all stages of the insects and mites that attack stone fruits. Proper identification is critical to making the correct management decisions. In addition, growers should develop a basic understanding of the pests' habits. The more you know about the pest, the better equipped you will be to make sound and effective management decisions. The following books contain color photographs of pests of stone fruits, as well as information on their biology.

*Common Tree Fruit Pests*
Authored by Angus Howitt and published in 1993 as North Central Regional Extension Publication #63 by Michigan State University Cooperative Extension Service. Phone: (517) 355-0240.

*Mid-Atlantic Orchard Monitoring Guide*
Edited by Henry Hogmire and published as NRAES 75 by the Northeast Region Agricultural Engineering Service, Cooperative Extension Service.
Phone: (607) 255-7654.

*oriental fruit moth*

## Oriental Fruit Moth



(*Grapholitha molesta*; order Lepidoptera, family Tortricidae)

**Damage:** The oriental fruit moth is one of the most serious pests of peaches in the Midwest. Early in the season, this insect damages succulent terminal growth. It attacks fruit in midsummer. Although there may be four to five generations each year, it is the second and third generations that cause most of the damage. In addition to peaches, this insect attacks apples, plums, cherries, pears, and nectarines.

**Appearance:** The oriental fruit moth is a small (1/4-inch), charcoal-colored moth. Fine alternating bands of light and dark lines on the wings give it a mottled appearance. The small, flat, oval eggs are laid individually or in small clusters on the foliage primarily, usually on the upper leaf surfaces of the terminal growth. The larva is pinkish white with a brown head and is 1/2-inch long when fully grown. The larva pupates in a silk cocoon in crevices in the bark or in litter at the base of the tree. The larva is similar to the codling moth larva but can be distinguished by the presence of an anal comb.

**Life Cycle and Habits:** The oriental fruit moth overwinters as full-grown larvae in cocoons in protected places on the trunk or around the base of the tree. They pupate beginning in late March, and moth emergence usually coincides with peach bloom. First-generation larvae tunnel into the young, tender terminal growth near the base of a leaf early in the season. The larvae may tunnel down the center of the twig for 2 to 6 inches before completing development or exiting and moving to another shoot. This injury causes dieback or flagging of these twigs. Larvae often damage two or three twigs before reaching maturity. These larvae can complete their development in less than a month.

Larvae of subsequent generations feed on fruit, when available, and twigs. As the twigs harden, the partially grown larvae leave them and enter the fruits to feed. Larvae commonly bore to the center of the fruit and feed around the pit. Larvae feeding on the fruit often causes it to drop. Young fruit often exude gum from the entrance and exit holes left by the larvae. Damaged fruit that remain on the tree are distorted. Occasionally, the larvae may tunnel into the fruit through the stem. In such instances, there may not be any apparent evidence of how the larvae entered the fruit after it was harvested.

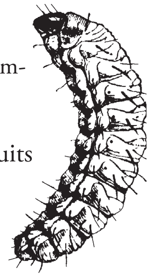
**Monitoring and Thresholds:** Pheromone traps are available for this insect to monitor moth activity and effectively time sprays. Traps are placed in the interior of the tree canopy at eye level or higher just before bloom. One trap per 10 acres is recommended for commercial orchards, with a minimum of two traps. Sprays for the first generation should be applied 6 days after peak flight, which coincides with peak egg laying. Examine trees regularly in the early spring for signs of wilted shoots. Examine wilted shoots carefully to determine if oriental fruit moth was the cause. Young trees with vigorous new growth are often very susceptible to this injury. Detection of early season shoot damage indicates the potential for fruit damage by later generations.

**Mating Disruption:** Some producers in Michigan and on the West Coast have successfully adopted mating disruption strategies for oriental fruit moth management in peaches. With mating disruption, pheromone dispensers are placed throughout the orchard. As the pheromone is released from the dispensers, male moths that normally use the pheromone to locate females become confused. This interferes with the mating process. Mating disruption is recommended only for orchards of 5 acres or larger. Mating disruption is expensive and does not eliminate the need for insecticide sprays to control other pests.

**Chemical Control:** Sprays for the first generation should be applied 6 days after peak flight. This often coincides with the time for plum curculio control. Sprays for the second and third generations need to be applied 3 days after peak flight. Depending on the anticipated harvest date for the fruit, sprays for the third generation may need to be adjusted or omitted in order to meet the necessary pre-harvest intervals (PHI) requirements for certain insecticides.

## Plum Curculio

(*Conotrahelus nenuphar*; order Coleoptera, family Curculionidae)

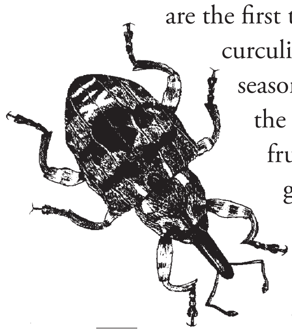


*plum curculio larva*

**Damage:** Plum curculio attacks stone fruits as well as apples and pears. Surface feeding and egg laying by the overwintering adults can scar or misshape the fruit by harvest, while feeding by the larvae causes premature drop of the fruit.

**Appearance:** The adult is a typical snout beetle, 1/4-inch long and dark brown with patches of white or gray. There are four prominent humps on the wing covers. The snout is one-quarter the length of the body, with mouth parts located at the end. The larva is a legless, grayish white grub with a brown head. Its length is about 1/3-inch when full grown.

**Life Cycle and Habits:** Plum curculio overwinters in the adult stage in ground litter or soil usually outside the orchard. Adults migrate into the orchards each spring, with border rows near woods often showing the initial injury. The first signs of damage typically coincide with the onset of 60°F nighttime temperatures. Eggs are laid on crescent-shaped flaps cut in the skin of young fruit. Often border rows near woods are the first to show injury. Fruits attacked by plum curculio will drop from the tree early in the season, along with unpollinated fruit. When the larvae are fully developed, they exit the fruit through clean-out holes, drop to the ground, and pupate 1 to 2 inches below ground. There is one generation per year.



*plum curculio adult*

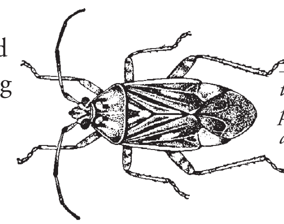
**Monitoring and Thresholds:** Currently there are no methods to accurately predict when plum curculio damage will occur. However, plum curculio pyramid traps are currently being tested in several midwestern states.

**Chemical Control:** Plum curculio is usually controlled with petal-fall and shuck-split sprays directed at the adult prior to egg laying. Considerable egg-laying damage can occur over a short period of time. Where plum curculio has been a problem in the past, use preventive sprays at petal fall and shuck-split to reduce damage. Cool weather during petal fall may delay the immigration of the adults into the orchard. Under these conditions, a first cover and possibly a second cover spray may be needed.

## Tarnished Plant Bug

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

**Damage:** Tarnished plant bug damages young peach buds, causing blossom drop and early fruit drop. After bloom, feeding by this insect causes cat-facing and increased fruit drop. Tarnished plant bug cat-facing is characterized by sunken corky areas on the surface of the fruit.

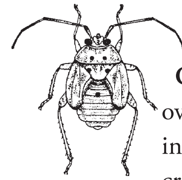


*tarnished plant bug adult*

**Appearance:** Adults are 1/4-inch long, mottled brown insects with wings folded over the abdomen. A yellow-tipped triangle is present in the middle of their backs. Nymphs are small and greenish and resemble the adult without wings. Both nymphs and adults have a beak used for sucking plant juices.

**Life Cycle and Habits:** Adult tarnished plant bugs overwinter under bark, in leaf litter, and other such protected places. The adult feeds on opening buds or flowers in early spring, and later on developing fruit. They lay eggs in the plant tissue of their many hosts. Nymphs emerge about 1 week later and feed for about 3 weeks before reaching adulthood. Several generations of this insect occur each year.

**Monitoring and Thresholds:** Pay particular attention to plant bugs when buds are in the pre-bloom stage. Adults are difficult to find and will fly when disturbed. They can be monitored with 6-by-8-inch, non-UV-reflecting, white sticky traps. Use one to two traps for every 5 acres. Hang traps in border rows near wooded areas. Treatment is recommended if an average of one tarnished plant bug per trap per week is captured.



*tarnished plant bug nymph*

**Cultural Control:** Tarnished plant bugs overwinter in, feed on, and may build up in number on groundcover plants. Cover crop management is important in preventing tarnished plant bugs from moving into fruit trees. Because tarnished plant bug is attracted to flowering broadleaf weeds, management of annual weeds through regular mowing is an important practice.

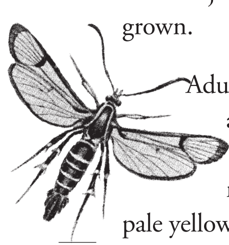
**Chemical Control:** Spray peaches at pink stage to reduce blossom drop. Sprays targeting tarnished plant bug at petal fall and shuck-split will reduce cat-facing injury to the fruit.

## Peachtree Borers

(order Lepidoptera, family Sesiidae)
Lesser Peachtree Borer (*Synanthedon pictipes*)
Peachtree Borer (*Synanthedon exitiosa*)

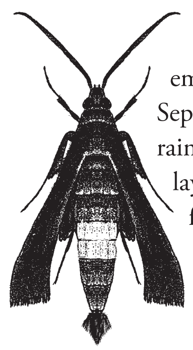
**Damage:** These borers attack the trunk and limbs of stone fruit trees, especially peaches. The peachtree borer is a pest of young trees, and a single borer can kill a tree. The lesser peachtree borer prefers to attack mature trees. Peachtree borer injury occurs a few inches above or below ground, and lesser peachtree borer injury may occur anywhere on the trunk or limbs where larvae can get under dead bark.

**Appearance:** Adult peachtree borers are moths that look more like wasps. The adult female has a dark blue-black body with an orange band on the abdomen, dark blue front wings, and clear hind wings. The male is blue-black, marked with narrow yellow bands on the abdomen, thorax, head, and legs; front wings and hind wings are clear, but the edges and veins are outlined with blue-black scales. The male is 3/4- to 1 1/4-inches, the transparent portions of his wings are tinted with yellow, and at least three to four narrow bands of yellow are usually visible on the abdomen. Eggs are small, oval, reddish brown, and hard. The larva is dull white with a brown head and three pairs of short jointed legs. Larvae are 1 1/4-inch when fully grown.



*male peachtree borer*

Adult male and female lesser peachtree borers are similar to each other in appearance and also look like wasps. Lesser peachtree borer moths are slender and dark blue with some pale yellow markings; both pairs of wings are clear, except for the edges and veins that have blue-black scales. Lesser peachtree borers resemble the male peachtree borer. Larvae of the lesser peachtree borer are similar to other clearwing borer larvae. They are about 1 inch when mature. The head is light brown and the body is creamy white, but some individuals may be pinkish.



*female peachtree borer*

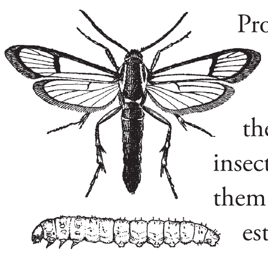
**Life Cycle and Habits:** The peachtree borer overwinters as larvae under the bark and resumes feeding and completes its larval stages in spring and early summer. When fully grown, the larva pupates under bark or in the soil near the tree base, then emerges as an adult. Adults start to emerge in mid-June; emergence peaks in midsummer and extends into September. Emergence is greater on days after a rain. Soon after adults emerge, the female moths lay eggs under bark scales or on rough bark. Each female lays about 400 eggs. Eggs hatch in 8 to 10 days into larvae that bore into the tree. It has only one generation per year.

Lesser peachtree borer overwinters as larvae underneath the bark. Larvae of all stages except the first may be found during the winter. The larvae feed for a period in the spring before burrowing just below the surface of the bark to pupate. Borers remain in the pupal stage from 18 to 30 days before emerging as adults. Female moths lay eggs in small clusters in cracks and crevices near wounds between ground level and 8 feet high. Females lay an average of 400 small oval, reddish brown eggs. Larvae begin to hatch in 8 to 10 days and burrow into the bark, often entering through cracks caused by other factors such as winter injury, pruning scars, or machinery wounds. Moths emerge from early May until late September. There are two generations a year, with adult emergence in May and June, then again in August and September.

**Monitoring and Thresholds:** While pruning in early spring, look for symptoms of borer. If symptoms are found, then an intensive control strategy is needed. To determine the most appropriate time to apply insecticide, a sticky trap or bucket trap baited with a pheromone lure can be used to monitor activity of peachtree borer or lesser peachtree borer. Traps for peachtree borer should be hung 3 feet from the ground and set up in late May. Traps for lesser peachtree borer should be hung 4 to 5 feet above ground and set up in late April. It is important to notice when emergence begins (when the first moth is trapped) and when emergence reaches a peak (when the number of moths trapped per week is highest).

The pheromone lure for each of these pests also can attract other similar clearwing borers such as the lilac-ash borer. Trapped moths thus should be examined carefully to be sure the correct species is being counted. If a trap for lesser peachtree borer is set up in the same planting as a trap for peachtree borer, the two traps should be separated by at least 60 feet to minimize trapping of nontarget species.

**Chemical Control:** Control needs to target small borer larvae before they bore into trees. Control may also be achieved by fumigant action of the insecticide, which can kill larvae already in trees at the time of application. An insecticide with long residual action gives the best control of peachtree borer.



*lesser peachtree borer*

Protection from peachtree borer is most critical during the first 3 to 5 years after planting. When new trees are planted, the roots and crowns should be dipped in insecticide before planting; this will protect them from borers during their first year. In established plantings, insecticide should be applied as a bark drench at a rate of 1/2 to 1 gallon of spray mix per tree. Thorough coverage is necessary. The insecticide should run down the trunk and soak the ground at the base of the tree. Any prunings, debris, or weeds at the base of trees should be removed so that they do not block the treatment. With lesser peachtree borer, an insecticide should be applied as a bark drench to the trunk and scaffold branches at a rate of at least 1/2 to 1 gallon of spray mix per tree.

The best time to treat and the number of insecticide applications needed for borer control depend on whether trees are known to be infested with these pests. One insecticide treatment is adequate in orchards where trees show some peachtree borer infestation; the best time to treat is at the time of peak adult flight, which is usually in early August. In orchards where borer injury is found on most trees, two treatments should be made: the first about 10 days after adults begin to emerge (late June) and the second at peak emergence about 6 weeks later (early August). In orchards where trees show signs of infestation by lesser peachtree borer, then an early application is needed to target the first generation in June, as well as an early-September application that targets the second generation. The first treatment should be applied 10 days after adults begin to emerge, which will probably be in mid-May.

## Cherry Fruit Flies

(order Diptera, family Tephritidae)
Cherry Fruit Fly (*Rhagoletis cingulata*)
Black Cherry Fruit Fly (*Rhagoletis fausta*)

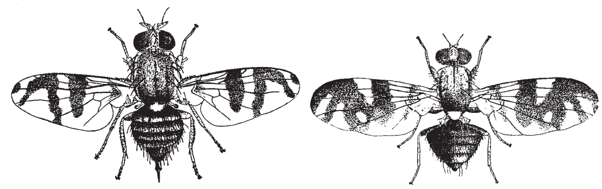
**Damage:** Cherry fruit fly maggots attack the fruit of sweet and sour cherries. Infested fruit often appear normal until the maggots are nearly fully grown. Damage appears as sunken, shriveled areas on the surface of the fruit. Fruit may be blemished by the egg-laying punctures made by the female near the bottom of the fruit.

**Appearance:** The adults are black flies with yellow heads and are somewhat smaller than a house fly. Between the base of the wings is a white- or cream-colored dot. The dark markings on the wings are used to distinguish the species. The abdomen of the black cherry fruit fly is entirely black, while the cherry fruit fly is marked with a series of white crossbands.

**Life History and Habits:** Cherry fruit flies spend 10 months of the year in the soil beneath the trees. Adults emerge from late May to early July and lay their eggs on the fruit. The black cherry fruit fly generally begins to emerge about 10 to 14 days earlier than the cherry fruit fly. There are usually 10 days between the fly emergence and egg laying. The eggs hatch in about a week, and the maggots feed for about 2 weeks before exiting the fruit and dropping to the ground. They pupate 1 to 2 inches beneath the soil surface. There is only one generation of each fly.

**Monitoring and Thresholds:** Monitor cherry fruit flies with yellow sticky cards hung in the trees in late May. Examine the wing bands to distinguish the species.

**Chemical Control:** Sprays need to target the adults *before* egg laying begins. Adults should be controlled 5 to 6 days after they emerge.

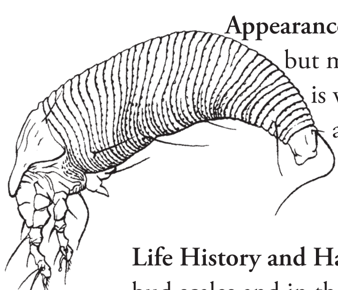


*black cherry fruit fly and cherry fruit fly*

## Peach Silver Mite

(*Aculus cornutus*; order Acari, family Eriophyidae)

**Damage:** Peach silver mite sucks sap and causes peach leaves to turn silver in appearance.



*peach silver mite*

**Appearance:** This is an extremely small mite but may be seen with a hand lens. It is whitish and somewhat triangular and may be found on both surfaces of the leaves, usually near the veins.

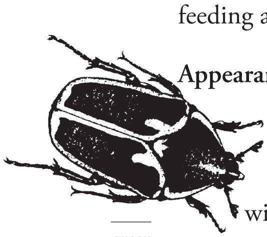
**Life History and Habits:** The adults hibernate under bud scales and in the bud axils. They become active in spring as the buds begin to open and foliage appears. Several generations are completed during the growing season.

**Chemical Control:** In general, sprays applied to control other mite species will control peach silver mite as well.

## Green June Beetle

(*Cotinis nitida*; order Coleoptera, family Scarabaeidae)

**Damage:** Because green June beetle is a direct feeder on peach fruit, a single adult can cause significant damage. Like the Japanese beetle, initial feeding by a few green June beetles often attracts additional beetles. These beetles can attack both green and ripening fruit, and their damage contributes to Japanese beetle fruit feeding activity.



*green June beetle*

**Appearance:** Green June beetles are 3/4- to 1-inch long and are emerald green except for a tan border on the sides of their wing covers. The grubs have stout, grayish to white bodies with brown heads. When mature, they are 1 1/2- to 2-inches long. Unlike other white grubs, green June beetle grubs are more straight-bodied and have the curious habit of crawling on their backs.

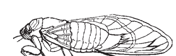
**Life History and Habits:** Green June beetle grubs feed more on compost, manure, or decomposing organic matter in the soil. However, they throw up mounds of soil, and their burrowing activity can disturb the root system of grasses. In October or November when soil temperatures begin to cool, the grubs cease feeding and move more deeply into the soil where they spend the winter. The following March they begin migrating back to the sod zone where they continue to feed. They stop feeding in late May and move back down into the soil to transform into adult beetles. Green June beetle adults emerge in early July and are usually obvious as they feed on trees, shrubs, and flowers of many plants. Eggs are laid in soil with decaying vegetation.

**Monitoring and Thresholds:** There are few threshold guidelines relative to when peaches need to be treated for green June beetle. However, the first colonizers in early July will attract others into the orchard, so early control can reduce later infestations.

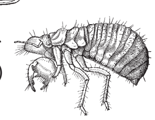
**Chemical Control:** Carbaryl is the most effective insecticide used in managing green June beetle. Repeated insecticide applications may be necessary at 7- to10-day intervals to prevent reinfestation during the adult flight period, or after heavy rains. Use of a spreader/sticker in the spray mix can increase the duration of effectiveness.

## Periodical Cicada

(See *Periodical Cicada* in *Apple and Pear Pests and Their Management* Section in Chapter 1)



*periodical cicada adult*



*periodical cicada nymph*

## San Jose Scale

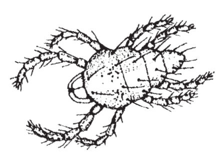
(See *San Jose Scale* in *Apple and Pear Pests and Their Management* Section in Chapter 1)

*San Jose scale*

## European Red Mite

(See *European Red Mite* in *Apple and Pear Pests and Their Management* Section in Chapter 1)

*European red mite female*



*European red mite male*

# Summary of Stone Fruit Pest Management Procedures

**Cultural controls when establishing a new orchard:**
- Choose a planting site with suitable soil and good water drainage.
- Purchase certified virus-free stock from a reputable nursery.
- Remove alternate hosts for plum curculio and black knot.

