

A Field Guide to Tree Fruit Disorders, Pests, and Beneficials

A Cooperative Effort of the Pesticide Education Program
and the Tree Fruit Team

This guide includes common tree fruit disorders, pests, and beneficials. If you do not find what you are looking for, contact your local Penn State Extension educator. For more detailed recommendations, refer to the most recent Penn State Tree Fruit Production Guide.



PennState Extension

Integrated Pest Management begins with Regular Crop Monitoring

The modern approach to managing pests is referred to as integrated pest management (IPM). IPM involves timely observations of crop health and pest populations to ensure that management decisions are economically, environmentally, and socially sound. It



advocates integrating as many suitable pest management tactics as possible, including biological control (using one organism to control another by predation, parasitism, or competition), cultural practices (specialized pruning, orchard sanitation, planting disease-resistant varieties), insect behavior modification such as mating disruption, and the judicious use of pesticides. This field guide will help you identify common fruit disorders, pests, and beneficials and provide basic principles of IPM. For ease of use, the disorders are coded by the fruit type and the plant part where you may notice a symptom.

Basics of Insect Monitoring with Sex Pheromone Traps

The presence (or absence) of insect pest species in the orchard can be detected and monitored by a wide variety of traps and/or other methods, but the utilization of traps with an insect sex pheromone is probably the simplest and, at the same time, the most accurate way to monitor insect pests. Although various designs of traps work best for different pests, the general principle of how the average trap works is almost always the same: each trap needs to have a source of pheromone or attractant (usually rubber- or plastic-based lure/septa with incorporated sex pheromone and/or attractant), means to capture visiting moths (usually floor or liner coated with nondrying glue) and some kind of plastic or paper dome to protect the lure and floor.

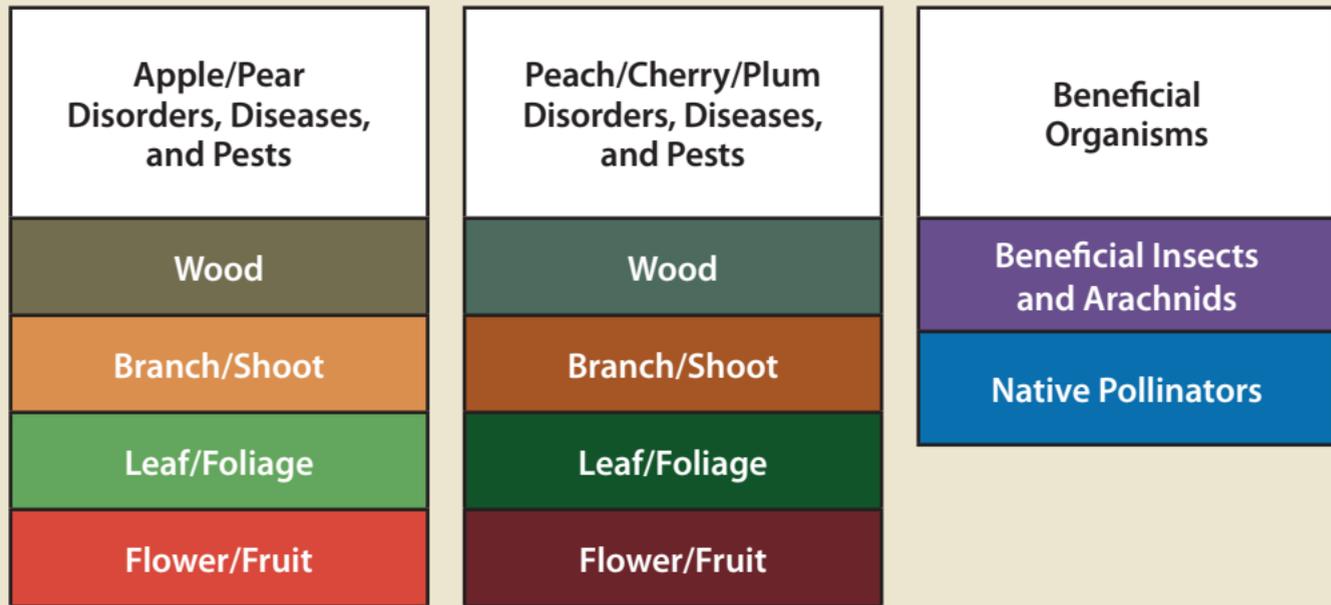
Record-Keeping

All IPM activities should be permanently recorded so they can be used for making decisions in subsequent years.

Fruit from the orchard at harvest time represents a cumulative record of insect and disease activity for the season. This record can provide valuable insight into how well an IPM program is working and what changes in the program need to be made the following year.

Contents and Color Codes

Many diseases and pests affect more than one plant part. The disorders in those cases are organized by the first plant part to monitor for possible pests or symptoms. The description and management recommendations are all-inclusive.