**Controls while maintaining an orchard:**
- Prune trees to ensure adequate spray coverage in all parts of the trees.
- Provide adequate but not excessive nitrogen fertilizer, especially to bacterial spot-susceptible cultivars.
- Mow orchard groundcover regularly to discourage tarnished plant bug.

**Monitoring for pests:**
*Insect traps*
- Hang pheromone traps for oriental fruit moth in trees prior to bloom and examine twice a week.
- Hang white, rectangular sticky cards for tarnished plants bugs prior to bloom.
- Hang pheromone traps for peachtree borer by late May and lesser peachtree borer by late April.

*Scouting*
- Pruning: look for scale injury to new wood and borer damage to trunk and limbs.
- Pink through second cover: look for plant bugs.
- Petal fall through second cover: look for plum curculio initial damage.
- Early June: begin looking for European red mite.
- Late June: begin looking for green June beetle.
- Harvest: evaluate for plum curculio, oriental fruit moth, and plant bug injury in order to help plan next year's management strategy.

**Applying insecticides and miticides:**
- Use a delayed dormant oil application to control European red mite and San Jose scale.
- Treat for peach leaf curl (or plum pockets) while trees are dormant.
- Avoid using products known to be highly toxic to predatory mites or predaceous insects.

**Consider using mating disruption for oriental fruit moth management.**

**Peach Orchard Management Calendar**

| | Pre-season | Dormant | Pink | Full bloom | Petal fall | Shuck-split | First cover | Second cover | Third cover | Summer cover | July | August | Pre-harvest | Harvest | September | October | November |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Check Trees, Put out Vole Bait | X | | | | | | | | | | | | | | | X | X |
| Dormant Pruning, Brush Removal | X | X | X | X | | | | | | | | | | | | | |
| Fertilization | X | | | | | X | X | | | | | | | | | | |
| Plant Trees | X | X | | | | | | | | | | | | | | | X |
| Pre-emergence Herbicides | X | X | | | | | | | | | | | | | | | |
| Phytophthora Root Crown and Collar Rots | | X | | | | | X | | | | X | | | | X | | |
| Cut Buds, Estimate Crop | | X | | | | | | | | | | | | | | | |
| Mites | | X | | | | X | X | X | X | X | X | X | X | | | | |
| Peach Leaf Curl | | X | | | | | | | | | | | | | | | X |
| Frost Protection | | | X | X | X | X | | | | | | | | | | | X |
| Brown Rot | | | X | X | X | X | X | X | X | X | X | X | X | | | | |
| Tarnished Plant Bug and Stink Bug | | | X | | X | X | | | | | | | | | | | |
| Oriental Fruit Moth | | | ● | | X | X | X | X | X | X | X | X | X | | | | |
| Plum Curculio | | | | | X | X | X | X | | | | | | | | | |
| Scab | | | ● | | | X | X | X | X | X | | | | | | | |
| Powdery Mildew | | | | | | X | X | X | X | X | | | | | | | |
| Bacterial Spot | | | | | | X | X | X | X | X | | | | | | | |
| Post-emergence Herbicides | | | | | | | | X | X | X | X | X | X | X | | | |
| Irrigation | | | | | | | | X | X | X | X | X | X | X | X | X | X |
| Fruit Thinning | | | | | | | | | X | X | | | | | | | |
| Peachtree Borer | | | | | | | ● | | | X | | | | | | | |
| Lesser Peachtree Borer | | | | | ● | | | | X | X | | X | | | | | |
| Foliar Analysis | | | | | | | | | | | X | | | | | | |
| Summer Pruning | | | | | | | | | | | X | | | | | | |
| Japanese Beetle | | | | | | | | | | | | | X | | | | |
| Green June Beetle | | | | | | | | | | | | | X | | | | |
| Fill in Ruts and Depressions | | | | | | | | | | | | | | | | X | X |

● Put pheromone traps in place or begin taking environmental data for pest prediction.

CHAPTER 3

# Weed Management

Young trees grow best with clean culture under the tree spread. Older trees grow and bear well in grass and sod. When present, grass should be mowed, and weeds should not be allowed to grow up through the trees. Care should be taken not to injure trees during mowing operations.

Mulches, applied 2 to 4 inches thick, control weeds effectively. Before choosing a mulch, consider availability, cost, and rodent protection. Mice can hide undetected in mulch; therefore, tree guards are a must. Mulches that are applied once during the growing season cut down on weeds significantly and conserve moisture.

## Site Preparation

Site preparation should begin several years before planting to allow time for:

- Increasing soil organic matter by growing and incorporating "green manure" cover crops,
- Adjusting soil pH and nutrients for optimum tree growth,
- Eliminating problem perennial weeds and suppressing annual weeds, and
- Establishing permanent sod cover on ground subject to erosion.

Herbicides are chemicals that are used to control weeds. Several herbicides can be used during site preparation and may be classified by method of application and mode of action.

**Preplant foliar, contact**—These herbicides are applied to growing plants, and they damage or kill tissue on contact. An example is paraquat. Preplant foliar contact herbicides kill annual weeds and kill or injure biennial and perennial weeds. This type of herbicide is not translocated within the plant and is most effective against young weed plants.

**Preplant foliar, systemic**—These herbicides are applied to growing plants and are absorbed and translocated within the plant. Examples include 2,4-D and glyphosate. Preplant foliar systemic herbicides are effective against both annual and perennial weeds.

The site preparation period is an important time for management of weeds, particularly perennial weeds. Several herbicides are either dangerous to use near fruit plants or are not labeled for use with fruits. Thus, the only period when these chemicals can be used is during site preparation when the fruit crop is not present. Remember that the herbicide label is the final authority concerning legal and safe usage.

Mechanical weed control includes the manipulation of the soil to destroy weed growth. During the site-preparation process, mechanical control is often the initial phase. The mechanical movement of the soil is useful not only for weed management but also for incorporation of nutrients and organic materials. Keep in mind that disturbance of the soil surface can lead to soil erosion.

## Deep Plowing

*A moldboard or disc plow is used to completely invert the soil.*

### Advantages

- Destroys annual and biennial weeds.
- Inflicts damage to the root systems of perennial weeds.
- Brings the root systems of perennial weeds close to the soil surface, where they can be destroyed by desiccation or freezing.

### Disadvantages

- Brings additional weed seeds to the soil surface, where they may germinate and cause additional problems if not managed.
- May have adverse effects on soil structure and soil fauna.

## Chisel Plowing

*A chisel plow is used to break the soil.*

### Advantages

- Action of the chisel plow can result in deeper freezing into the soil and destruction of perennial root systems.
- Perennial root systems are dragged to the soil surface, where they can be destroyed by desiccation or freezing.
- Chisel plowing results in less disturbance of the soil compared to deep plowing, reducing the risk of erosion and the movement of weed seeds to the surface.

## Mechanical Cultivation

*Movement of the soil by discs, tillers, harrows, rotary hoes, or other implements. Disturbance of the soil is shallow.*

### Advantages

- Effective for control of annual and biennial weeds.
- Shallow soil disturbance minimizes the number of weed seeds brought to the surface.
- Inflicts damage on the root systems of perennial weeds.

### Disadvantages

- Not effective for control of certain perennial weeds.

# Preplant Cover Crops

Tillage by plowing, discing, and rotovation may be needed to kill weeds and existing sod to prepare the ground for cover crops. Based on soil test results, ground should be amended to proper pH, phosphorus, potassium, and other nutrient levels required for tree fruit production. Prior to seeding, 40 to 50 lb of actual nitrogen per acre is needed to establish the crop and to promote rapid breakdown after incorporation.

Seeding rates are adjusted according to need, lower for soil erosion control and higher for weed suppression and maximum organic matter addition. A grass or grain drill with press wheels is the preferred method for seeding crops. Broadcast seeding followed by rolling or cultipacking is acceptable when a drill is not available. Depending on the crop, plowing, discing, rototilling, or a combination of these may be required to incorporate "green manure" into the soil.

Where enough time is allowed before planting the orchard, several successive cover crops can be planted. Winter annual grains (barley, oats, rye, wheat) are seeded in late summer through early fall depending on region and incorporated the following spring. Summer covers (spring oats, buckwheat, sorghum-sudangrass, Japanese millet, annual ryegrass) are seeded in spring or early summer, grown, and then incorporated later in the season. Legumes (alfalfa, clovers, and vetch) are alternative covers that add nitrogen to the soil. Typically, they are seeded early or late in the growing season.

After a year or two of cover cropping, permanent sod can be established for the orchard, particularly on ground subject to erosion. Trees can then be planted into tilled or herbicide-"killed sod" strips. The advantage of this compared to full-field cultivation is the minimal disturbance to the soil, which reduces weed seed germination and soil erosion. However, growers should be aware that permanent sod could be very competitive with young trees and manage it accordingly.

**Alfalfa** is a perennial legume that requires a well-drained soil with a high pH (6.0 to 7.0). The most desirable periods for planting are early April to late May or late July to mid-August. The recommended seeding rate is 145 lb per acre. Alfalfa grows tall enough to become difficult to incorporate if allowed to overwinter from a spring seeding. The cost of alfalfa seed is much greater than the cost of clover seed. It is recommended that alfalfa seed be inoculated when seeded on an area for the first time.

**Buckwheat** can be seeded successfully on sites with low soil pH. While there is fast growth of the top portion of this grain, there is little organic matter contribution from the roots. The plants should not be allowed to mature, since reseeding will readily occur. Early seedings in late May or early June are better than summer seedings in late July. Buckwheat may be seeded at 60 lb per acre.

**Alsike**, **ladino**, and **white clovers** have low to moderately upright growth and tend to establish a good legume stand in about 10 weeks. Alsike clover, a very short-lived perennial, can be established on low pH soils. Ladino and other common white clovers respond to high soil fertility (notably phosphorus) and high soil pH. All of these clovers are fair to moderately good nitrogen-producing crops. They establish best when seeded in early April to late May or from late July to mid-August. Early seedings in either season are more successful. A late fall or late winter broadcast application to open ground may be another effective method of seeding these crops, depending on the soil-seed contact that follows.

The cost of seed varies with the type of clover; common white clover and alsike clover are cheaper than ladino. The cost of seed per acre is low for clover preplant cover crops, since the recommended seeding rate is only 4 lb per acre of alsike and common white clover and 2 lb per acre for ladino. Volunteer clovers grow naturally in most fields, so it may not be necessary to inoculate clover seed; however, several pounds of seed can be treated with inoculant for only a few dollars.

**Red clover** produces a top growth of 12 to 18 inches and establishes relatively quickly, depending on soil moisture and seed bed conditions. Red clover grows best in soils with a pH of 5.6 or higher. Like other clovers, red clover should be seeded early in April or late May or from late July to mid-August. Early seedings in either season are more successful. As with white clovers, a late fall or late winter broadcast application on open, unfrozen soil may produce a successful seeding. Red clover is a good nitrogen-producing crop and is adapted to a broader range of soil conditions than alfalfa. The seeding rate for red clover is 8 lb per acre.

**Sweet clover** is a slow- to moderately fast-establishing biennial legume that responds better to higher soil pH than other clovers. It also responds well to soils with good phosphorus levels and is most easily established when seeded from early April to mid-May or during the first half of August. Large, deeply penetrating roots and heavy top growth make large contributions of nitrogen and organic matter to the soil when incorporated. Second-year top growth may exceed 50 inches. However, this growth must be cut at a lower height and incorporated after cutting. The seeding rate is 12 lb per acre.

**Hairy vetch** is adapted to a range of soil conditions and is a moderately fast-growing winter annual when seeded in August or very early September. In the Northeast, the best practice to ensure good growth is early establishment. This vetch can supply much nitrogen to the soil when grown under ideal conditions. In the mid-Atlantic states, hairy vetch can provide up to 125 lb of nitrogen for the next crop. Hairy vetch is a true vetch with purple flowers and viney growth, and it should not be confused with another legume known as crown vetch, which is commonly seeded along highways for bank stabilization. Hairy vetch is seeded at a rate of 40 lb per acre.

Annual **field brome** is a fast-establishing winter annual grass and has a much more extensive and fibrous root system than most other green manure crops. Seedings made during July and August tend to be much more successful than seedings made in late spring. The following year's spring growth is rapid and, after the seeds ripen in July, the crop can be easily reestablished with no further seeding. Since this is not desirable with a preplant cover crop, thoroughly disc or plow down the heavy root system early in the spring. This seed is not readily available, so plans for obtaining it should be made well in advance of the seeding date. Annual field brome is usually seeded at a rate of 20 lb per acre.

**Japanese millet** is a fast-growing summer annual, which competes well with weeds and establishes faster on cooler soils than sudangrass. If planted between late May and mid-July, millet will grow 4 feet high in 7 to 8 weeks. Unlike small-seeded legumes and grasses, the large millet seed should be covered from 3/10- to 1-inch deep in a firm seedbed. The planting may be cut back and allowed to regrow at any time after reaching 20 inches of growth. Millet should not be allowed to mature and drop seed. Millet seed is relatively inexpensive; seed at a rate of 20 lb per acre.

**Spring oats**, when used as a very early spring green manure crop, should be planted in early to mid-April. Because of the fast spring growth, plan to incorporate the planting in early to mid-June. Oats will grow on soils of relatively low soil pH (5.5) and with moderately good fertility; however, this crop requires good soil drainage. A mid-August seeding will provide good growth and groundcover for protection against soil erosion during the fall and winter months. Oats will be gradually killed back by successive frosts and will not grow again in the spring. The dead plant residue is easily incorporated with very light tillage equipment. Three bushels of oats (approximately 100 lb) are usually seeded per acre.

**Annual ryegrass** seedlings establish very rapidly in spring or late summer. Ideal dates for spring seedings range from early April to early June; late-summer seedings are more successful when made from early August to early September. Heavy root growth and rapid seedling development make annual ryegrass a very desirable green manure cover crop in areas where good soil-water relations can be maintained. Ryegrass will die out early in the second year, leaving a heavy root system and a moderate top growth residue to incorporate into the soil. A seeding rate of 10 lb per acre is suggested.

**Perennial ryegrass** seedings become established more quickly than seedings of other common perennial grasses such as timothy, bromegrass, and orchardgrass. The fibrous root system is extensive and, with the vigorous top growth, provides substantial material for incorporation into the soil in early spring. The dry matter root growth of perennial ryegrass is approximately equal to the top growth. For many other crops, the top growth represents 60 to 70 percent of the material turned under at plowing. A seeding rate of 25 lb per acre is recommended.

**Winter rye**, a cereal grain, establishes quickly from late summer and early fall seedings. However, fall seedings made after October 1 are likely to provide only winter cover and are slower to produce heavy spring growth. Excessive early spring top growth can create tillage problems if the crop is not incorporated by early to mid-May. This date will vary with the location and season. The seed is readily available and is usually sold in bushel quantities of 56 lb. Use a seeding rate of 2 bushels per acre to establish.

**Sudangrass** is a summer annual that requires much heat for good growth. Seedings made in late May or early June will guarantee a more vigorous growth than seedings made in late June or early July. Hybrid sudangrasses may have larger seeds and should be planted at heavy rates. Like millet and sorghum-sudan hybrids, which also have large seeds, sudangrass should be seeded to a depth of 1/2- to 1-inch into a firm seedbed. Similarly, this summer annual will recover after being cut. Due to its tall growth habit, sudangrass should be cut back when growth exceeds 20 to 25 inches or plowed down if a second growth is not desired. Use a seeding rate of 80 lb per acre.

**Sorghum-sudangrass** hybrids require more heat for growth than sudangrass. It is more expensive to establish and fails to adapt to most soils as readily as Japanese millet. This crop will grow to a greater height than sudangrass under ideal conditions of heat, moisture, and fertility, but the 4- to 6-foot growth is very difficult to incorporate with small or moderately sized tillage equipment. Like sudangrass, this crop will make a second growth if climatic conditions permit. Growth will cease by mid-September if night temperatures drop to near freezing. The seeding rate will vary from 35 to 50 lb per acre, depending on seed size.

This section courtesy of W. Lord, I. Merwin, and J. Mitchell, *Bramble Production Guide*, NRAES publication #35.

# Common Orchard Weeds

## Annual Grasses

An inclusive term for several of the grassy weeds such as crabgrass, goosegrass, barnyard grass, fall panicum, giant foxtail, etc., which can be a problem because they grow tall, up to 4 feet, and require frequent mowing. They can interfere with spraying and harvest operations. All are annuals, reproducing from seed, and most are controlled with pre-emergent herbicides, or post-emergence grass control materials.

## Perennial Grasses

These grasses live over from year to year. They spread by seed and by vegetative means. Examples are Johnsongrass, orchardgrass, and quackgrass. The systemic-type post-emergence herbicides such as Poast, Fusilade, and Roundup are effective for control but may require repeat applications for complete eradication. After killing the grass, a residual pre-emergence herbicide can retard new infestations. The combination of Gramoxone Extra plus Princep or other residual herbicide also can be effective in killing perennial grasses.

## Annual Broadleaf Weeds

An inclusive term for many of the annual broadleaf weeds commonly found in orchards. Included are pigweed, prostrate pigweed, purslane, lambsquarter, etc. Most are reproduced only by seed, but some, such as purslane, can reproduce vegetatively. Most are readily controlled by the appropriate pre-emergence herbicides or by post-emergence broadleaf weed control materials.

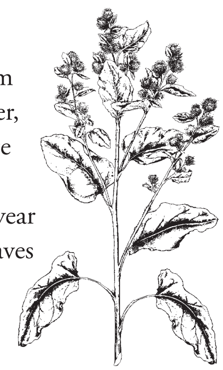
## Perennial Broadleaf Weeds

These pests persist for many years. Poison ivy, Canada thistle, climbing milkweed, and others are difficult to control and require repeated timely spot applications of a systemic post-emergence herbicide. Where severe problems have occurred, some growers have returned to grass cover under the trees and use a swing-arm mower for vegetation control.

### Bindweed, Field and Hedge

Perennial weeds, reproducing from seed and from spreading roots, which can be very large. Field bindweed has a deep root system, while hedge bindweed has more shallow-growing, fleshy roots. Plant is a branched vine, spreading over the ground or over small trees or other plants in the orchard. Leaves are arrow-head-shaped and 2 to 3 inches long. Flowers are white or pink, resembling morning glory. Very difficult to control because of the extensive root system.

### Burdock

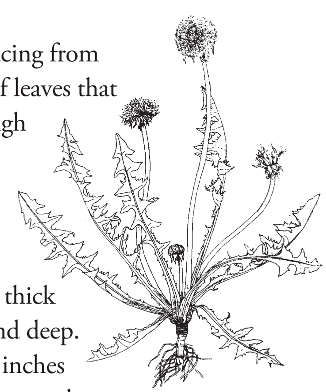


A biennial weed reproducing from seed. Taproot lives over one winter, flowers, and dies. Plant is a rosette the first year and develops an upright branched plant the second year that can reach 3 to 5 feet tall. Leaves are large, hairy, and roughly heart-shaped. Burs are about 1/2-inch in diameter and have hooked spines that readily catch on clothing and are thus spread.

### Canada Thistle

A very serious perennial weed reproducing both from seeds and from horizontal roots. Plants are vigorous and 2 to 4 feet tall. Leaves are large, with crinkled, spiny edges. Flowers are borne at the tops of plants and are purple or lavender. Seeds in flower heads have whitish down attached, and when mature the seeds are distributed by wind. A very persistent weed, it is considered legally noxious in most states. Control in orchards is primarily with post-emergence systemic herbicides such as Roundup before weeds flower.

### Dandelion



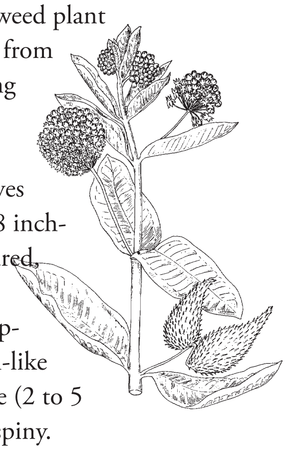
Perennial weed reproducing from seed. Plant is a rosette of leaves that can be 8 to 12 inches high and 6 to 15 inches in diameter. Leaves are 3 to 10 inches long and 1 to 2 inches wide, variously lobed. Root is thick and fleshy, branched, and deep. Flower heads are 1 to 2 inches in diameter, bright yellow, and upon maturing bear seed with down attached. Seeds detach readily and are wind disseminated. Spring flush of dandelion bloom coincides with apple bloom and can compete for bee activity during the pollination period. Since 2,4-D is no longer registered for apple orchards, close mowing just before and during apple bloom is the only current method of minimizing this competition.

## Horsenettle

Perennial broadleaf weed propagated by seed or roots. Weed grows 1 to 3 feet tall, usually branched, has many small spines or prickles. Leaves are oblong, lobed, 2 to 4 inches long. Fruit is round and yellow when mature. Difficult to control because of extensive, deep root system.

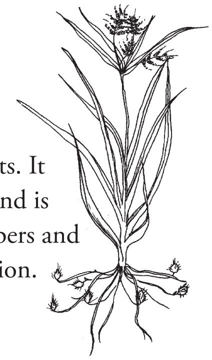
## Milkweed, Climbing

A perennial climbing plant that is reproduced by seeds and by spreading roots. Stem is climbing and can be a problem both in young and bearing orchards. Stems can cause girdling in young trees. Distinguished by small whitish flowers and by a large seed pod that resembles the common milkweed pod, except that it is smooth. This is a difficult weed to control.



## Milkweed, Common

The easily recognized milkweed plant is a perennial, reproducing from seed or from long, spreading roots. Stems are erect and become woody, reaching 3 to 4 feet, unbranched. Leaves are oblong and large, 4 to 8 inches long. When plant is injured, it exudes a milky juice. Flowers are borne on the upper part of the plant in ball-like clusters. Seed pods are large (2 to 5 inches long), pointed and spiny.

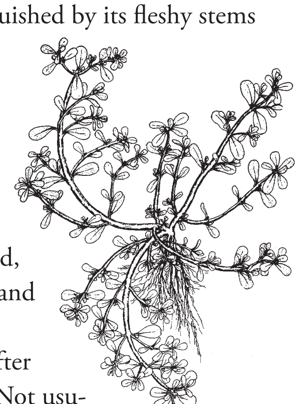


## Nutsedge, Yellow

A grasslike plant growing to about 1 foot tall, with large, branched inflorescence; it reproduces from seed or from small nutlike tubers on the roots. It can be a problem weed in orchards and is difficult to control because of the tubers and the problem of spreading by cultivation.

## Poison Ivy

A woody perennial weed frequently found in orchards. Reproduces by seed, which may be spread by birds and by creeping stems that can spread some distance in a season. Plant is either an upright shrubby plant 2 to 3 feet high or, more commonly, a vine that climbs on trees and fences. Plants are distinguished by the three shiny leaflets on each leaf. Leaflet edges are smooth to roughly toothed and can be variable in shape. Flowers are small and insignificant, fruits are small (1/8-inch in diameter), round, and waxy white in color. Plants may be spread through birds eating the fruit and spreading the seed in their droppings. Leaves develop attractive autumn coloration of reds and orange. Plant contains poisonous oils that can produce a serious rash on contact or by being in the smoke of burning plants. A very troublesome weed to control in orchards, but control is important because of the hazard to persons pruning or harvesting

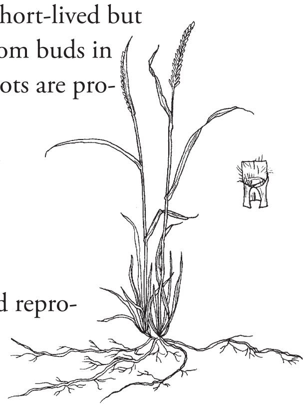


## Purslane

Low-growing weed distinguished by its fleshy stems and leaves that break off easily. Leaves and stems sometimes are reddish. Root system is shallow. An annual weed reproducing by seed, but can reproduce vegetatively when cultivated, as plants tend to break up and spread farther. Not readily controlled by cultivation after the plants are established. Not usually a major problem in orchards, but can be troublesome in small fruit plantings.

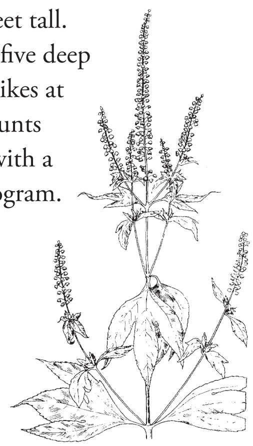
## Quackgrass

Perennial grass 1 to 3 feet tall found in most orchard situations. Reproduces by seeds and underground rhizomes. Rhizomes are short-lived but produce new rhizomes from buds in the axils of leaf scales. Roots are produced only at the nodes. Can be a persistent weed.



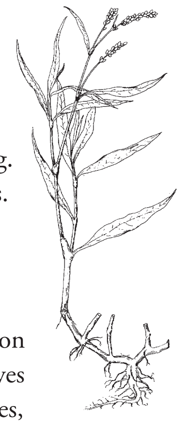
## Ragweed, Giant (Horseweed)

An annual broadleaf weed reproducing from seed that has a strong vigorous stem that under fertile conditions can grow 8 to 15 feet tall. Leaves are large, with three to five deep lobes. Male flowers on long spikes at tips of stems release large amounts of pollen. Readily controlled with a good herbicide or mowing program.



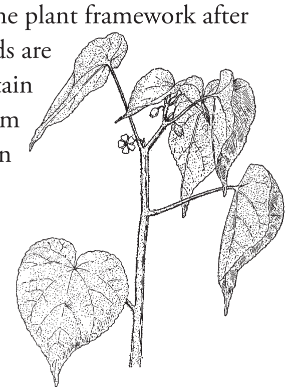
## Smartweed, Pennsylvania

Annual weed, reproducing by seed, fast growing, branching, reaching 1 to 4 feet in height. Leaves are lanceolate, smooth, 2 to 6 inches long. Stems are topped by pink floral heads. Reproduced by seeds.



## Velvetleaf (Buttonweed)

Annual weed growing 3 to 8 feet tall on sturdy, woody, light green stems. Leaves are large, heart-shaped on long petioles, and covered with velvety pubescence. Seed pods are prominent, persisting on the plant framework after leaves have fallen. Seed pods are upright, cup-like, and contain many seeds. More a problem in small fruit plantings than in well-managed orchards.



CHAPTER 4

# Wildlife Management

## Mice and Voles

These rodents damage young and bearing trees alike by eating the bark off the trunk and roots at and just below the ground line.

**Controls:** Control of ground vegetation immediately around trees is of prime importance in the control of voles. A 4-foot radius around the tree should be kept bare to eliminate cover for the animals. Frequent close mowing of the orchard groundcover helps considerably in reducing vole populations. Flail or rotary mowers help reduce the thatch layer that provides cover for the voles. Tree guards of hardware cloth with no larger than 1/4-inch mesh can be effective if they extend several inches above and below the ground line. Thiram is an effective repellent sprayed on the trunk in the dormant season. It will not be effective on pine voles that work largely underground. It is necessary to use a toxicant in northern areas where there is snow cover. Heavy snow compounds vole problems. A discussion of mouse or vole control by use of baits is found in the current spray guide.

## Rabbits

Rabbits damage young trees by eating the bark. In areas where heavy snows occur, damage can extend as far up into the tree as snowdrifts occur, sometimes stripping entire scaffold areas.

**Controls:** Mechanical guards are the most positive protection. Use an 18-inch square piece of hardware cloth bent into a cylinder around the trunk, or plastic guards are available from orchard supply houses. The spiral guards must be regularly readjusted to prevent girdling trees. Thiram is an effective but expensive rabbit control on young trees. Thiram can be applied only in the dormant season. Read and follow label instructions. Removal of habitat favorable to rabbits adjacent to orchards will do much to reduce the rabbit population. Keeping fencerows and herbicide strips clean and the orchard mowed will help. In extreme conditions, hunting and trapping rabbits can help to reduce the population. Your wildlife specialist has plans for a box trap for small game.

## Deer

Deer have become an increasingly serious problem in midwestern orchards, and populations have doubled in the last 10 years. Deer damage includes dormant season feeding on buds and young twigs of fruit trees, with apples the preferred forage. In the dormant season, bucks also damage trees by "rutting," or rubbing antlers on young trees. During the growing season, deer browse on foliage, buds, young shoots, and fruit. Heavy deer pressure can seriously interfere with growth and training of fruit trees.

**Controls:** Repellents can provide some relief from deer damage, although the effect of repellents is usually temporary and works best when the deer population is not high. Repellents seldom provide complete protection from deer damage and in most cases only slow down the damage. Repellents vary in weather resistance, but most must be reapplied after heavy rains. Repeated applications of repellent materials can be very expensive. In areas and times when deer pressure is intense, repellents do not usually offer satisfactory protection. Repellents are classified as area or contact materials. Area repellents are applied next to trees and usually repel by smell alone. Examples of area repellents include Hinder (ammonia soaps of higher fatty acids), human hair, soap, and blood meal. Contact repellents are applied directly to the trees and repel by creating an unpleasant taste. Examples of contact repellents include Big Game Repellent (BGR), Deer-Away (putrescent egg solids), Miller Hot Sauce (capsaicin, an extract of hot peppers), Gustafson 42-S, and Chaperone (Thiram). A study at Pennsylvania

State University indicated that under semi-field testing Hinder and Deer-Away were very good. Gustafson 42-S Thiram Repellent at the 42 percent concentration is one of the most effective repellents, reducing damage 80 to 90 percent. This material needs to be used with a sticker such as Roplex.

Midwestern growers have found motel-size soap to be effective for a limited time. The time period appears to be extended if the wrapper is left on the soap. Soap bars are attached to each tree by wires or by placing bars in plastic apple bags and attaching the bags to the tree with a pinch-type clothespin. In either method, the soap must not drip down the trunk since rabbits like the taste of soap and are more likely to damage the trunks of soap-covered young trees.

Eight-foot deer fences are effective, but not really practical for orchards because of their expense. Where deer populations are high and hunting is not a viable option, one of the most cost-effective techniques that provide excellent control is the use of a permanent electrified deer fence. New Zealand electric fences using hi-tensile poly tape work well. Poly tape can be found in white and orange, with orange being the preferred color. One strand of poly tape placed at a height of 32 inches is recommended, and effectiveness is improved by attaching strips of tin to the poly tape and baiting these with peanut butter. The figure-four fence and the Penn State S-wire electric fence are more effective where deer pressure is very high. Plans for these fences can be obtained from your state wildlife biologist or your horticultural specialist.

Controlled hunting has been the most cost-effective means of reducing populations over a period of years. For hunting to effectively control deer populations, does must be removed annually. Special-permit, antlerless deer hunts can be arranged during the regular hunting season. Removing only bucks will not solve the problem since each doe produces two fawns a season. Contact your state wildlife biologist for more information. Laws vary considerably from one state to another.

## Groundhogs and Woodchucks

These pests are occasionally a problem in orchards since they dig burrows in the ground and create dangerous holes and mounds in the area. Woodchucks can be trapped in the spring using box traps. They can also be gassed using USDA gas cartridges, which are usually available from your county agent or farm advisor. All entrances to the burrow must be sealed for gassing to be effective. Springtime treatment is more effective because the young leave the den in midsummer.

## Birds

Birds destroy cherries by feeding, and they damage apples and peaches by pecking the ripening fruit. Noisemakers and avian alarm calls can be effective for a while and may serve during a harvest season. Under extreme conditions, trapping can be done. Contact your state wildlife biologist. Shooting many bird species carries a hefty fine.

CHAPTER 5

# Pesticide Management

## Pesticide Safety

**Toxicity of Pesticides:** All pesticides must be toxic, or poisonous, to kill the pests they are intended to control. Because pesticides are toxic, they are potentially hazardous to humans and animals as well. Since pesticide toxicity varies widely, persons who use pesticides must have a general knowledge of the relative toxicity of the products being used.

The toxicity of a particular pesticide is determined by subjecting test animals (usually rats, mice, rabbits, and dogs) to different dosages of the active ingredient in a pesticide product. The active ingredient is the toxic portion of the pesticide formulation.

The toxicity of each active ingredient is determined by at least two methods: oral toxicity, by feeding the chemical to test animals; and dermal toxicity, by exposing the skin to the chemical and measuring its absorption through the skin into the bloodstream. Toxicity is usually expressed at $LD_{50}$ (lethal dose 50), or the dose that kills 50 percent of the test animals.

All pesticide labels have important signal words. Highly toxic pesticides have the words "DANGER-POISON" on the label plus skull and crossbones. Moderately toxic pesticides have the word "WARNING" on the label, while the least toxic materials have the signal word "CAUTION." Table 9 shows the toxicity ratings and the amounts of pesticide that could be injurious or lethal to people. All products bear the statement "KEEP OUT OF REACH OF CHILDREN."

## Pesticide Applicator Certification

The EPA has designated a number of fruit pesticides as "Restricted-Use Pesticides." Growers who wish to use these restricted materials must be certified as private applicators. A fruit grower can be certified as a private applicator by attending training sessions conducted by the Cooperative Extension Service in each state. Applicators must learn and understand labels and labeling; safety factors, including employee safety; potential environmental concerns; identification of common pests encountered; pesticides and their usage; proper equipment use; application techniques; and applicable state and federal regulations. County staff members usually conduct these training meetings. A test usually may be taken in place of the training. Contact your county Extension office for information.

**Re-entry times:** All pesticide labels specify the minimum re-entry interval (REI) after application. Workers not wearing protective clothing are restricted from entering sprayed fields until the longest re-entry time of the pesticides that were applied has expired. Check the "Agricultural Use Requirements" section of the pesticide label for the minimum re-entry time.

**Table 9. Oral, dermal, and inhalation toxicity ratings of pesticides.**

| Toxicity rating | Signal words | Oral $LD_{50}$ (mg/kg) | Dermal $LD_{50}$ (mg/kg) | Lethal oral dose, 150-pound person |
|---|---|---|---|---|
| High | Danger-Poison (skull and crossbones) | 0-50 | 0-200 | few drops to 1 teaspoon |
| Moderate | Warning | 50-500 | 200-2,000 | 1 teaspoon to 1 ounce (2 tablespoons) |
| Low | Caution | 500-5,000 | 2,000-20,000 | 1 ounce to 1 pint, or 2 pounds |
| Very low | Caution | 5,000+ | 20,000+ | 1 pint or more, or 2 pounds or more |

## Safe Storage of Pesticides

- Store pesticides in a clean, cool, dry, well- ventilated building. Keep the building locked so children, untrained persons, and animals cannot come in contact with the pesticides. Mark the storage facility with an appropriate warning sign.
- The area should be equipped with absorbent materials such as absorbent clay, sawdust, paper, or kitty litter. Other dedicated equipment should include a fire extinguisher (ABC rated), a shovel, broom, dustpan, detergent, hand cleaner, and water.
- Never store herbicides with other pesticides; the danger of cross-contamination is too great.
- Do not store pesticides where food, water, feed, seeds, fertilizers, or pesticide safety equipment (such as respirators) can become contaminated.
- Emulsifiable material should not be subjected to freezing temperatures. Freezing temperatures will destroy the emulsion, resulting in loss of effectiveness, and may cause serious plant injury.
- Check containers frequently for leaks and breaks.
- Clean up spilled chemicals promptly and properly. If the spill is large enough, inform your state and local emergency response office. Dispose of broken or damaged containers and any pesticide waste in an approved and safe manner.
- Keep an inventory of all chemicals. Mark each container with the year of purchase. Do not remove labels.
- Inform your local fire department and emergency response office of any agricultural chemicals (including fertilizers) stored in large quantity. Conform with federal and state regulations concerning reportable quantities of hazardous materials.
- Store all pesticides in their original containers.
- READ THE LABEL for specific storage instructions and precautions.

## Safe Pesticide Use

- READ THE LABEL BEFORE USING PESTICIDES. *Use pesticides only when necessary and only at the recommended dosages and times* to keep residues within the tolerances set by law.
- USE THE RIGHT PESTICIDE FOR THE JOB! Mistakes in using the wrong material can be costly.
- Avoid spray drift to other crops and nontarget animals. Cover food and water containers in livestock areas. Protect beehives.
- Bathe and change clothing after applying pesticides. Wash clothing after each day's use.
- Do not contaminate the environment with pesticides.
- Use proper protective equipment according to instructions on the label. Never eat, drink, or smoke while applying pesticides.
- Avoid spilling spray materials on skin or clothing. If an accident occurs, wash immediately with soap and water.
- If pesticide poisoning is suspected, show the physician the label from the material suspected of causing the poisoning. The physician can contact a Poison Control Center for complete treatment information.
- Notify workers of the application and post-application information in accordance with the Worker Protection Standards.

**Table 10. Gallonage of dilute spray per acre required to provide equivalent coverage for mature trees of different sizes and spacing.**

| Distance between Rows (feet) | Tree Height (feet) | Tree Width (feet) | Maximum Tree Volume/Acre (1,000 Cubic Feet)[a] | Maximum Dilute Spray (Gallons per Acre)[b] |
|---|---|---|---|---|
| 30 | 20 | 15 | 436 | 300 |
| 26 | 16 | 12 | 354 | 225 |
| 24 | 14 | 10 | 254 | 180 |
| 22 | 14 | 10 | 272 | 200 |
| 20 | 12 | 10 | 261 | 185 |
| 18 | 10 | 10 | 242 | 175 |
| 16 | 8 | 8 | 174 | 125 |
| 14 | 6 | 8 | 149 | 105 |
| 12 | 6 | 6 | 131 | 90 |

a Maximum tree volume/acre = tree width x tree height x running feet of row per acre. Running feet of row/acre = 43,560 divided by the distance between rows.
b Minimum dilute gallons/acre = approximately 0.7 gallons/1,000 cubic feet of tree volume.

**Personal Protective Equipment (PPE):** Every pesticide label provides a specific description of the Personal Protective Equipment required during mixing, loading, application, and cleanup of that pesticide as well as for early entry that requires contact with anything that has been treated.

**Pre-harvest Interval (PHI):** The pre-harvest interval is the minimum amount of time required between application and harvest for specific crops. This time is indicated on the pesticide label. Some pesticides may allow the treated crop to be harvested the same day. Failure to abide by the pre-harvest interval may result in illegal pesticide residue levels.

**Spraying the Orchard:** Trees are sprayed with insecticides, fungicides, bactericides, growth regulators, and nutrient solutions in many different formulations and concentrations and at various stages of tree development. The principal target in tree spraying may be the foliage, the blossoms, the fruit, the woody surfaces, or all of these components. Obviously, the equipment and methods used for such a diverse spraying program must be versatile, and the equipment must be properly calibrated for each type of application to produce the desired results.

**Dilute Spraying:** During the early development of orchard application methods, trees were sprayed with gallonages sufficient to wet the target surfaces to the point of runoff (160 to 400 gallons per acre [GPA]). Spraying to the point of runoff is still the standard dilute application. Recommended rates for application of pesticides were developed on this dilute basis. Most recommendations required adding specific amounts of pesticide per 100 gallons of water for effective pest control. The GPA required for dilute spraying vary greatly, depending on the size and growth stage of the trees. Table 10 lists the gallons of dilute spray per acre required to provide equivalent coverage for mature trees of different sizes and spacings. Dilute is considered 1x concentration.

Growth regulators may be applied by high-pressure hand-guns or by air-blast sprayers, either dilute or low-volume. Low-volume application may be more risky because any mistakes in concentration are magnified.

Read the growth regulator label for suggestions on application methods. Some labels suggest dilute sprays with full coverage, whereas others suggest a specific amount of chemical in a specific amount of water per acre.

**Low-volume Spraying:** Low-volume, or concentrate, spraying refers to the use of less water per acre in applying pesticides. In low-volume spraying, the volume of water applied per acre is reduced in proportion to the increased concentration used. Thus, if a 3x concentration is used, apply only one-third the water per acre that would be used in dilute spraying.

**Table 11. Gallons of spray per acre (approximate) for various concentrates.**

| | lx | 2x | 3x | 4x | 5x | 6x | 7x | 8x | 9x | l0x |
|---|---|---|---|---|---|---|---|---|---|---|
| Apples | 300 | 150 | 100 | 75 | 60 | 50 | 45 | 38 | 33 | 30 |
| Peaches | 200 | 100 | 67 | 50 | 40 | 33 | 29 | 25 | 22 | 20 |
| Percent water savings over dilute | | 50% | 67% | 75% | 80% | 84% | 86% | 88% | 89% | 90% |
| | | | GREATEST SAVINGS | | | | | DIMINISHED SAVINGS | | |

Low-volume sprays must be applied with air-blast sprayers which use a high-velocity airstream to distribute the spray mixture. Most conventional air-blast sprayers can be used to apply spray mixtures up to 6x concentration. Sprayers specifically designed for ultra low-volume application should be used for applications at 10x or greater.