Apple Wood – Crown/Collar/Root Rot

Fungi-like organisms in the genus *Phytophthora* are a major cause of tree death in orchards. The fungus requires high levels of moisture and cool temperatures for growth and reproduction; it grows best at temperatures around 56°F. Trees, therefore, are attacked at about blossom time (April) and during the onset of dormancy (September).

The fungus may infect apple trees in the following ways:

- collar rot – infection above the tree union
- crown rot – infection of the lower trunk and root bases
- root rot – infection of the root system

The most obvious symptom found on affected trees is partial or complete girdling of the trunk. Close examination shows reddish-brown, water-soaked areas of the roots and wood tissue. The necrotic area usually extends upward to the graft union. Old trees can tolerate this microorganism, whereas younger trees cannot.

Photo: J. Travis, Penn State



Crown/Collar/Root Rot

Cultural Disease Management

- Avoid poorly drained soils.
- Plant rootstocks with resistance to *Phytophthora*, such as M.9 and B.9. Cornell Geneva rootstocks have also shown resistance.

Chemical Disease Management

- Chemical management is successful when employed as a preventative treatment during excessive rainfall. Aliette, Ridomil Gold SL, and phosphorous acid/potassium phosphite products (e.g., Rampart, ProPhyt, Phostrol) are currently registered for *Phytophthora*-caused wood and root rots on apple and stone fruits. Refer to the label for specific use recommendations.

Apple (Peach) Wood – Apple Union Necrosis and Peach Stem Pitting

Apple union necrosis (top) and peach stem pitting (lower left) are both caused by tomato ringspot virus (ToRSV).

Apple trees infected with ToRSV normally begin to exhibit symptoms when they reach bearing age. Removal of the bark above and below the graft union reveals abnormally thick, spongy, orange-colored bark and a distinct necrotic line at the scion-rootstock union.

Peach trees infected with ToRSV have unusually thick and corky bark at below-ground portions of the trunk. When bark is removed from an infected rootstock, pits or grooves may be seen in the wood. The pitting may or may not extend across the graft union. Some affected trees may break off easily at ground level or below.

Photos: J. Halbrecht, Penn State;
I.M. Smith, EPPO, Bugwood.org



Apple Union Necrosis and Peach Stem Pitting

Disease Management

Since both diseases are caused by a virus, it is important to purchase certified virus-free trees and to manage broadleaf weeds such as dandelion that may provide a reservoir for the virus.

Tomato ringspot virus is transmitted by dagger nematodes. Nematode management prior to planting is necessary:

- Two years before planting, take soil samples from the site (preferably around early September) and send to a nematode clinic to determine the nematode species present in the soil.
- If dagger nematodes are present, remediate soil using biofumigation:
 - In early June, plant ‘Sudex’ (a sorghum x sudangrass hybrid variety of *Sorghum bicolor*). In mid-August, chop, macerate, and immediately incorporate into the soil.
 - In early September, plant ‘Dwarf Essex’ rapeseed. The goal is for the rapeseed to have developed a rosette by winter so that it will overwinter well.
 - The following spring, in mid- to late April, mow rapeseed with a flail mower and immediately plow down residue. Delays in incorporation of rapeseed or sudangrass into the soil reduce their efficacy for nematode control.

Contact Penn State Extension for assistance with submitting soil samples and for more details on biofumigation.

Apple Wood – Burr Knots

Burr knots are tight clusters of adventitious primordial roots occurring on the stems of exposed apple rootstock shanks. They may also occur higher up in the tree where the foliage is dense and allows moisture to be trapped against the trunk. They are most commonly found on rootstock shanks that have been exposed above the soil line. Since rootstocks are selected for their propensity to produce roots, they can develop on exposed areas of the rootstock. Some rootstocks, such as M.26, seem to have a greater tendency to produce them. Burr knots can be sites for insect pests (e.g., dogwood borer) to burrow into a trunk, which may result in tree decline and potential death.

Photo: T. Baugher, Penn State



Burr Knots

Reducing Burr Knot Occurrence

Prevent burr knots at the time of planting a new orchard by placing the bud union at the proper height—high enough to prevent rooting of the scion yet low enough to reduce adventitious root development. In recent years, some growers have been planting trees with the bud unions much higher than the traditional 3- to 4- finger width above the soil line in an attempt to induce greater tree size control. It is better to choose a more dwarfing rootstock and instead keep the graft union closer to the soil surface to reduce the chance for burr knots.

Photos: R. Crassweller, Penn State



Apple Wood – Winter Injury

Trunk splitting is a type of winter injury that may appear on the trunks of pome and stone fruit trees. The injury usually occurs on the southwest side and is often referred to as “southwest injury.” It occurs when the winter sun warms the trunk by as much as 30°F above the air temperature due to late afternoon exposure. When the sun drops below the horizon the bark temperature quickly drops, and this sudden change can result in bark splitting.

Photo: R. Crassweller, Penn State



Winter Injury

Preventing Trunk Splitting Injury

Painting tree trunks with white latex paint up to the lowest scaffolds will help reflect the sun's warming rays and prevent bark splitting. Alternatively, the use of white Tyvek tree trunk wraps can reduce the heating. The use of the Tyvek may also serve to reduce damage from voles.