Using low-volume sprays requires less labor, less water, less time, and fewer refills than 1x or dilute mixtures. However, savings in gallonage and application cost decrease most rapidly down to about 50 gallons of water per acre. Below that, the savings may not be worth the additional risk of proper application and problems with wind. Table 11 illustrates an 80 percent savings of water at 5x but only an additional 10 percent savings by increasing the concentrate to 10x.

Following are some precautions in the use of low-volume pesticide or growth regulator applications:

1. Use extreme care in calibrating the sprayer and maintaining a constant sprayer speed. As gallonage is decreased, errors become much more critical.
2. Choose calm, yet good drying conditions for spraying. This may mean spraying at night or early in the morning. Good coverage cannot be achieved in windy weather (over 5 mph).
3. Prune trees well to a very open canopy for spray penetration. Spray droplets will not penetrate large, thick trees.
4. Choose pesticide formulations that will mix satisfactorily. Pay careful attention to increased operator hazards and drift problems.

**Tree Row Volume Spraying:** Tree row volume (TRV) is a method of determining the dilute (1x) volume of spray solution necessary to cover the entire tree surface. This is an objective method of determining the differences in spray volume required for different tree size and age.

With the TRV method, the volume of dilute spray needed per acre can be easily calculated for each orchard based on tree age, size, amount of pruning, row spacing, etc. To determine the TRV, the between-row spacing, maximum tree height, and cross-row limb spread of trees must be accurately measured. See the step-by-step procedure below.

The TRV method can also be used to determine the pesticide rate for an orchard. Calculate the TRV gallonage for the orchard. Multiply this gallonage by the recommended dilute pesticide rate per 100 gallons to determine the rate of pesticide for dilute application. For example, a fungicide is recommended at 2.0 lb/100 gal. and is to be applied in an orchard with a TRV gallonage base of 400 gal./acre.

Therefore, the per acre rate for this pesticide is:
2 lb/100 gal. x 400 gal./acre = 8 lb/acre

To determine the rate of fungicide or insecticide per acre when spraying low volume (3x or greater), first calculate the *dilute* TRV gallonage. Multiply this gallonage by 0.75 to obtain a *concentrate* TRV gallonage. Multiply this concentrate gallonage times the recommended dilute pesticide rate per 100 gal. to determine the rate of pesticide per acre for concentrate application. For example, a fungicide is recommended at 2.0 lb/100 gal. dilute and is to be applied at 5x in an orchard with a TRV base of 400 gal./acre. The rate of pesticide per acre is calculated as:

(TRV gallonage)
x (0.75)
x dilute pesticide rate/100 gal.
= concentrate pesticide application rate/acre

400 gal./acre x 0.75 x 2 lb/100 gal. = 6.0 lb/acre.

**Table 12. Determining density factors using tree density estimates.**

| | |
|---|---|
| 0.70 gal./1000 cu ft | Trees extremely open, light visible through entire tree, less than 15 scaffold limbs per tree or young tree. |
| 0.75 gal./1000 cu ft | Trees very open, 18 to 21 scaffolds per tree, light penetration throughout tree, healthy spurs within tree canopy. |
| 0.80 gal./1000 cu ft | Trees well pruned, adequate light in trees for healthy spurs throughout trunk and scaffold limbs, many holes in foliage where light can be seen through tree. |
| 0.85 gal./1000 cu ft | Trees moderately well pruned, reasonable spur population within canopy, tree thick enough that light cannot be seen through bottom two-thirds of tree. |
| 0.90 gal./1000 cu ft | Trees pruned minimally, spurs inside canopy are weak due to limited light, very few holes where light can be seen through the tree. |
| 1.00 gal./1000 cu ft | Tree unpruned, extremely thick, no light visible anywhere through tree canopy, trees more than 20 ft high. |

If the TRV base gallonage is less than 200 gal./acre, use 200 gal. to compute the pesticide application rate.

How to calculate tree row volume gallonage:

**Step 1**

Calculate feet of row/acre.

$$\frac{\text{43,560 sq ft/acre}}{\text{between-row spacing (ft)}} = \text{feet of row/acre.}$$

**Step 2**

Calculate cubic feet of TRV/acre.

Feet of row/acre (from Step 1)

x tree height (ft)

x cross-row limb spread (ft)

= cu ft of TRV/acre.

**Step 3**

Select density factor from Table 12.

Select one of the density factors that best indicates the canopy density of each separate orchard or block.

**Step 4**

Calculate TRV gallonage/acre.

$$\frac{\text{cu ft of TRV/acre (from Step 2)} \times \text{density (from Step 3)}}{1{,}000}$$

= gal. of dilute solution applied per acre

= TRV gal./acre.

*Example*

An orchard has rows spaced 20 ft apart, tree height is 14 ft, and cross-row limb spread is 12 ft. The tree density is 0.85.

*Step 1*

43,560 sq ft/20 ft

= 2,178 ft of row/acre.

*Step 2*

2,178 x 14 ft x 12 ft

= 365,904 cu ft TRV/acre.

*Step 3*

Density has been given as .85.

*Step 4*

(365,904 x .85)/1,000

= 311 TRV gal./acre.

## Orchard Sprayer Calibration

### *Determining Sprayer Speed*

The rate of travel needed for proper distribution of spray within and to the tree top can be determined by trial or by placing special water-sensitive paper patches in trees. In general, a travel speed of 0.5 to 3 miles per hour has proven to be satisfactory, depending on the size and density of the trees.

Before a sprayer can be calibrated, the travel speed must be determined in miles per hour (mph). Load the sprayer with clear water, and make a test run in the orchard to determine travel speed. Speed can be calculated by measuring the time required to travel any measured distance. The following formula can be used to determine travel speed:

$$\text{Speed (mph)} = \frac{\text{distance (ft)} \times 60}{\text{time (sec)} \times 88}$$

For example, if it requires 60 seconds to travel a measured distance of 176 ft, the travel speed is:

$$\text{mph} = \frac{176 \times 60}{60 \times 88} = 10{,}560 = 2 \text{ mph}$$

Another method for checking travel speed is to count the number of trees passed in 1 minute. Table 13 will help you determine travel speed (mph) with tree spacings from 10 to 30 ft.

### *Determining Nozzle Flow Rate*

To select the correct nozzle and whirlplate sizes, the total gallons per minute (GPM) of output for each particular application is determined. To determine the GPM, it is necessary to know the travel speed of the sprayer (mph), the gallons per acre (GPA) to be applied (of total volume), and the spacing (W) between the rows of trees. Once these three variables are measured or selected, a simple equation can be used to calculate the GPM. This equation is for one side of the sprayer manifold only. Double the calculated answer if both sides of the sprayer are to be used. Once the nozzle and whirlplate combinations are determined, place the same size nozzles and whirlplates in both sides of the sprayer if both sides will be used.

**Step 1**

Calculate the total GPM required per side:

$$\text{GPM (per side)} = \frac{\text{GPA} \times \text{mph} \times \text{W}}{1{,}000}$$

GPM = gallons per minute (per side)
GPA = gallons per acre
mph = speed in miles per hour
W = spacing between rows of trees in feet

*Example*

You have decided to apply 80 gal. per acre while traveling 2 miles per hour, with rows spaced 25 ft apart. What would the gal. per min per side be?

$$\text{GPM (per side)} = \frac{80 \times 2 \times 25}{1{,}000} = \frac{4{,}000}{1{,}000} = 4 \text{ GPM}$$

**Step 2**

Select the correct nozzle-whirlplate combination and operating pressure. Air-blast sprayers normally use disc-core-type cone spray tips. This information can be acquired either from the sprayer manufacturer or from a nozzle manufacturer. The correct size nozzles and whirlplates can be selected by using a table which indicates the nozzle size and gallons per minute output at various pressures using specific whirlplates. These tables can be found in the sprayer manufacturer's literature or in nozzle catalogs.

The arrangement of nozzles in the sprayer manifold should be such that approximately two-thirds of the total flow comes from nozzles in the upper half of the manifold and one-third from nozzles in the lower half. This should be adjusted to provide uniform coverage throughout the tree. It should provide adequate penetration to the top and top center of the tree while avoiding excess application rate in the lower outside areas. This is especially important when applying growth regulator materials, such as chemical thinners.

**Step 3**

Install the nozzles in their proper outlets. Inspect all nozzles and outlets for foreign material, and determine that the sprayer is operating correctly. Nozzles are a very important part of the sprayer; if any defects or wear are showing in the nozzles, they should be replaced.

**Table 13. Determination of speed for air-carrier sprayers for selected tree spacings.**

| Number of trees passed per minute | Tree spacing in the row (feet) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **10** | **12** | **14** | **16** | **18** | **20** | **22** | **24** | **28** | **30** |
| | **Miles per hour** | | | | | | | | | |
| 2 | - | - | - | 0.4 | 0.4 | 0.5 | 0.5 | 0.6 | 0.6 | 0.7 |
| 3 | - | - | 0.5 | 0.5 | 0.6 | 0.7 | 0.8 | 0.8 | 1.0 | 1.0 |
| 4 | - | 0.5 | 0.6 | 0.7 | 0.7 | 0.9 | 1.0 | 1.1 | 1.3 | 1.4 |
| 5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 | 1.1 | 1.3 | 1.4 | 1.6 | 1.7 |
| 6 | 0.7 | 0.8 | 1.0 | 1.1 | 1.2 | 1.4 | 1.5 | 1.6 | 1.9 | 2.1 |
| 8 | 0.9 | 1.1 | 1.3 | 1.5 | 1.6 | 1.8 | 2.0 | 2.2 | 2.6 | 2.7 |
| 10 | 1.1 | 1.4 | 1.6 | 1.8 | 2.0 | 2.3 | 2.5 | 2.7 | 3.2 | 3.4 |
| 12 | 1.4 | 1.6 | 1.9 | 2.2 | 2.4 | 2.7 | 3.0 | 3.3 | 3.8 | 4.1 |
| 16 | 1.8 | 2.2 | 2.5 | 2.9 | 3.3 | 3.6 | 4.0 | 4.4 | 5.1 | 5.5 |
| 20 | 2.3 | 2.7 | 3.2 | 3.6 | 4.1 | 4.5 | 5.0 | 5.5 | 6.4 | 6.8 |

**Step 4**

Measure the total GPM from all the nozzles selected in Step 2. Fill the sprayer tank to a graduated mark on the sight gauge. It should be at least half full. Prime the sprayer system, and check all the nozzles to make sure none are clogged or partially clogged. Record the exact amount of water in the spray tank. Bring the sprayer up to the desired pressure, and turn the nozzles on. Use a stopwatch to record the amount of time the sprayer is running. The sprayer should be operated for at least 3 minutes.

*Example*

The spray tank is filled to the 200-gal. level. It was predetermined that the nozzles selected would give a total gal. per min output of 8. The sprayer was operated for 5 minutes at 150 psi on the gauge. After the 5 minutes, the sight gauge was read and found to be at a level of 170 gal.

The actual output was 200 gal. (start)—170 gal. (stop) = 30 gal. per 5 min or 6 GPM. The calculated output, however, was 8 GPM.

When the actual output is different from the calculated output, adjustments can be made by changing the pressure when the difference is small. When the difference is large, you will need to change the nozzle sizes.

Repeat these calibration procedures whenever changes are made in the speed, gallons per acre, or row spacing. Periodically check the output from the nozzles during the spraying season. Remember, the effectiveness of the spray material is directly dependent on your skill as an operator.

*Field test to confirm calculations:*

GPA (gallons per acre)

$$= \frac{\text{Gal. sprayed x 43,560 sq ft x No. passes per row}}{\text{distance traveled (ft) x row width (ft)}}$$

## Herbicide Sprayer Calibration

Herbicides used in the orchard must be applied carefully to obtain uniform application over the soil surface or over the vegetation to be controlled. Here is a suggested technique for calibrating the herbicide boom that is attached to the side of a tractor:

1. Clean sprayer and replace all worn or defective parts; fill tank with water.
2. Adjust pressure and speed of tractor for nozzle size and output using manufacturer's directions.
3. Check to confirm that nozzle delivery rates are uniform. Catch output from each nozzle for 30 seconds. Output from all nozzles should be uniform within 10 percent. If not, replace out-of-range nozzles. Nozzles should be re-checked at least once each season.
4. Refill spray tank and spray 1/4 acre (10,890 sq ft). Distance of travel will vary with boom coverage.

For example, a 6-foot boom must travel 1,815 feet to cover 1/4 acre.

$$\frac{\text{1/4 acre (10,890 sq ft )}}{\text{Boom width (6 ft)}} = \text{Distance (1,815 ft)}$$

5. Measure amount of water needed to refill the spray tank to the same level as before. This amount was applied to the 1/4 acre; thus, four times this amount is the gallonage of spray per acre. For example, if it required 10 gallons to spray the 1/4 acre, then the per acre gallonage would be 40.
6. Adjustment in gallonage may be made either by varying tractor speed or by changing nozzle size. Do not use changes in pressure to change gallonage since the nozzle pattern will be affected. Recalibrate after each adjustment.
7. Calculate acres covered by full tank of spray solution. Add required amount of herbicide for the total area sprayed.
8. Calibrate spray tank for less than full tanks so that small blocks can be sprayed without having an excess of spray material.
9. Some herbicide materials may cause slight differences in nozzle patterns and output. To increase accuracy, calibrate for each different herbicide or combination being used. To do this, as you apply a new herbicide to the orchard, observe closely the point at which the tank of spray is exhausted. If this differs substantially from the calculated point of ending, then adjust the gallonage accordingly.

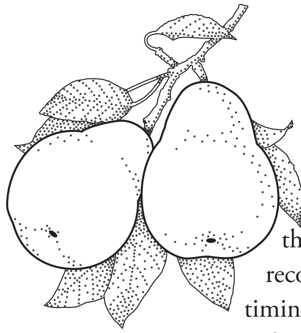
## Reducing Spray Drift

Herbicides may drift through the air from the point of application and cause injury at another location if contact is made with susceptible plants. Spray drift is a function of the wind speed, droplet size, height above the ground from which the spray was released, and herbicide volatility. Generally there is less wind just before sunrise, just after sunset, and during the night. Thus, these are usually the best periods for spray applications. Winds tend to be more gusty and turbulent from 2 p.m. to 4 p.m. As droplet size is reduced, spray drift increases, and as droplets fall, evaporation may take place, producing extremely small droplets or particles. Generally high pressures produce small droplets, and low pressures produce large droplets. Small nozzles usually produce small droplets. Droplets larger than 200 microns fall to the ground fairly rapidly, while those below 150 microns fall very slowly. The height above the ground from which the spray is released is important. The greater the height, the longer it takes for droplets to reach the ground. Furthermore, wind velocities tend to be lower closer to the ground. Herbicide volatility refers to the tendency of a herbicide to vaporize or produce fumes. Highly volatile herbicides can produce vapor drift. The amine and sodium salts formulations of 2,4-D have little or no volatility problems, while the ester formulations vary from low to high volatility. Fruit growers generally avoid the 2,4-D ester formulations because of the capacity of these materials to move great distances from the application point, particularly when temperatures are 80°F or higher.

Reduce spray drift by using lower pressures, larger nozzles, and less volatile herbicides and by spraying when there is little wind and temperatures are not too hot. Also, set the boom or nozzles as close to the ground as possible.

C H A P T E R 6

# Orchard Pesticides



## Fungicides and Bactericides

Several fungicides are registered for use on tree fruit, and each may be very effective against some diseases, yet have little or no effect against others. Most fungicides are effective primarily as protectants—they must be applied before infection occurs to prevent damage. Some are locally systemic and have curative activity which provides some control of infections that have already started. When developing a fungicide spray program for tree fruit in the Midwest, many things must be considered. Your state's commercial tree fruit spray guide provides much of the information that you require related to recommended materials, rates, and proper timing, and it should be used in conjunction with this handbook. The following table summarizes general information on the fungicides currently registered for use on tree fruit. Growers should refer to product labels and the up-to-date annual spray guide for further details on rates, restrictions, timing, and application methods.

NOTE: When peach is listed in this table, it generally includes nectarines and apricots. Check the label for specific fungicides to ensure that they are labeled on that crop.

**Table 14. Orchard Fungicides and Bactericides.**

| Trade Name | Common Name | Formulation | For Use On |
|---|---|---|---|
| Aliette | fosetyl-Al | 80 WDG | Apples |
| | Registered for control of Phytophthora crown and root rot on apples. It is applied as a foliar spray. | | |
| Bayleton | triadimefon | 50 DG | Apples<br>Pears |
| | Registered for control of powdery mildew, rust, and scab on apples. Also registered for control of powdery mildew on pears. It is a sterol-inhibiting (SI) fungicide with good activity against mildew and rust but has poor activity against scab. Where scab is a problem, it should be combined (tank-mixed) with a good scab fungicide. Has little or no activity against summer diseases. | | |
| Benlate | benomyl | 50 WP | Apples<br>Cherries<br>Peaches<br>Plums |
| | Registered on apples for control of scab and powdery mildew. Very active against summer diseases such as sooty blotch, flyspeck, black rot, and white rot. Also registered on pears for control of scab, Fabraea leaf spot, and sooty blotch. On stone fruit, it is registered for control of brown rot, peach scab, and cherry leaf spot. Development of resistant strains of pathogenic fungi is a problem with benomyl. It should be tank-mixed with fungicides that have a different mode of action to delay resistance development. Topsin-M (thiophanate-methyl) has the same mode of action as benomyl. | | |
| Bordeaux Mixture | copper sulfate + hydrated lime | See Comments | Apples<br>Peaches<br>Pears |
| | Recommended for use as a dormant application on apples and pears for control of fire blight. On peaches it is recommended as a dormant application for control of peach leaf curl and bacterial spot. Can cause severe injury if applied to green tissue. Due to the large volume of spray lime used to make Bordeaux mixture, it has many compatibility problems with other pesticides. Check pesticide labels for incompatibility with copper and lime. | | |

**Table 14.** *continued*

| Trade Name | Common Name | Formulation | For Use On |
|---|---|---|---|
| Bravo | chlorothalonil | 720 F<br>720 Weather Stik<br>Bravo Ultrex | Cherries<br>Peaches<br>Plums |
| | Registered for control of peach leaf curl, brown rot blossom blight, and cherry leaf spot. May not be applied after shuck-split. | | |
| Captan | captan | 50 WP,<br>80 WP,<br>4 L | Apples<br>Cherries<br>Peaches<br>Plums |
| | Registered for use on apples for control of scab and summer diseases. A good broad-spectrum protectant fungicide. Especially good for summer diseases on apples when mixed with Benlate or Topsin-M. Will not control powdery mildew or rust and is weak against flyspeck. A standard for tank-mixing with sterol-inhibiting fungicides or benzimidazoles to provide additional protectant activity and fungicide-resistance management. On stone fruit, it is registered for control of brown rot, peach scab, and cherry leaf spot. May be phytotoxic (e.g., cause shot-hole or yellowing on young peach leaves under cool, slow-drying conditions; may cause severe leaf burn on some sweet cherry cultivars such as Emperor Francis, Schmidt, and Giant). Captan should not be used on Japanese-type or Stanley plums until July, or severe shot-hole type leaf injury may occur. Captan should not be tank-mixed with sulfur, lime, or oil and should not be applied within 7 to 10 days of a sulfur, lime, or oil application. | | |
| Carbamate | ferbam | 76 WP | Apples<br>Peaches<br>Pears |
| | Registered for scab and summer disease control of apples and pears, although not generally used on apples. On stone fruit, it is very effective as a dormant application for control of peach leaf curl. Late-season applications may result in unsightly black residue on fruit. | | |
| Elite | tebuconazole | 45 DF | Cherries<br>Peaches<br>Plums |
| | Registered for control of brown rot blossom blight and fruit rot, powdery mildew, and cherry leaf spot. A sterol-inhibiting (SI) fungicide with locally systemic activity. For best disease control and to delay fungicide resistance, do not use below the labeled rate. | | |
| "Fixed" copper | See comments | See comments | Apples<br>Peaches<br>Pears |
| | Fixed copper materials are relatively insoluble in water compared to Bordeaux mixture and are therefore usually less injurious to plant tissues than Bordeaux mixture. However, fixed copper materials have a tendency to be phytotoxic and are often incompatible with other pesticides. Generally not recommended for use during the growing season. They are recommended as an early-season spray on apples and pears for control of fire blight. Applications beyond green tip may result in injury or harm fruit finish. On peaches, it is recommended as a dormant application for control of peach leaf curl and bacterial spot. Available in many forms and formulations. | | |
| Indar | fenbuconazole | 75 WSP | Cherries<br>Peaches |
| | Registered for control of brown rot blossom blight and fruit rot, peach scab, and cherry leaf spot. It also provides moderate control of powdery mildew on sour cherries. Indar is a sterol-inhibiting (SI) fungicide with locally systemic activity and is highly effective for control of brown rot. | | |
| Mancozeb | mancozeb | 80 WP, 75 DF<br>See comments | Apples<br>Pears |
| | Registered for control of scab and summer diseases of apples and pears. Good broad-spectrum protectant fungicide. A standard for tank-mixing with sterol-inhibiting (SI) fungicides or benzimidazoles to provide additional protectant activity and fungicide-resistance management. May be applied at 6 lb/acre prebloom for a total of four applications, or at 3 lb/acre as a tank mix for a total of seven applications. May not be applied within 77 days of harvest. There are many trade names and formulations for mancozeb. See your state's commercial tree fruit spray guide for additional information. Mancozeb is an EBDC fungicide. | | |

**Table 14.** *continued*

| Trade Name | Common Name | Formulation | For Use On |
|---|---|---|---|
| Mycoshield | oxytetracycline | 17% SP | Peaches |
| | Registered for control of bacterial spot on peaches. Oxytetracycline is an antibiotic. See your state's commercial tree fruit spray guide for further information. | | |
| Nova | myclobutanil | 40 WP | Apples<br>Cherries<br>Peaches |
| | Registered for control of scab, powdery mildew, and rust on apples. A sterol-inhibiting (SI) fungicide with locally systemic activity and good curative activity when used at the proper rates. Control of fruit scab on apples is increased when mixed with a broad-spectrum protectant fungicide such as captan or mancozeb. Tank-mixing also allows Nova to be used in an extended protectant program on apples. On peaches, it is registered for control of brown rot blossom blight and powdery mildew. For best disease control and to delay fungicide resistance, do not use below the labeled rate. | | |
| Orbit | propiconazole | 41.8% L | Cherries<br>Peaches<br>Plums |
| | Registered for control of brown rot blossom blight and fruit rot. A sterol-inhibiting (SI) fungicide with locally systemic activity. For best disease control and to delay fungicide resistance, do not use below the labeled rate. | | |
| Polyram | metiram | 80 WP | Apples |
| | Registered for control of scab, rust, and summer diseases on apples. Polyram is an EDBC fungicide and is very similar in activity and has the same use recommendations on apples as mancozeb (see mancozeb). Reported to provide good fruit finish on russet-prone varieties such as Golden Delicious. May not be applied within 77 days of harvest. | | |
| Procure | triflumizole | 50 WS | Apples |
| | Registered for control of scab and powdery mildew on apples and pears. A sterol-inhibiting (SI) fungicide with locally systemic activity. Procure has activity on apple similar to Nova and Rubigan. For best disease control and to delay fungicide resistance, do not use below the labeled rate. | | |
| Ridomil | metalaxyl<br>mefoxam | 2 E<br>Ridomil Gold | Apples<br>Cherries<br>Peaches<br>Plums |
| | Registered for control of Phytophthora root and crown rot on apples and stone fruit trees. Ridomil may aid in control of crown and root rot when used in conjunction with good cultural practices such as improved soil drainage and rootstocks that are most tolerant to the disease. Applications should be made before symptoms are visible, especially in areas of the orchard (wet areas) that are more favorable for disease development. Ridomil will not revitalize trees showing moderate to severe crown rot symptoms. Ridomil Gold is a new formulation that will eventually replace Ridomil 2 E. | | |
| Ronilan | vinclozolin | 50 WP | Cherries<br>Peaches |
| | Registered for brown rot blossom blight and fruit rot. Not registered for use on plums. A good protectant fungicide with slight locally systemic activity. A dicarboximide fungicide that has the same mode of action as Rovral. Both Ronilan and Rovral are at high risk for resistance development in the brown rot fungus. These fungicides should not be tank-mixed with each other or alternated with each other in the spray program. Preharvest use is restricted to a single spray, and it may not be applied within 14 days of harvest. | | |
| Rovral | iprodione | 50 WP, 4 L | Cherries<br>Peaches<br>Plums |
| | Registered for control of brown rot blossom blight and fruit rot on cherries, peaches, and plums, and provides moderate control of cherry leaf spot. A good protectant fungicide with slight locally systemic activity. A dicarboximide fungicide that has the same mode of action as Ronilan. Both Rovral and Ronilan are at high risk for resistance development in the brown rot fungus. These fungicides should not be tank-mixed with each other or alternated with each other in the spray program. Rovral and the related fungicide Ronilan (vinclozolin) are especially effective at inhibiting spore production by the brown rot fungus and therefore are particularly recommended in wet years that are conducive to rapid disease buildup. | | |

**Table 14.** *continued*

| Trade Name | Common Name | Formulation | For Use On |
| --- | --- | --- | --- |
| Rubigan | fenarimol | 1 EC | Apples<br>Cherries<br>Pears |
| | Registered for control of scab and powdery mildew on apples and pears, and rust on apples. A sterol-inhibiting (SI) fungicide with locally systemic activity and good curative activity when used at the proper rates. Control of fruit scab is increased when tank-mixed with a broad-spectrum protectant fungicide such as captan or mancozeb. Tank-mixing also allows Rubigan to be used in an extended protectant program on apples. Registered on cherries for control of cherry leaf spot and powdery mildew. It has poor activity against brown rot. For best disease control and to delay fungicide resistance, do not use below the labeled rate. Specifically, Rubigan should not be used at a concentration less than 3 fl oz per 100 gal. of water. | | |
| Streptomycin | streptomycin | Agri-strep<br>Agrimycin | Apples<br>Pears |
| | Streptomycin is an antibiotic registered for control of fire blight on apples and pears. It is a foliar spray effective during bloom. Although streptomycin is most effective when used alone, it can be tank-mixed with most other commonly used orchard insecticides and fungicides except Bordeaux mixtures or highly alkaline materials. Once absorbed into plant tissues, streptomycin is fairly stable. However, the absorption of streptomycin is reduced when used in combination with captan, dodine, or sulfur. Absorption can be improved significantly with the use of spreader-activator type adjuvants like Glyodin or Regulaid. Normally, streptomycin is used at 8 oz per 100 gal. of water, but where the above adjuvants are used, this rate can be reduced to 4 to 6 oz per 100 gal. Foliar injury may occur when streptomycin is used at the 8-oz rate with a spreader-activator adjuvant. Streptomycin is also recommended for control of blister spot on apples. In the Midwest, streptomycin-resistant strains of the fire blight bacterium have been reported in parts of Michigan and Missouri. | | |
| Sulfur | sulfur | 95 WP, 6 F, Dust | Apples<br>Cherries<br>Peaches<br>Plums |
| | Registered for control of scab and powdery mildew on apples. When used in a protectant schedule, it has good activity on powdery mildew and is relatively weak for scab control. On stone fruit, it is registered for control of brown rot blossom blight and fruit rot, peach scab, and powdery mildew. It is generally considered less effective for control of brown rot than captan or the "newer" brown rot fungicides. Many formulations of sulfur are available. Avoid use of sulfur at high temperatures (80° to 90°F) because of the potential for leaf injury and fruit russeting. Sulfur should not be applied with or within 7 days of captan on Red Delicious and not within 7 days before or after oil on most apple varieties. | | |
| Syllit | dodine | 65 WP | Apples<br>Cherries |
| | Registered for control of scab on apples and cherry leaf spot. Will not control powdery mildew, rust, or summer diseases on apples. Syllit-resistant strains of the apple scab fungus have been reported where the material has been used as a predominant scab fungicide for long periods of time (8 to 10 years). Syllit is particularly useful on established apple scab lesions where resistance is not present. It does not eradicate the lesion but suppresses both the production and germination of spores. When Syllit is used for this purpose, apply 3/4 lb per 100 gal. and follow with a second application 7 to 10 days later with 1/2 lb per 100 gal. However, applying Syllit to sporulating lesions greatly increases the probability of developing resistance. Syllit may cause fruit injury if applied at freezing or near-freezing temperatures, particularly if slow-drying conditions exist. Syllit may russet Golden Delicious, especially if applied during bloom, petal fall, or early cover sprays. It is compatible with oil and most fungicides formulated as wettable powders. | | |
| Thiram | thiram | 65 WP | Apples<br>Peaches |
| | Registered for control of scab, rust, and summer diseases of apples. A protectant fungicide that is not as effective for scab control as captan, mancozeb, dodine, benomyl, or thiophanate-methyl. It provides only fair control of summer diseases on apples (sooty blotch and flyspeck). Registered for control of brown rot blossom blight and fruit rot, peach leaf curl, and scab on peaches. | | |

**Table 14.** *continued*

| Trade Name | Common Name | Formulation | For Use On |
|---|---|---|---|
| Topsin-M | thiophanate-methyl | 70 WP<br>4.5 F | Apples<br>Cherries<br>Peaches<br>Plums |
| | Registered on apples for control of scab and powdery mildew. Very active against summer diseases such as sooty blotch, flyspeck, black rot, and white rot. On stone fruit, it is registered for control of brown rot, peach scab, and cherry leaf spot. Development of resistant strains of pathogenic fungi is a problem with thiophanate-methyl. It should be tank-mixed with fungicides that have a different mode of action to prevent or delay resistance development. Benlate (benomyl) has the same mode of action as thiophanate-methyl. | | |
| Ziram | ziram | 76 DF | Apples<br>Cherries<br>Peaches<br>Pears |
| | Registered on apples and pears for control of scab and summer diseases and will also control rust on apples. A protectant fungicide that is not as effective for scab control as captan, mancozeb, dodine, benomyl, or thiophanate-methyl. It provides fair to good control of summer diseases when used at higher rates. On stone fruits, it is registered for control of brown rot, peach leaf curl, and scab. On peaches, it is a good alternative to captan on those peach cultivars that are subject to captan injury. | | |

DF = Dry flowable; DG = Dispersible granule; E = Emulsifiable; EC = Emulsifiable concentrate; F = Flowable; L = Liquid; SP = Soluble powder; WDG = Water dispersible granule; WP = Wettable powder; WS = Water soluble; WSP = Water soluble powder

# Insecticides and Miticides

Insecticides and miticides in the following list have been placed in groups according to their chemical composition. These summaries include formulations, crop site, pests for which registered, signal word, and other brief information. This information should help growers who desire to rotate from one group or class to another when pesticide resistance is suspected or to select a similar product from the same class.

## Carbamate Products

**Carzol (formetanate hydrochloride):** This product is registered as a 92% SP for use on apple trees to control tentiform leafminer, white apple leafhopper, European red and two-spotted mites; on pears to control European red, two-spotted, and rust mites; and on peaches, plums, and prunes to control mites, lygus bugs, and stink bugs. Carzol is less effective in the summer when eggs, nymphs, and adults are equally abundant. This product is highly toxic to predator mites. Signal word: Danger—Poison.

**Lannate (methomyl):** This fast-acting contact insecticide, formulated as Lannate 90% WSP (in soluble pouches) and Lannate LV (2.4 lb/gal. WSL), is registered for use on apple trees to control apple aphid, rosy apple aphid, tufted apple budmoth, green fruitworm, tarnished plant bug, codling moth, leafrollers, lesser appleworm, white apple leafhopper, tentiform leafminer, and cutworms. Use on peach trees to control cat-facing insects (plant bugs and stink bugs), oriental fruit moth, and green peach aphid. Best results follow direct spraying on target pest using fine spray droplets at low volume. Lannate provides very little residual activity. Product may be fatal or cause blindness if swallowed. Do not get in eyes, on skin, or on nonprotective clothing. Do not apply through any irrigation system. Lannate L and LV are restricted-use pesticides (RUP). Signal word: Danger—Poison.

**Sevin (carbaryl):** This product is usually formulated as a 50% WP. Other formulations are also available. It is a broad-spectrum insecticide that may be used on apples, peaches, nectarines, plums, prunes, and cherries. Do not apply to apple trees for insect control within 30 days of bloom since Sevin acts as a thinner on many varieties. Sevin is highly toxic to bees and

**Table 15. Effectiveness of selected fungicides against apple diseases.**

| Fungicide | Scab | Powdery mildew | Rust | Black rot and white rot | Bitter rot | Sooty blotch | Flyspeck |
|---|---|---|---|---|---|---|---|
| Bayleton | P | E | E | O | O | O | O |
| Benlate* | E | E | O | G | P | E | G |
| Captan | E | O | O | G | E | F-G | F-G |
| Ferbam (carbamate) | F | O | G | F | P | F | F |
| Mancozeb (Dithane, Manzate, Penncozeb) | G | O | G | G | E | E | E |
| Nova | E | E | E | O | O | O | O |
| Polyram | G | O | G | G | E | E | E |
| Procure | E | E | E | O | O | O | O |
| Rubigan | E | E | E | O | O | O | O |
| Sulfur | F | G | O | F | – | P | P |
| Syllit* | E | O | P | P | O | P | P |
| Thiram | F | O | G | F | P | F | F |
| Topsin M* | E | E | O | G | P | E | G |
| Ziram | F | O | F | P | E | F-G | F-G |

– = unknown or doesn't apply; O = none; P = poor; F = fair; G = good; E = excellent.

* Many areas of the Midwest may contain strains of the apple scab and powdery mildew fungus tolerant of these chemicals. Therefore, these fungicides may not be effective in some areas.

**Table 16. Effectiveness of selected fungicides against stone fruit pathogens.**

| | Brown rot | | | | | | |
|---|---|---|---|---|---|---|---|
| Fungicide | Blossom blight | Fruit rot | Peach leaf curl | Peach scab | Powdery mildew | Cherry leaf spot | Black knot of plum |
| Benlate* | E | E | – | G | F | G | F |
| Bravo | G | – | E | G | O | E | E |
| Captan | G | F-G | – | G | O | G | G |
| Elite | E | E | – | – | G | G | – |
| Ferbam | – | F | E | – | O | F | – |
| Fixed copper | – | – | G | – | F | G | P |
| Indar | E | E | – | – | G | E | – |
| Nova | E | – | – | – | E | E | – |
| Orbit | E | E | – | – | – | – | – |
| Ronilan | E | E | – | P | – | P | – |
| Rovral | E | E | – | P | – | F | – |
| Rubigan | – | – | – | – | G | E | – |
| Sulfur | F | P | – | G | G | P | O |
| Syllit* | – | P | – | – | O | G | – |
| Thiram | P-F | P-F | G | G | – | – | – |
| Topsin M* | E | E | – | G | F | G | F |
| Ziram | P-F | P-F | G | G | – | F | – |

– = unknown or doesn't apply; O = none; P = poor; F = fair; G = good; E = excellent.

* Many areas of the Midwest may contain strains of the brown rot, powdery mildew, and cherry leaf spot fungi tolerant of these chemicals. Therefore, these fungicides may not be effective in some areas.

should not be used near bloom. Signal word: Caution. Low mammalian toxicity makes this product desirable for use by the general public. However, it does not provide the level of control desired by commercial growers for most pests.

**Vydate (oxamyl):** Vydate L is an insecticide/nematicide formulated as a 2 lb/gal. WSL used on apple trees to control spotted tentiform leafminer, European red and two-spotted mites, and white apple leafhopper. Do not apply at bloom or within 30 days after full bloom, or fruit thinning may occur. Vydate is used on pear trees to control European red, McDaniel, two-spotted, and pear rust mites. Vydate is highly toxic to predator mites. Vydate is a restricted-use pesticide. Signal word: Danger—Poison.

## Chlorinated Hydrocarbon Products

**Kelthane (dicofol):** This miticide is registered as 35 W and 50 W formulations for use on apples and pears. It is effective against European red and two-spotted spider mites. Resistance may be a problem in some areas, so apply only once per year on apples. Rotate with other miticides to slow development of resistance. Kelthane is highly toxic to predatory mites at high rates and moderately toxic at lower rates. Signal word: Warning.

**Marlate (methoxychlor):** This insecticide is registered as a 50% WP for use on apple and pear trees to control apple maggot, codling moth, Japanese beetle, plum curculio, and tent caterpillars. Marlate is used on apricot, cherry, nectarine, peach, plum, and prune trees to control cherry fruitworm, cherry fruit flies, Japanese beetle, plum curculio, rose chafer, tent caterpillar, and cankerworms. Signal word: Caution, making this product desirable for use by the general public. Methoxychlor does not provide the level of control desired by most commercial growers.

**Thiodan (endosulfan):** The 50% WP and 3EC formulations are registered for use on apple trees to control apple aphid, rosy apple aphid, green fruitworm, tarnished plant bug, white apple leafhopper, apple rust mite, and woolly apple aphid; and on pears for green fruitworm, tarnished plant bug, rust mite, pear blister mite, and pear psylla. Registration for apricot, nectarine, and peach trees is to control peachtree borer, lesser peachtree borer, cat-facing insects, green peach aphid, peach twig borer, and green fruitworm. Signal word: Danger—Poison.

## Organo-phosphate Products

**Defend and Dimethoate (dimethoate):** These two products are formulated as a 2.67 lb/gal. EC systemic insecticide-miticide primarily registered on apples and pears primarily for control of sucking insects such as aphids and leafhoopers. It is also registered for apple maggot and codling moth. Do not apply when substantial numbers of weeds in the orchard are in bloom because it is highly toxic to honeybees. Signal word: Warning.

**Diazinon (diazinon):** This product as a 50% WP is primarily registered to control apple maggot; codling moth; green, rosy, and woolly apple aphids; and is very effective on San Jose scale crawlers. It suppresses mites but is not considered a miticide. It is also registered for control of other pests on pear, cherry, nectarine, peach, plum, and prune trees. Some formulations of Diazinon are restricted-use products. Signal word: Warning. Diazinon is moderately toxic to *Stethorous punctum* larvae and adults.

**Guthion and Sniper (azinphos-methyl):** Guthion is formulated as a 35% WP, and Guthion and Sniper as 50% WP water-soluble packets for use on apple trees to control apple maggot, codling moth, European apple sawfly, eye-spotted bud moth, Forbes scale, green fruitworm, leafhoppers, leafrollers, plum curculio, San Jose scale, stink bug, and tarnished plant bug. Use on nectarines, peaches, plums, and prunes provides control of scale insects, lesser peachtree borer, mites, peachtree borer, plum curculio, stink bug, and tarnished plant bug. Registration for cherries includes use for control of eye-spotted bud moth, fruit flies, fruit-tree leafroller, lesser peachtree borer, mites, plum curculio, and scale insects. Guthion is commonly recommended in IPM programs because it is not highly toxic to mite predators. Guthion is a restricted-use pesticide. Signal word: Danger—Poison.

**Imidan (phosmet):** This product is registered as a 70% WP and is very effective against many fruit pests. It is used on apple trees to control apple maggot, codling moth, green fruitworm, Japanese beetle, leafrollers, plum curculio, and tarnished plant bug, and on pears for most of the same insects. On apricot, nectarine, plum, and prune trees, it controls apple maggot, oriental fruit moth, peach twig borer, plum curculio, and red-banded leafroller; on peach trees, Japanese beetles, oriental fruit moth, peach twig borer, plum curculio, and tarnished plant bug. Imidan is not effective against aphids or leafhoppers, and leafhoppers may become abundant where it is used regularly. Imidan is commonly recommended in IPM programs because it is not highly toxic to mite predators. Signal word: Warning.

**Lorsban (chlorpyrifos):** This product is registered as a 4 lb/gal. EC for application with spray oil as a dormant or delayed dormant spray on apple trees to control rosy apple aphid, San Jose scale, Pandemis leafroller, and climbing cutworms; on pear trees for San Jose scale, climbing cutworms, and pear psylla adults; on plum and prune trees for San Jose scale, mealy plum aphid, climbing cutworms, and peach twig borer; and on peach, nectarine, and cherry trees to control San Jose scale, peach twig borer, and climbing cutworms. Lorsban 4E is also registered to control peachtree borers as a tree trunk application made before newly hatched borers enter the trees, and also on cherry trees to control lesser peachtree borer, peachtree borer, and American plum borer. Follow specific instructions on label for timing. There is a limit of one application per season. The 50% WP is registered for full-season general insect control and is effective against aphids, apple maggot, codling moth, green fruitworm, leafrollers, periodical cicada, plum curculio, San Jose scale, woolly apple aphid, and dogwood borer. Make no more than eight applications per season. Lorsban may cause russeting on Golden Delicious. Signal word for both formulations: Warning.

**Malathion (malathion):** This general-use product is formulated as a 57% EC, 25% WP, and 50% WP and is labeled for use to control aphids, codling moth, leafhoppers, leafrollers, mites, plum curculio, and San Jose scale. It is not effective for mite control in orchards where mites have developed resistance to organophosphate products. Signal word: Caution, making this product desirable for use by the general public.

**Penncap-M (encapsulated methyl parathion):** This encapsulated formulation of methyl parathion with its extended residual activity is registered for use on apple trees to control apple maggot, codling moth, green fruitworm, leafrollers, plum curculio, oystershell scale, San Jose scale, tarnished plant bug, and woolly apple aphid. It is used on nectarine, peach, plum, and prune trees for control of lesser peachtree borer, peachtree borer, cat-facing insects, oriental fruit moth, plum curculio, and peach twig borer; and on cherry trees for black cherry aphid, cherry fruit fly, green fruitworm, leafrollers, and plum curculio. Penncap-M is a restricted-use product. Penncap-M is very hazardous to bees and must not be applied whenever flowering weeds occur in or around the orchard. Signal word: Warning.

## Synthetic Pyrethroid Products

Use of pyrethroid insecticides is likely to cause mite outbreaks in apples. These materials are highly toxic to mite predators and have a long residual activity.

**Ambush (permethrin):** Ambush is registered as 2 lb/gal. EC and a 25% WP for apple trees to control apple aphid, leafrollers, plum curculio, white apple leafhopper, spotted tentiform leafminer, and tarnished plant bug. Do not use after petal fall for apples. Use on cherry and peach trees to control lesser peachtree borer, rose chafer, green fruitworm, red-banded leafroller, plum curculio, and tarnished plant bug; and on pears to control pear psylla, codling moth, and green fruitworm. Ambush is a restricted-use product. Signal word: Warning.

**Asana XL (esfenvalerate):** Asana is registered as a 0.66 lb/gal. EC on apples to control leafrollers, codling moth, white apple leafhopper, tentiform leafminer, San Jose scale (on fruit only), aphids, plum curculio, apple maggot, green fruitworm, tarnished plant bug, stink bugs, and periodical cicada. It is used on stone fruits to control peach twig borer, oriental fruit moth, peachtree borer, lesser peachtree borer, periodical cicada, aphids, leafrollers, leafhoppers, and green fruitworm. It is used on pears to control pear psylla, codling moth, green fruitworm, plum curculio, leafrollers, pear slug, and periodical cicada. Asana is a restricted-use product. Signal word: Warning.

**Pounce (permethrin):** Pounce is registered as a 3.2 EC and 25% WP to control the same insects as Ambush. Pounce is a restricted-use product. Signal word: Warning.

## Other Products

**Agri-Mek (abamectin):** AgriMek is registered as a 0.15 lb/gal. EC. It is used to control pear psylla on pears and European red mite and spotted tentiform leafminer on apples. Agri-Mek is very effective when timed properly. Agri-Mek is used post-bloom and is most effective when used within 6 weeks of petal fall. During this period after petal fall, Agri-Mek can still penetrate into the leaf. Used early (up to 6 weeks after petal fall), Agri-Mek will provide excellent control; when used later in the season, control is only fair. Agri-Mek is most effective when applied with a minimum 1 percent of oil. Agri-Mek has a different mode of action from that of Apollo and Savey and can be alternated in a yearly rotation with these miticides to prevent development of mite resistance. Signal word: Warning.

**Apollo (clofentezine):** Apollo is formulated as 42% SC and registered as an ovicidal miticide on apples, pears, and stone fruits. Target species include European red and two-spotted spider mites. It works best when applied to eggs or young mobile stages. It is not effective against older nymphs and adults. Apollo is limited to one application per year, with best results achieved with application at petal fall on pears and stone fruits. It must be applied by tight cluster on apples. There are no direct effects on predatory mites or bees. Keep in mind that Apollo and Savey have very similar modes of action, and both should not be used in the same season because of resistant-management concerns. Signal word: Caution.

**Insecticidal Soaps and Horticultural Oils:** SunSpray Ultra-Fine, Saf-T-Side, and M-Pede (a potassium salt of fatty acids, previously called an insecticidal soap) are relatively new insecticides that may be used in certified organic production systems. Summer oils and M-Pede are effective against only the insects that are present and contacted by sprays at the time of application. These sprays provide no residual control. Nonetheless, they appear to be useful in certain situations.

A summer oil alone at a concentration of 1 to 2 percent by volume provides some control of mites and aphids (rosy apple aphid, apple grain aphid, green apple aphid, and spirea aphid). Limited observations suggest that aphid control is likely to be greatest if oil is applied when clusters are at the 1/4-inch green stage.

M-Pede alone reduces mite, aphid, pear psylla, and white apple leafhopper populations, but control may not be satisfactory or long-lasting unless multiple sprays are applied. Unlike oils, M-Pede is not ovicidal. If applied alone, a summer oil is likely to be more effective for aphid and (especially) mite control than M-Pede. Data from Michigan indicate that adding M-Pede at 2 percent by volume to full-rate sprays of Omite, Vendex, Kelthane, and presumably other miticides greatly enhances the control they provide.

Phytotoxicity, leaf drop, and fruit blemishes should be a major concern in decisions on the use of a summer oil or soap. To prevent damage to foliage or fruits, never use a summer oil with Captan, Sevin, or other sulfur-containing pesticides. Allow at least 14 days between applications of sulfur-containing compounds and the use of a summer oil. Do not apply oils if temperatures exceed 90°F or if drying conditions are poor. Because of concerns about fruit russeting, some authorities suggest that insecticidal soaps should be used only in nonbearing orchards. Russeting problems appear to be linked to quality problems in soap formulations produced before 1992. To minimize any risk of fruit damage in bearing orchards, use only M-Pede, not older soap products. Oils and soaps must be mixed at the proper dilution (1 to 2 percent); concentrated sprays will be less effective and more phytotoxic. Deposits of large droplets or the coalescing of droplets on fruit or foliage also increases the likelihood of leaf damage and fruit blemishes.

**Mitac (amitraz):** This formamidine insecticide- miticide is available as EC and 50 WP formulations for use on pears to control mites and pear psylla that are resistant to organophosphates and pyrethroids. Not effective in cold weather. Apply when temperatures exceed 60°F. Signal word: Warning.

**Morestan (oxythioquinox):** Morestan is formulated as a 25% WP in water-soluble packets and registered for control of mites and mite eggs on apple and pear (fruit-bearing) trees in pre-bloom sprays (delayed dormant, pre-pink, or pink). It is also effective against pear psylla nymphs and assists with early-season powdery mildew control. Do not apply after first bloom. Can also be applied post-harvest. It can be used on apricots as a post-harvest application for mites. This product can be applied to nonbearing cherry, nectarine, peach, plum, and prune trees, but not to trees that will bear fruit within 1 year of application. Signal word: Caution.

**Provado (imidacloprid):** Provado is a 1.6 lb/gal. flowable formulation and is registered for post-bloom control of leafhoppers, San Jose scale, leafminers, and aphids. Applications timed at petal fall will provide greatest leafminer control. Indications are that Provado does not affect beneficial insects severely in apples. These products show some systemic or translaminar activity. With foliar applications, good coverage of the foliage is needed for optimal control. Provado is highly toxic to honeybees, so sprays must be applied after petal fall and should not drift onto flowering weeds. Signal word: Caution.

**Pyramite (pyridazinone):** Pyramite is registered as a 60% WP in water-soluble packets for control of European red mites and two-spotted spider mites on apples and the same mites as well as pear psylla on pears. While all stages of mites are affected, Pyramite is most effective against immature motile stages. Pyramite provides long residual activity and is highly toxic to mite predators.

**Savey (hexythiazox):** Savey is formulated as 50% WP and registered as an ovicidal miticide on apples and pears. Target species include European red and two-spotted spider mites. It works best when applied to eggs or young mobile stages. It is not effective against older nymphs or adults. Savey is limited to one application per year, with best results achieved with application at petal fall on pears. It must be applied prior to bloom on apples. There are no direct effects on predatory mites or bees. Keep in mind that Apollo and Savey have very similar modes of action, and both should not be used in the same season because of resistant-management concerns. Signal word: Caution.

**Superior Oil:** Superior-type oils are highly refined to eliminate most possibilities of oil toxicity to leaf tissue and yet give a maximum insect and mite control. Best control is found to be for dilute spray applications. Thorough coverage is important for good control. Do not apply when temperatures are near freezing during the 24 hours before or after the application is to be made.

**Vendex (hexakis, fenbutatin-oxide):** Both formulations, 50% WP and 4 L, are reported to give long residual control of mites on apple, cherry, peach, pear, plum, and prune trees. Both formulations can readily be dispersed in water and can be used in conventional dilute or concentrate sprayers, even when honeybees and/or beneficial mites are present. Vendex is relatively nontoxic to bees and predator mites. This product is corrosive and may cause skin irritation, respiratory irritation, and eye damage. Do not apply through an irrigation system. Vendex is relatively slow-acting. Signal word: Danger.

**Table 17. Effectiveness of selected insecticides and miticides against peach pests.**

| Material | Green peach aphid | Plum curculio | Tarnished plant bug | European red mite | Cherry fruit flies | Oriental fruit moth | Peachtree borer | Lesser peachtree borer |
|---|---|---|---|---|---|---|---|---|
| Ambush | G | G | E | - | E | E | G | G |
| Apollo | - | - | - | E | - | - | - | - |
| Asana XL | G | G | E | - | E | G | E | E |
| Carzol | - | - | G | E | - | - | - | - |
| Diazinon | G | G | G | - | G | E | E | E |
| Endosulfan | - | - | - | - | - | - | E | E |
| Guthion | P | E | G | - | E | E | G | G |
| Imidan | P | E | G | - | E | E | G | G |
| Kelthane | - | - | - | E | - | - | - | - |
| Lannate | E | G | G | - | G | E | F | F |
| Lorsban | - | - | - | - | - | - | E | E |
| Penncap-M | P | E | E | - | E | E | G | G |
| Pounce | G | G | E | - | E | E | G | G |
| Sevin | P | F | F | - | G | G | F | F |

Rating system; E = excellent, G = good, F = fair, P = poor, - = not rated.

# Orchard Herbicides

**2,4-D Amine:** This systemic post-emergence broadleaf herbicide is absorbed by foliage and translocated to other parts of the plant. Growth regulator type of action causes abnormal growth and death of susceptible plants. Used in apple and pear orchards to control orchard floor perennial broadleaf weeds such as dandelion, etc. Must be applied as a directed spray at low pressure to eliminate drift because the fruit trees are also susceptible to the herbicide. Do not allow spray to contact leaves, fruit limbs, or trunk as injury will result. It is best applied after harvest. 2,4-D is almost impossible to remove completely from sprayers. Do not use 2,4-D in a sprayer which will later be used for foliar application to fruit crops. Do not use 2,4-D if grapes are grown nearby.

**Casoron, Norosac (dichlobenil):** A pre-emergence herbicide controlling both seedling broadleaf and grassy species. Dichlobenil should be applied in the dormant season. Dichlobenil is usually available as a

**Table 18. Insecticide and miticide efficacy guide for apple pests.**

| Material | Apple maggot | Plum curculio | Codling moth | Red-banded leafroller | Green fruitworm | Rosy apple aphid | Green apple aphid | Woolly apple aphid | San Jose scale | Tarnished plant bug | Spotted tentiform leafminer | | White apple leafhopper | European red mite | Two spotted spider mite | Apple rust mite | Predator mites |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | Adult | Larva | | | | | |
| AgriMek | - | - | - | - | - | - | - | - | - | - | - | E | G | E | E | G | MT |
| Ambush | E | G | E | E | E | F | F | - | - | E | E | P | G | - | - | E | HT |
| Apollo | - | - | - | - | - | - | - | - | - | - | - | - | - | E | E | P | ST |
| Asana | E | G | E | G | E | F | F | - | G | E | E | P | G | - | - | G | HT |
| Carzol | - | - | - | - | - | - | - | - | - | - | G | - | E | G | G | G | HT |
| Dimethoate | G | F | G | F | P | G | E | E | G | - | - | P | G | F | F | F | ST |
| Diazinon | G | F | G | G | F | F | G | G | G | P | - | F | F | - | - | - | ST |
| Guthion | E | E | E | G | F | P | P | F | F | P | P | - | P | - | - | - | ST |
| Imidan | E | G | E | G | F | P | F | F | F | P | P | - | F | - | - | - | ST |
| Kelthane | - | - | - | - | - | - | - | - | - | - | - | - | - | F | F | F | HT |
| Lannate | F | F | G | E | G | G | G | - | - | G | G | E | E | - | - | - | HT |
| Lorsban | G | F | G | E | G | G | G | E | E | P | P | F | P | - | - | - | MT |
| Morestan | - | - | - | - | - | - | - | - | - | - | - | - | - | G | G | G | - |
| Oil 70 Sec. | - | - | - | - | - | F | F | - | E | - | - | - | - | E | E | P | ST |
| Penncap-M | E | G | E | E | G | G | F | G | E | F | P | P | F | - | - | - | ST |
| Pounce | E | G | E | G | E | F | - | - | - | E | E | P | - | - | - | E | HT |
| Pyramite | - | - | - | - | - | - | - | - | - | - | - | - | G | E | E | - | HT |
| Provado | - | - | - | - | - | G | G | - | - | - | - | E | E | - | - | - | MT |
| Savey | - | - | - | - | - | - | - | - | - | - | - | - | - | E | E | - | ST |
| Sevin | G | G | G | F | F | F | G | P | F | - | - | - | G | - | - | - | HT |
| Thiodan | - | F | F | F | G | G | G | E | F | G | E | P | F | - | - | E | ST |
| Vendex | - | - | - | - | - | - | - | - | - | - | - | - | - | F | F | F | ST |
| Vydate | - | - | - | - | - | G | G | - | - | - | - | G | G | G | G | G | HT |

Rating system: E = excellent, G = good, F = fair, P = poor, - = not rated for this insect or mite, HT = highly toxic, MT = moderately toxic, ST = slightly toxic.
NOTE: Rating system is based on moderate insect pressure; heavy pressure may require higher dosages, shorter spray intervals, or both.

4 percent granular material. Care must be taken to apply uniformly, especially on young trees. A tractor-mounted granular spreader is desirable for uniform application. Dichlobenil can evaporate rapidly at higher temperatures, so shallow incorporation or rainfall after application would be helpful. Seed germination and growth of young seedlings are inhibited. The emerging sprouts of some perennial weeds are inhibited at higher dosages. When fall- or winter-applied at 6 lb of active ingredient (150 lb of 4 percent granules) per acre this product can be expected to control weeds and grasses until late summer. Regrowth of weeds at this time may be desirable to slow down growth of trees in preparation for winter.

**Devrinol (napropamide):** Devrinol is a pre-emergence herbicide that can be used in newly planted or bearing orchards. It is most effective on annual grasses. It must be applied to weed-free soil or supplemented with a post-emergence herbicide. Devrinol is quickly decomposed by light and must be incorporated by tillage, rainfall, or irrigation within 24 to 48 hours of application. Because of the need for incorporation, Devrinol has limited application for tree fruit plantings.

**Fusilade (fluazifop-p-butyl):** A post-emergence grass herbicide. Fusilade is not effective on broadleaf weeds. Should be used in about 25 gal. of water per acre with a crop oil concentrate or nonionic-surfactant (check product label). Should be used on actively growing grasses generally less than 6 to 8 inches tall. Cannot be expected to control annual bluegrass or grasses that have overwintered. Labelled only for nonbearing fruit trees that will not bear a crop within 1 year of application.

**Goal (oxyfluorfen):** At lower rates, Goal is a post-emergence herbicide for control of broadleaf weeds. At higher rates, it is a post-emergence and long-term pre-emergence material. It is registered for use in apple, pear, peach, plum, cherry, and prune orchards. Can be tank-mixed with certain other pre-emergence materials for broader spectrum control (see label). Can also be combined with paraquat or glyphosate for post-emergence weed control. Goal must be applied only between October 1 and February 15 to avoid potential plant injury.

**Gramoxone Extra (paraquat):** A post-emergence nonselective herbicide. Effective in killing most annual weeds and grasses when applied to actively growing weeds less than 4 to 6 inches in height. Helps to suppress some perennial weeds by killing top growth. Weed kill is very rapid under high temperatures. There is no residual action, and new seedlings or new growth may emerge from perennial weeds. Acts as a chemical hoe. Thorough coverage of foliage is necessary, and the addition of a wetting agent or spreader will enhance effectiveness. May be combined with pre-emergence herbicides for season-long weed control. Do not allow spray to contact foliage, fruit, or stems of plants as severe damage may result. Do not allow spray to contact immature, green bark of trunk as damage will result. Paraquat is very toxic to humans. Extreme care should be taken to prevent any contact with the concentrated material. Inhalation of spray mist can be hazardous. Never save paraquat in an unlabeled container or a food-type container. Gramoxone Extra is a restricted-use material.

**Karmex (diuron):** A pre-emergence annual grass and broadleaf weed herbicide. Applied in spring at the recommended dosage to weed-free soil, Karmex can be expected to provide season-long control. Use only on established trees.

**Kerb (pronamide):** Kerb is a pre-emergence herbicide primarily for annual and perennial grasses and certain broadleaf weeds. It is not effective on some of the broadleaf weeds. Should be applied to weed-free ground in the cool season after harvest in the fall but before the leaves drop and the soil freezes. Under dry conditions, added moisture will improve effectiveness. Sensitive to soil type, with lower rates for light-colored sandy soils and higher rates for darker soils with more organic matter. Not effective on organic soils.

**Poast (sethoxydim):** Poast is a post-emergence grass herbicide that controls most annual and perennial grasses. It is not effective on broadleaf weeds. Cannot be expected to control small grain plants that have tillered or overwintered. Should be used with a crop oil concentrate or nonionic surfactant (check product label). Apply on actively growing grasses 4 to 6 inches tall. Do not apply under trees that will be harvested within 1 year of application.

**Princep (simazine):** Princep is a pre-emergence herbicide that is effective on germinating seeds and young seedling plants. It can be combined with a post-emergence material for broad-spectrum control. When applied in late fall or early winter after harvest, no post-emergence herbicide is necessary, and Princep will control annual weeds and grasses and, to a large extent, the perennial grasses. Princep is sensitive to soil type, with lower rates suggested for lighter soils with less organic matter and higher rates for darker soils with more organic matter content. Do not apply to newly planted trees.

**Prowl (pendimethalin):** Prowl is a pre-emergence herbicide registered for nonbearing fruit trees only. Apply to weed-free soil. It controls most annual grasses and certain broadleaf weeds. Controls germinating seed, but will not control established weeds. Requires 1/2-inch of moisture from rainfall or irrigation within 7 days after application to incorporate.

**Rely (Glufosinate-ammonium):** A post-emergence nonselective contact herbicide that is slightly systemic. Cleared on bearing and nonbearing apples, but not on trees within 1 year of transplanting. Avoid contact with the fruit tree foliage or green bark. Controls a wide range of annual and perennial broadleaf weeds and grasses. Can be applied with a wick or as a broadcast or spot spray.

**Roundup Ultra (glyphosate):** A post-emergence nonselective herbicide, Roundup Ultra will control both annual or perennial weeds. It is foliar-applied and translocates downward to the root system. For this reason, it is best applied close to bloom or late in the season when weeds are growing actively and translocating carbohydrates downward. Application too early may result in regrowth of weeds. Effective in control of such perennial weeds as Canada thistle, field bindweed, etc. It is inactivated rapidly on contact with soil. Do not allow contact with any part of the fruit plant, especially when applied late in the season as severe damage may result. Frequently symptoms of glyphosate damage do not appear until growth begins in the spring following application. Contact with suckers or low limbs after about July 1 can result in selected branches having very small leaves the following season. Early-season contact to suckers around base of tree does not usually cause damage.

**Sinbar (terbacil):** Sinbar is a pre-emergence herbicide that is effective on germinating seeds and on young seedling plants. It is a very stable material that has long residual life, so buildup in the soil can occur. Because of the long residual period, do not use on orchards that will be removed and planted again within 2 years. Sinbar moves readily in sandy soils and can result in damage to fruit plants. Do not use on soils having less than 1 percent organic matter. Trees must be established at least 3 years.

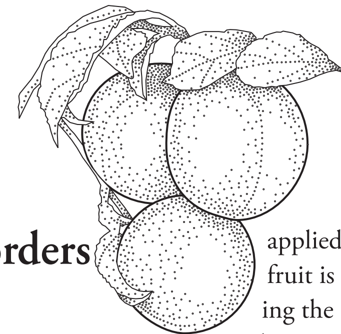
**Solicam (norflurazon):** This pre-emergence broad-spectrum herbicide is registered for most fruit crops. See the current spray guide for crops and rates. Solicam is not effective on emerged weeds, so it must be applied to weed-free soil or combined with a post-emergence herbicide. Solicam is more effective on grasses than broadleaf weeds, and combinations with other herbicides will improve overall results. Solicam needs 1/2-inch of rainfall to be activated. Do not use on very coarse soils as root damage may result.

**Surflan (oryzalin):** This pre-emergence broad-spectrum herbicide will control most annual grasses and some broadleaf weeds. It is labeled for most fruit crops. See the current spray schedule for crops and rates. Must be applied on weed-free soil or combined with a post-emergence herbicide. Check labels for suggested tank-mixes. Surflan needs 1/2-inch of rain to move it into the soil and to activate it. Can be used safely on both established and newly planted trees after the soil has settled around the trees.

**Touchdown (Sulfosate):** A systemic nonselective post-emergence herbicide. Effective when foliarly applied in controlling a wide range of broadleaf, annual, and perennial grasses and some woody perennials. Requires a nonionic surfactant and may be applied as a broadcast, band, spot, or wick application. Can be tank-mixed with labeled pre-emergence herbicides for residual control. Cleared on nonbearing trees up to 1 year prior to harvest. Avoid contact with the fruit trees or serious injury can occur.

CHAPTER 7

# General Orchard Management



## Preventing Apple Disorders

### Storage Scald on Apples

Storage scald is a physiological disorder of apples that results in a brown discoloration of the skin. It is usually a problem only when apples are held in long-term storage. The disorder usually does not extend below the skin, but the skin discoloration makes fruit unmarketable. Cultivars differ in susceptibility to scald. Susceptible cultivars include McIntosh, Cortland, Red Delicious, Stayman, Turley, and Rome Beauty. Other cultivars can occasionally develop scald.

#### *Conditions that may result in increased scald include:*

- Hot temperatures in the pre-harvest period;
- Overloading storage at harvest time, resulting in slow cooling; and
- Harvesting and storing fruit that is too immature.

#### *Scald incidence can be minimized by considering the following:*

- Pick fruit at optimum maturity for long-term storage;
- Get fruit cooled to storage temperature as quickly as possible; and
- Promote good color development on fruit by the optimum harvest time, e.g., avoid excessive vegetative growth, high nitrogen levels, and excessive pruning that results in heavy growth and shading.

**Control:** Diphenylamine (DPA) can be found in the U.S. as "No Scald DPA EC-283" 31% a.i. from Elf Atochem North America and "Shield DPA" 15% a.i. from Pace International LP. It can be applied only as a post-harvest drench. See product label for rates.

The drench should be applied within 7 days after harvest (before storage) and is more effective when applied to warm, dry fruit. Results are poor if fruit is cooler than 50°F. Scald is initiated during the first 30 to 40 days of storage for some cultivars, and after this time, treatment with DPA may have no beneficial effects. Do not mix calcium chloride or other chlorine products with DPA as they may react with the DPA. Drench fruit thoroughly by dipping the entire container or by overhead drenching of the containers long enough to cover fruit thoroughly, but not to exceed 30 seconds. Be sure the DPA solution is well drained out of containers, or fruit injury may result. Tilt bins if necessary. Do not use bins with liners. Wash and brush fruit either before treatment or after storage. Follow label instructions for rates for each cultivar. Some cultivars are more easily injured by DPA than others. Do not treat too much fruit with a batch of solution. The solution should be replaced with a fresh solution daily or more often if it becomes dirty, usually after dipping 30 bins (750 bushels) in 100 gal. of solution. Keep solution well agitated to avoid stratification. Test kits are available from the company from which the DPA was purchased for testing solution concentration. Test concentration of solution daily and adjust the chemical concentration in the treatment solution (Table 19). Do not rinse apples after treatment. Cool fruit as rapidly as possible after treatment.

If apples are to be shipped to another country, a determination needs to be made if the country will permit the sale of treated fruit. The statement "Treated with

**Table 19. Recommended concentration for DPA solution.**

| DPA (ppm)[a] | Cultivar |
|---|---|
| 1,000 | Rome Beauty, Turley |
| 1,111 | Baldwin |
| 1,000-1,500 | McIntosh |
| 1,500-2,000 | Stayman |
| 2,000 | Cortland, Delicious, Idared, R.I. Greening, Fuji |

a DPA is not recommended for Golden Delicious.

Diphenylamine to retard spoilage" is required on the shipping container in the U.S. Fruit treated with DPA may not be used for livestock feed, as illegal residues may occur in meat or milk.

**Disposal:** DPA cannot be discharged into lakes, streams, or rivers since it is toxic to fish. Disposal should be in a manner recommended by the manufacturer. Common methods of disposal include spraying the diluted DPA on the orchard floor (not to exceed 1,200 gal./acre), disposal into a plastic-lined evaporation pond, or disposal through a commercial waste treatment company.

## Internal Breakdown

Internal breakdown is characterized by a browning of the flesh of the fruit and eventual softening and disintegration of the fruit. It is increased substantially by delayed harvesting. Fruit should be harvested at the optimum stage of maturity. Late-harvested fruit should be marketed promptly to minimize breakdown problems. Cultural practices that increase nitrogen levels and decrease calcium levels can increase breakdown problems.

**Controls:** Harvest promptly at the optimum maturity and market in a timely fashion. Harvesting at pressure tests of 12 lb or more for Red Delicious will help. Calcium sprays or dips as discussed under "Cork Spot and Bitter Pit" also can be helpful.

## Cork Spot and Bitter Pit

Cork spot and bitter pit are physiological disorders of apples generally caused by calcium and/or boron deficiency during the fruit development period or the storage period. Cork spot is characterized by greenish to brown sunken spots on the fruit or in the fruit flesh. Spots can occur in midseason. The spots themselves are brown, corky, dead tissue. Typically, spots are grouped on the distal part of the fruit close to the calyx. If spots are present throughout the flesh, boron deficiency is probable. If spots are limited to the outer flesh, calcium deficiency is suspected.

Severity of cork spot varies from year to year. Excessively wet or dry periods in the spring resulting in inadequate uptake of calcium or boron can increase severity of the problem. Cork spot is more severe on trees that are coming into bearing, that have light crops, or that were heavily pruned or excessively fertilized with nitrogen. Soils that are too low in pH or in available calcium are conducive to cork spot or bitter pit.

**Controls for Cork Spot:** Cultural practices which increase pH to 6.2 to 6.5 and increase available calcium and boron to optimum levels will minimize cork spot and bitter pit. Adequate boron nutrition will help reduce cork spot. Be careful with soil applications as too much can be harmful. Where foliar analysis shows boron is deficient, soluble boron sprays at petal fall will be helpful. Calcium sprays will help to increase fruit calcium levels and thus help to reduce both cork spot and bitter pit. Early-season sprays are helpful in cork spot treatment, and late-season sprays are helpful with bitter pit. Many growers now include calcium chloride in all cover sprays after checking compatibility with pesticides. Generally 25 to 40 lb/acre per season or 3.2 to 5 lb/acre in each cover spray for eight sprays is necessary.

Bitter pit usually appears close to or after harvest and frequently after storage. Bitter pit is characterized as small, brown, sunken spots, with corky tissue under the spot, which are located around the calyx portion of the fruit. Jonathan spot is very similar to, or a form of, bitter pit.

**Controls for Bitter Pit:** Calcium chloride sprays before harvest can reduce bitter pit substantially. In addition, as with cork spot, severity of bitter pit can be reduced by lowering nitrogen levels, reducing the severity of pruning through annual moderate pruning, and promoting smaller size fruit through heavier cropping. Fruit should be harvested at optimum maturity. Harvesting immature fruit will promote bitter pit.

A post-harvest dip or drench of calcium chloride can reduce bitter pit substantially. Michigan research has shown that a 4 percent dip or drench of calcium chloride containing 33 lb of actual calcium chloride per 100 gal. of water will reduce the disorder or delay its development. The calcium chloride should be food-grade or technical-grade material. The treated fruit should be stored immediately. The calcium chloride must remain on the fruit. After storage, the fruit must be washed to remove the calcium chloride before marketing or processing. Apples with finish problems may be damaged by calcium chloride. Calcium chloride can be combined with DPA for scald control. Include a fungicide to minimize storage rots. Calcium chloride is corrosive to metal, so care should be exercised in providing good maintenance of equipment and containers.

### Measles (Internal Bark Necrosis)

This is a physiological disorder characterized by raised bumps or pimples on 2- and 3-year-old branches. The area in the cambial region under the bumps has brown to black necrotic streaks and spots. In severe cases, growth is reduced, and young trees may die. The problem is largely limited to spur-type Red Delicious trees. Measles usually results from either boron deficiency or manganese toxicity.

**Control:** Soil and foliar analysis can help determine possible causes. Boron sprays or soil applications can be helpful if needed. Excess manganese can only be reduced by raising soil pH in the root zone. Soil pH should be in the range of 6.0 to 6.5. On young trees, a degree of success can be obtained by injecting hydrated lime into the soil around the trees. Fifty pounds of hydrated lime is suspended in 100 gal. of water, and 5 gal. of this suspension is injected into the soil around the tree. A much better technique is to correct the orchard soil pH before the trees are planted, with a soil analysis and liming as needed.

## Tree Nutrition

A great deal of judgment is needed in managing the nutritional status of fruit trees, especially in applying nitrogen. Growth as well as production and fruit quality are useful indicators of nutritional status. The average length of terminal growth on bearing apple trees should be 6 to 10 inches; on peach trees, 12 to 20 inches. If the average does not fall within these ranges, both fertilizing and pruning practices should be modified.

### Leaf Analysis

Leaf analysis also helps in managing fruit tree nutrition. Leaf analysis (foliar analysis) is a more reliable indicator of a tree's nutritional status than soil analysis. Leaf samples should be taken between July 15 and August 15. Correct sampling techniques are essential for reliable results. Normal blocks are sampled every 3 to 5 years.

When a suspected nutrient deficiency or excess exists, take samples as soon as visual symptoms appear. Take samples both from trees where the suspected nutrient problem exists and from "normal" trees of the same variety, but keep the samples separate. The closer the "affected" and "normal" trees are together in the orchard, the better the comparisons will be. Do not include dead or severely affected leaves in the sample.

To increase the reliability of leaf analysis results, take leaves from different trees but from the same areas on the trees. Pull leaves from all sides of the trees in a band 4 to 6 feet above ground. Collect leaves from the middle of the current season's shoot growth, or if there is little or no shoot growth, collect spur leaves. Do not include the oldest or youngest leaves on a shoot. For one sample, collect four to eight leaves per tree from 25 trees of the same cultivar and apparent condition.

Avoid selecting dusty or soil-covered leaves if possible. Under normal conditions, rainfall is frequent enough to keep leaves fairly clean. If necessary, brush or wipe with a damp cloth to remove dust. If leaves are covered with spray materials, wash quickly in a mild detergent solution and rinse quickly in water. Do not let samples remain in the wash or rinse water very long. Contact your state Extension specialist for information on how and where to send the sample.

Soil conditions and nutrients available will vary widely from state to state, especially as soil pH changes. Inexperienced growers are advised to consult state Extension horticulture specialists to develop a fertilizer program.

## Nitrogen

The "rule of thumb" about nitrogen for apple trees is 1 oz of actual nitrogen (3 oz of 33 percent ammonium nitrate) per year of tree age up to 1 lb of actual nitrogen per tree. For peaches, the suggestion is 2 oz of actual nitrogen (6 oz of 33 percent ammonium nitrate) per year of tree age up to 1 lb of actual nitrogen per tree.

For example, the suggested amount for an 8-year-old apple tree is 8 oz of actual nitrogen or 24 oz (1 1/2 lb) of 33 percent ammonium nitrate; for an 8-year-old peach tree, 16 oz of actual nitrogen, or 3 lb (48 oz) of 33 percent ammonium nitrate.

The amount of nitrogen applied should be adjusted according to the vigor and performance of the tree, the variety, and the amount of pruning. Increase the amount of nitrogen for weak trees and reduce the amount for vigorous trees. When pruning is heavy, reduce the amount of nitrogen applied, or add no nitrogen for one season. Also, when low-temperature injury occurs, do not apply nitrogen fertilizers.

Excess nitrogen increases fruit size and cork spot, but it delays maturity and seriously reduces color, sugar content, flavor, shelf life, and storage life. Excess nitrogen also increases the amount of pruning required and delays the hardening-off of the trees in the fall, making them more susceptible to winter injury.

A ground application of nitrogen is preferred to foliar feeding. If supplemental nitrogen is needed on red apple varieties, urea or calcium nitrate may be added to pesticide sprays. Apply during the period from pink to 30 days after petal fall. Use up to 5 lb of urea or up to 3 lb of calcium nitrate per 100 gal. of water. Do not use foliar applications on yellow apple varieties or on peaches or other stone fruits.

Ground applications of fertilizer may be made in the late fall, or in the early spring 4 to 6 weeks before bloom. Fall application frequently is more convenient because of the crush of pruning and other spring work. Numerous studies indicate little if any difference in effectiveness between fall and spring applications. The roots of fruit trees are active in nutrient absorption whenever the ground is not frozen, even though the tops are dormant. Peach growers may wish to apply half of the nitrogen in the fall or early spring and the other half about petal fall if a normal crop is present.

## Phosphorus

In the central states, very few leaf samples are low or deficient in phosphorus. Soils apparently supply adequate amounts of phosphorus for normal fruit tree growth without the addition of phosphorus fertilizer. If soil tests show low phosphate levels, the cover crop may need phosphate fertilization.

## Potassium

About a third of the leaf samples from commercial peach orchards and about a fourth of the leaf samples from commercial apple orchards in some midwestern states have been low in potassium. Harvested fruit removes considerable quantities of potassium. Each 100 bu of apples or peaches contain about 10 lb of potassium oxide ($K_2O$). Prunings also remove sizable amounts of potassium. Therefore, periodic maintenance applications of potassium are advisable.

For peaches, a maintenance application of potassium should be made each crop year. On soils with low available potassium (below 200 lb per acre by soil test), apples should also receive an annual maintenance application. If the soil has more than 200 lb of potassium per acre, apples should receive maintenance amounts every other year. Check the nutrition conditions by leaf analyses.

Potassium should be applied to the soil rather than the leaves, since the leaves do not absorb appreciable quantities of this nutrient. Either muriate of potash (0-0-60) or sulfate of potash (0-0-50) may be used. Potassium may also be applied in mixed fertilizers if the rates are adjusted to apply amounts equivalent to the rates suggested. A general suggestion for apples is 1 lb of muriate or sulfate of potash per tree for young trees, 2 lb per tree for dwarf or semi-dwarf trees in full production, and 4 lb per tree for large trees in full production. For broadcast applications, use 150 to 200 lb per acre.

For peaches, apply 1 lb of muriate or sulfate of potash per tree for young trees and 2 lb per tree for trees in full production; or apply 150 to 200 lb per acre broadcast.

Since the levels of phosphorus and potassium vary among geographic locations, preplanting soil tests are strongly advised.

### Boron

Boron is the minor element most likely to become low in central states apple orchards. So far, leaf analyses do not indicate a shortage of boron on peaches.

Boron is most conveniently applied to apple trees as a foliage spray. Boron is essential for pollen germination; therefore, the first application should be in the pink stage. Add 1 lb of Solubor per 100 gal. of water (2 lb per acre for low-volume sprays) to the pink spray, and again in the petal-fall spray. Do not exceed this amount. Excess boron can be toxic. Do not mix Solubor with calcium chloride.

### Calcium

Low levels of calcium in the leaves and fruit of apple trees are associated with the physiological disorders bitter pit and Jonathan spot. Although low levels of calcium are not considered to be the primary cause of these disorders, their severity is frequently reduced by increasing the calcium levels of the leaves and fruit.

Spray applications of calcium chloride are suggested, especially for varieties subject to corking disorders. Starting with the first-cover spray, add calcium chloride at the rate of 2 lb per 100 gal. of dilute spray (4 lb per acre for low-volume spray) until late July. Then increase the calcium chloride rate to 3 lb per 100 gal. of dilute spray (6 lb per acre for low-volume spray) for the later cover sprays.

During prolonged dry weather, eliminate calcium chloride applications to prevent an excessive buildup on the foliage, which may cause leaf burn. If there has been no rain for two calcium chloride applications, wait until rain washes the calcium chloride off before reapplying. Increasing the calcium chloride application rate just before harvest helps to prolong the shelf life and storage life of the fruit.

Adding calcium chloride to the regular insecticide and fungicide sprays should have no effect on the action of these materials. Likewise, the addition of calcium chloride to the regular sprays should have no adverse effect on the fruit finish. The commercial grade of calcium chloride (94% to 97% $CaCl_2$) at the rates added to cover sprays does not greatly affect spray water pH. Added to alkaline tap water, it tends to make the water less alkaline.

Calcium chloride is corrosive to metal. After spraying with calcium chloride, rinse the sprayer thoroughly, and hose down the sprayer and the tractor.

### Soil Reaction (pH)

Soil reaction (pH) affects fruit trees indirectly through its effects on the availability of several soil nutrients. In strongly acidic soils (pH below 5.0), the availability of phosphorus is reduced and the solubility of iron, aluminum, and manganese is increased so much that they may become toxic to plants. The pH of orchard soil should be kept in the 5.5 to 7.0 range through applications of agricultural lime.

Spray materials and fertilizers applied to fruit trees may cause the soil under the trees to become more acidic. In testing for pH, it is advisable to test samples taken under the trees separately from samples taken from the aisles. The soil under the trees may be more acidic and thus may require more lime than that in the aisles.

Young apple trees sometimes develop a condition called “measles” (internal bark necrosis) when the soil pH is 5.5 or below. Red Delicious trees are especially susceptible. Some growers have prevented or reduced the symptoms of measles by watering each tree with 5 gal. of a solution of 40 lb of hydrated lime in 100 gal. of water.

## Pollination

Pollination of flowers on all midwestern-grown fruit plants is required for fruit production. Viable seeds are required for fruit development in all fruits. In apples, pears, and quince, multiple seeds are required for good fruit development. In most fruits, self-pollination will result in the development of fruit. However, cross pollination is required for some cultivars of fruits.

In apples, pears, sweet cherries, and some plums, adequate numbers of pollenizer trees with compatible pollen must be provided throughout each orchard block to provide for pollination. Peaches and tart cherries do not require cross pollination.

Ideally, no tree should be farther than 100 feet from a pollenizer tree, and the nearer the pollenizer is to the main cultivar, the better the chances are of good pollination. Be careful that the cultivars used as pollenizers have viable pollen. Mutsu (Crispin), Sir Prize, Jonagold, Stayman, and a few others are triploids that do not have viable pollen, so they cannot be used as pollenizers.

In most blocks, double rows of pollenizer trees can be planted between rows of the main cultivar in a pattern such that the 100-foot requirement is satisfied. The double rows are suggested to improve management of the second or pollenizer cultivar. Because of the possibility of lack of overlap of bloom in some years, at least two pollenizer cultivars are suggested. Another pollination scheme is to plant a solid block of the main cultivar and interplant crabapple trees trained to a single slender spindle. Care must be taken to select crabapple cultivars that will bloom at or just ahead of the main cultivar. Extremely early-blooming cultivars such as Braeburn benefit from crabapple pollenizers. Most midwestern orchards grow enough fruiting cultivars that the cultivars can be interplanted to provide a satisfactory pollinating mix. Yet another configuration of pollenizers used is every third tree in every third row. This represents a minimum of supplied pollen, however, and it also creates management problems.

## Bees

Pollination is accomplished primarily by insects such as bees and wasps. The domestic honeybee is the most important insect pollinator for the fruit industry. Bees pick up pollen in the process of visiting flowers of the fruit plants. This pollen is redistributed in the course of the bees' travels to hundreds of flowers on each flight. Recent work in Michigan indicates that pollen exchange among bees in the hive is an important method of achieving cross pollination of fruit crops.

In placing bees in an orchard for pollination, it is suggested that at least one strong hive be used per acre of fruit. Strong hives with plenty of worker bees are much better than weak hives or package bees that have not been established. The number of bees will depend on the weather during bloom and the amount of viable pollen available. Rainy, cold, windy weather will reduce bee activity and result in poor pollination. Tree canopies that are open and admit adequate light will be most conducive to good bee activity. Very low humidity during bloom can reduce the time that flower stigmas are receptive.

Hives need not be placed individually across the orchard, but may be placed in groups of four to six hives where they may be more conveniently handled. Choose sites that are well distributed through the orchard, but that are also sunny and protected from wind. Bring bees in at about 10 to 20 percent bloom and remove after good pollination has been achieved or before the petal-fall spray is applied. Remove all competing bloom on the orchard floor or in adjacent spaces by mowing or chemical weed control so that the bees are not distracted.

For most growers it is probably better to rent bees unless the orchardist is interested in beekeeping as a separate enterprise. Bees may usually be rented for a reasonable fee, and the contractor will bring the bees into the orchard and remove them promptly when notified that the petal-fall spray is to be applied. The fruit grower must notify the contractor and must not spray with insecticides during the time the bees are in the orchard. A written contract would be desirable.

## Protecting Honeybee Colonies during Pollination

Mow orchard cover crops before placing hives in or near the orchard. This eliminates the availability of competing pollen and nectar plants and also reduces the risk of pesticide injury to bees.

After honeybees have moved into the orchard, no work should be done during honeybee activity which might interfere with pollination, such as overhead irrigation, pesticide application, or cultivation when dust will be excessive. These activities not only disturb bees, but they also interfere with normal pollen gathering, germination, and fertilization.

Provide an uncontaminated water supply for the bees. Notify neighboring farmers around the orchard of the dates the bee colonies will be placed in the orchard and for how long. Applying pesticides to plants that bloom near orchards and are attractive to bees should be done with caution.

## Chemical Fruit Thinning of Apples

Chemical fruit thinning of apples enables growers to overcome the alternate bearing habits of some cultivars and to improve the size and quality of the fruit in years of heavy set. The materials suggested are Accel (benzyladenine), NAA (naphthaleneacetic acid), Amid-Thin (naphthaleneacetamide), and Sevin (carbaryl). Suggested materials and dosages for the different varieties are given in your state's tree fruit spray guide.

Because of variability of chemical thinner response, it is recommended that growers use all thinners on a trial basis until they become experienced. If seed numbers are small, or trees are weak, or if the weather is cool and cloudy, use lower concentrations of thinner chemicals. Also, remember that young trees are generally easier to thin than mature trees. All thinner applications should be based on average fruit diameter. Average fruit diameter should be determined by measuring all growing fruitlets per cluster. Sample randomly selected clusters throughout the tree canopy and orchard. At least 100 fruitlets should be measured to calculate average diameter. Measure each cultivar separately. All hand-gun applications should be made to the point of runoff at a rate of chemical use that is one-third to one-half the rate recommended for an airblast application.

### Accel

Accel (benzyladenine) is a relatively new thinner that was introduced in 1994. Accel thins over a wide window, probably bloom to 30 days after full bloom, and is reported to promote cell division. It is labeled post-bloom (10 mm fruit size). It is a gentle, mild thinner and is dose-dependent. It can be applied to all cultivars; however, further testing is being done on some cultivars, and the latest label should be checked for the list of cultivars and rates. At the present time, Accel is not recommended to be used with NAA or NAD on the same tree within the same year. The combined use, in the same year, of Accel and NAA or NAD on Red Delicious has resulted in more pygmy fruit.

### NAA

On Lodi, Early Gold, and Transparent, a combination of NAA and Sevin applied at petal fall usually gives better results than either material alone. On Golden Delicious, some growers have had good results with the combination of NAA and Sevin applied at the normal time for applying NAA on Golden Delicious.

On Starkrimson and other spur-type Red Delicious strains, NAA has occasionally caused problems with pygmy fruit. Instead of dropping off, these seedless pygmy fruit remain on the tree until harvest, growing to about one-fourth normal size. Where pygmy fruit presents a problem, Sevin should be used for thinning. Do not apply high NAA concentrators late in the thinning season.

When NAA is the only thinning agent applied, its absorption and effectiveness are greatly increased by use of an activator. The concentration of NAA can roughly be cut in half if Tween 20, Amway wetting agent, or Regulaid is used. These activators help to counteract the variable effects of weather conditions on the absorption and effectiveness of Amid-Thin and Sevin.

Because of variable growing conditions, NAA sprays are best timed according to fruit size rather than days after full bloom. NAA is most effective on fall and winter varieties when most of the fruits are 8 to 10 millimeters in diameter, the king blossom fruit is 10 to 13 millimeters, and the smallest fruits are less than 8 millimeters.

### NAD

NAD is similar to NAA, but milder. Its use should be limited to petal fall as later use can result in pygmy fruit. It is recommended for use on cultivars that ripen before McIntosh and works best when applied under slow drying conditions. Frequently, follow-up thinning is required.

## Sevin

XLR Plus is the preferred formulation of Sevin for thinning. Sevin, an insecticide, is toxic to bees, and they should be removed from the orchard before use. Sevin is dose-dependent up to a point; however, it seldom over-thins. It can be used from petal fall to about 21 days after bloom. It is frequently combined with Accel or NAA for heavy thinning late in the thinning window. The limit is about 25 millimeters fruit size. Over-thinning has been reported with these combinations, so local experience is the best way to determine rates.

**Important reminders about chemical thinning:** NAA generally gives best results under fast drying conditions, and when the temperature is between 70° and 75°F. Amid-Thin gives the best results under slow drying conditions and is often applied in the evening. Accel is most effective when air temperature is 70° to 75°F.

Thorough spraying and uniform coverage are necessary for satisfactory results. However, if you want to reduce the degree of thinning or are afraid of over-thinning, reduce the concentration but not the gallonage applied per tree.

Lower limbs are easier to thin than upper ones. Reduce the spray application on the lower limbs by shutting off one or more nozzles; some spray applied to the tree tops will fall on lower limbs.

Concentrate sprays of chemical thinners have been satisfactory. Care should be exercised that calibration is correct so that the right amount of material is applied to all parts of the tree and row. Be careful to avoid double applications to row ends, etc. Miscalculation of the sprayer manifold is magnified in concentrate application. Concentrating more than 4x has resulted in variable results and should be avoided.

Applying chemical thinning sprays after frost or freezing temperatures is risky. Foliage exposed to such conditions absorbs chemicals much more readily, and over-thinning may result. If you must spray under such conditions, reduce the concentration 25 to 30 percent.

Chemical thinners are generally more effective under the following conditions:

- low-vigor trees,
- light pruning,
- heavy bloom,
- poor pollination,
- high humidity before spraying,
- slow drying of spray,
- poor air drainage, and
- cloudy, cool weather preceding or following the bloom period.

You should keep records of the conditions prevailing when you make applications and should leave several trees unsprayed to evaluate critically the results of thinning applications. This way you will be able to work out the concentrations best suited for your orchard conditions.

According to Schwallier, "The weather during and just after the thinning application is the most important factor to consider in predicting the thinning response."

**Summary:** Apply thinning sprays separately from other sprays. When possible, use dilute concentrations with full coverage of the tree parts to be thinned. Low-volume application involves more risk. Growers having only low-volume spraying equipment should use the highest volume possible with these machines.

# Fruit Maturity Analysis

Starting 3 weeks before the anticipated harvest, select at random two fruit per sample tree, record the cultivar, then determine the following indices of maturity: skin color (striped or solid), seed color, soluble solids, fruit pressure, and starch-iodine test. Taste, dark brown seeds, skin color, and pressure tests in the 16 to 19 lb range indicate fruit ripeness.

**Starch-iodine Testing:** As fruit mature, starch is converted to soluble sugars. Iodine turns starch black; therefore, an iodine solution can be used to determine the amount of starch remaining in the fruit. A solution of 10 grams of potassium iodide and 2.5 grams of iodine in 1 liter of water should be used. During mixing and use of this solution, make sure the area is well ventilated—iodine fumes are toxic. This solution should be stored in a plastic or glass container as it is corrosive to metals. Providing the container is well stoppered, the solution will keep for long periods of time. Fruit should be cut in half through the equator and the cut surface dipped or sprayed with the iodine solution from a plastic spray bottle. The starch patterns will develop in approximately 1 minute. As fruit mature, starch clears from the core first, followed by the cortex. These patterns will be slightly different for each variety. The following photograph shows a generalized pattern that can be adapted for a given variety (Figure 8). Compare the starch iodine index of the fruit with those in Figure 8. The starch index at which fruit should be harvested depends on the intended length of storage. As a guide, fruit destined for storage should be harvested at a starch-iodine index of 4 to 5, whereas fruit for immediate sale should be harvested at an index of 6 to 7. As with any indicator of fruit maturity, the starch-iodine index should be used in combination with other maturity tests.

**Pressure-testing Fruit:** Pressure testing is one means to determine fruit maturity. A suitable sample will consist of 10 fruit selected at random from a number of trees within a block and from various locations within the trees. Two measurements should be taken on each fruit—one on the blush side and the other on the opposite side, at the midpoint of each side, after removing a 1/2- to 3/4-inch diameter disc of peel.

Use a 7/16-inch (large) plunger. Hold the fruit firmly in the left hand, while holding the fruit pressure-tester between the thumb and forefinger in the palm of the right hand. Set the indicator hand to zero and then place the plunger against the fruit, and press with increasing strength until the plunger tip penetrates into the pulp up to the notch.

Slow penetration of the plunger is essential. Sharp movements and sudden pressure application may impair your measurements. In order to avoid mistakes and to assure slow penetration of the plunger, hold the apple firmly and keep your arm rigid. You may want to hold the apple on a table for this.

**Soluble-solids Testing:** The soluble solids level in the fruit refers primarily to the fruit sugar level. The equipment needed includes a refractometer, paper towels or toilet paper, and a squeeze bottle of water. Clean the prism and cover it with water; then look through the instrument and adjust the refractometer to read 0 for the water if necessary. Clean and dry the prism, and squeeze a few drops of apple juice on the prism from the bottom portion of an apple not used in the starch-iodine test. Read and record the soluble solids (SS). Note the correction for the present temperature. Rinse and dry the prism between each reading. Usually the instrument will need calibration only once a day. It should be checked with water at the start of each site. Record one SS per apple pressure tested. Ripe Delicious apples usually have soluble solids of greater than 10 percent.

**Seed Color:** Seed color is recorded from the apples that are sampled above. Record seed color as white, light brown, dark brown, or black. Seeds from mature fruit will be dark brown to black.

## Getting Good Fruit Finish

Obtaining good fruit finish on apples is a perennial problem in the Midwest because of our variable weather patterns. A roughness of the skin, commonly called russet, is most likely to occur on Golden Delicious but sometimes affects other cultivars. Although russet does not affect the flesh, it detracts from the appearance of the fruit, thus reducing its value.

Weather conditions alone can cause russet, but most russet results from a combination of weather conditions and spray programs. Certain chemicals are more likely to cause russet than other chemicals when applied during certain weather conditions.

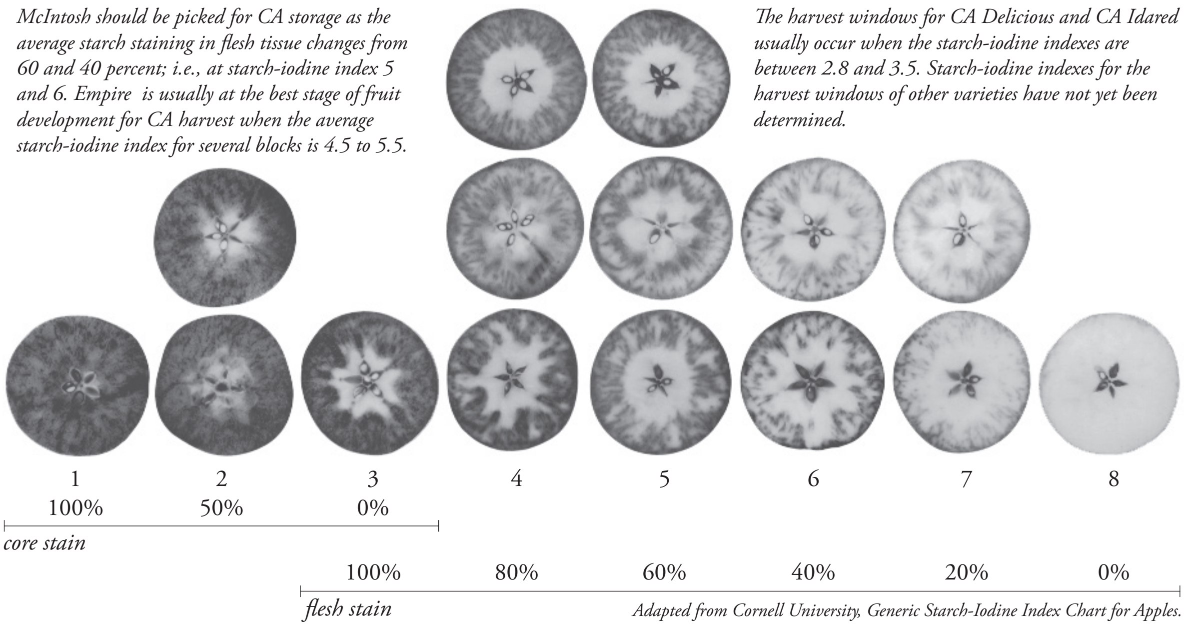
**Table 20. Anticipated days from bloom to harvest for a number of cultivars.**

| Cultivars | Days from Bloom to Harvest |
|---|---|
| Yellow Transparent | 70-90 |
| Lodi, Pristine | 75-95 |
| Mollies Delicious, RedFree | 120-125 |
| McIntosh, Cortland, Gala | 125-145 |
| Jonathan, Liberty, Grimes Golden, Empire, Red Delicious, Jonafree, Golden Delicious, Jonathan | 140-145 |
| Mutsu | 145-170 |
| York Imperial | 155-175 |
| Rome, Winesap, Stayman | 160-175 |
| Granny Smith, Fuji, Braeburn, Goldrush, Enterprise | 180-210 |

**Figure 8. Starch-iodine indexes for Red Delicious apples.**

*McIntosh should be picked for CA storage as the average starch staining in flesh tissue changes from 60 and 40 percent; i.e., at starch-iodine index 5 and 6. Empire is usually at the best stage of fruit development for CA harvest when the average starch-iodine index for several blocks is 4.5 to 5.5.*

*The harvest windows for CA Delicious and CA Idared usually occur when the starch-iodine indexes are between 2.8 and 3.5. Starch-iodine indexes for the harvest windows of other varieties have not yet been determined.*




*Adapted from Cornell University, Generic Starch-Iodine Index Chart for Apples.*

The most critical period for russet development is between the pink-bud stage and the third cover spray. But the period from the fourth cover spray until harvest is also important.

## *Some Precautions for Getting Good Finish:*

- Do not apply the bloom, calyx, or first two cover sprays within 24 hours before a predicted freeze, during a freeze, or within 24 hours after a freeze. Almost any chemical will damage fruit if used during these weather conditions. Cyprex is especially dangerous in freezing or near-freezing weather. To be completely safe, do not spray when temperatures are below 45°F, particularly in the lower elevations of the orchard.
- Do not use any copper materials (Bordeaux mixture, insoluble coppers) except during the dormant and delayed dormant periods.
- Do not apply cover sprays in the heat of the day. Never spray when the temperature is above 90°F. During the late spring and summer, spraying at night, in the early morning, or after 4:00 p.m. is suggested.
- Do not use sulfur in any form when the temperature is 85°F or above.

The suggestions given apply to all varieties but are most pertinent for Golden Delicious. Two additional precautions should be taken for this cultivar:

- Select fungicides that are least likely to cause injury. Captan, Polyram, mancozeb, Nova, and Rubigan are the best suggestions.
- The organophosphates are likely to cause injury in the petal-fall spray. Most orchards that are well cared for and in which other varieties are sprayed with an insecticide in the early petal-fall and first-cover periods probably could use fungicides only in these two sprays on the Golden Delicious and would have less cull fruit. Make sure the aphids are controlled before the pink-bud stage.

If disease, insects, or mites should become critical during any period when spraying might cause russet, then you will have to decide which is the lesser of the evils.

APPENDIX A

# Insect Degree-Day Models

The following are examples of degree-day models used to predict insect development and optimize timing of insecticide applications.

| Pest | Region | Threshold (° F) | Biofix | DD target | Event |
|---|---|---|---|---|---|
| Codling moth | Midwest | 50 | First sustained moth flight | 250 | 3% egg hatch; apply an insecticide |
| San Jose scale | Midwest | 51 | First scale capture in pheromone trap | 405 | Crawler emergence |
| Oblique-banded leafroller* | NY | 43 | First adult capture | 600 | Sample for second and third instar larvae |
| Spotted tentiform leafminer* | NY | 43 | Start of second generation flight | 690 | Sample for third generation sap feeding |
| Tufted apple bud moth* | PA | 45 | First sustained flight | 525-550 | 10% egg hatch; apply an insecticide and again in 300 DD |
| Oriental fruit moth* | CA | 45 | First moth captured | 387 | Egg hatch |
| Apple maggot* | NY | 43.5 | March 1 | 1130 | Emergence of adults |
| Pear psylla* | WA, OR | 41 | January 1 | 144 | Peak spring counts |
| Fruit-tree leafroller* | B.C. | 41 | February 1 | 277 | 50% egg hatch |
| Peachtree borer* | AR | 50 | January 1 | 1440 | Start of consistent trap catches |

* Many of these models have been developed outside of the Midwest, and they may need to be validated for use in this region.

APPENDIX B

# Sources of Pest Management Supplies

**Traps and General Equipment**

*Great Lakes IPM*
(for traps, lures, and other monitoring supplies)
10220 Church Street, NE
Vestaburg, MI 48891
(517) 268-5693

*Gempler's, Inc.*
(for traps, lures, and other monitoring supplies)
211 Blue Mounds Road, P.O. Box 270
Mt. Horeb, WI 53572-0270
(800) 332-6744

*Forestry Suppliers, Inc.*
(for magnifiers, Optivisors, tally counters, waterproof notebooks, stake flags, etc.)
P.O. Box 8397
Jackson, MS 39284-8397
(800) 752-8460

*BioQuip Products*
(for beating sheets, vials, magnifiers, etc.)
17803 LaSalle Avenue
Gardena, CA 90248-3602
(310) 324-0620

**Natural Enemies**

*ARBICO*
P.O. Box 4247
Tucson, AZ 85738
(800) 827-2847

*Beneficial Insectary*
245 Oak Run Road
Oak Run, CA 96069
(916) 472-3715

*Planet Natural*
(formerly Bozeman Bio-Tech)
P.O. Box 3146
Bozeman, MT 59772
(406) 587-5891

*G. B. Systems, Inc.*
P.O. Box 19497
Boulder, CO 80308
(303) 473-9144

*Rincon-Vitova Insectaries, Inc.*
P.O. Box 1555
Ventura, CA 93002
(800) 248-2847

*Stanley Gardens*
P.O. Box 913
Belchertown, MA 01007-0913
(413) 323-6196

A 31-page directory, *Suppliers of Beneficial Organisms in North America*, Charles Hunter, 1992.
Available from:

*State of California*
*Department of Pesticide Regulation*
*Environmental Monitoring and*
*Pest Management Branch*
*Attn: Beneficial Supplies Booklet*
*1020 N Street*
*Room 161*
*Sacramento, CA 95814*
(916) 324-4101

APPENDIX C

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