Photos: R. Crassweller, Penn State



Apple Wood – Vole Injury

Damage from the feeding of voles on roots and trunk bark may easily go undetected until whole trees begin to decline. Voles are small rodents with short legs, stocky bodies, small eyes and ears, and short tails. Two species—the meadow vole (*Microtus pennsylvanicus*) and the pine vole (*Microtus pinetorum*)—damage fruit trees. Monitor orchards for vole runways and breather holes, and maintain a weed-free area around tree trunks. Meadow voles are 5.5 to 7.5 inches while pine voles are 4 to 5 inches long.

Photos: T. Baugher, R. Crassweller, Penn State



Vole Injury

Monitoring

Surface runways in grass groundcover indicate meadow vole presence. Vole droppings in runways are evidence of their activity. Place slices of apple in suspected runways and check after 24 hours for tooth marks that indicate level of incidence.

Biological Control

Encourage biological control whenever possible. Hawks, owls, foxes, and other wildlife feed on voles and help keep populations at low levels.

Habitat Modification

Repeated mowing limits both food and cover and exposes voles to predators. Too much delay between mowing results in excessive vegetation, which when cut, forms a thatch layer that protects voles. Establish vegetation-free zones under tree canopies extending at least 2 ft from tree trunks to discourage voles from getting established.

Population Fluctuations

Voles exhibit regular population fluctuations of about four-year intervals, and rodenticides may be needed as an additional control during peak population years.

Apple Branch/Shoot – Woolly Apple Aphid

Colonies of woolly apple aphid, *Eriosoma lanigerum*, may develop around leaf axils on sprouts or on new growth, particularly at abrasions or cuts, where they prevent injured bark from healing. They are often found on the crowns of trees just above the roots and may also develop in large knots on roots, where they can be more damaging.

Photos: K. Peter, D. Biddinger, Penn State



Woolly Apple Aphid

Biological Control

Effective biological control agents include a number of syrphid flies (*Heringia calcarata* and *Eupeodes americana*), whose larvae are predators, and the tiny wasp *Aphelinus mali*. Some pesticides, e.g., certain carbamates and pyrethroids, encourage outbreaks by killing parasites and predators. These products should be used sparingly when woolly apple aphids are present.

Chemical Control

An application of a summer aphid treatment should control woolly apple aphids on shoots. There are presently no control methods for underground aphids. Trees may have only aerial infestations, without their roots becoming infested.

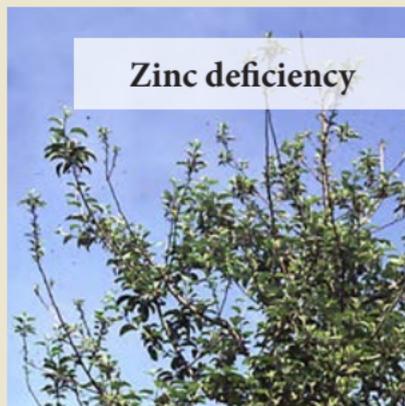
Cultural Control

The best control for woolly apple aphid is to select rootstocks with genetic resistance. Some rootstocks in the Cornell Geneva apple rootstock series are resistant, as are rootstocks from the Malling Merton series.

Apple Branch/Shoot – Micronutrient Disorders

Iron (Fe), zinc (Zn), and manganese (Mn) are micronutrients that are required by plants in smaller amounts than macronutrients such as nitrogen (N) and calcium (Ca). Fe deficiency is associated with high soil pH, and Mn toxicity, with low soil pH. Fe deficiency is observed on young leaves as a loss of green color between the veins. Zn deficiency appears as tufts of leaves on terminal shoots. Mn toxicity shows up as necrosis (both external and internal) on branches and is referred to as measles or internal bark necrosis.

Photos: R. Crassweller, Penn State



Micronutrient Disorders

Preventing Nutrient Deficiencies and Toxicities in Orchards

Pre-Plant Soil Analysis

Adjust fertility and pH to optimum levels prior to planting a new orchard, as lime and certain fertilizers move very slowly in soils. With some of the bitter pit-prone cultivars, such as Honeycrisp, it is especially important to adjust pH to 6.5 prior to planting your trees.

Regular Leaf Analysis in Established Orchards

Since orchards are a perennial crop, foliar analysis is the most accurate way to determine nutritional status. Collect samples from mid-July through mid-August. Randomly select 50 to 60 leaves from the mid-section of current season shoots (see example) of at least ten representative trees per orchard variety and block.

Visit your local Penn State Extension office to obtain soil or leaf analysis kits, and carefully follow instructions prior to submission of samples to the analytical lab.

Photo: R. Crassweller, Penn State



Apple Leaf – Apple Scab

Apple scab is caused by a fungus, *Venturia inaequalis*, that overwinters in infected leaves that have fallen to the ground. As spring approaches, spores within the leaf tissue begin to mature and are discharged during rainy periods into air currents and carried to developing apple buds. Leaf wetness and temperature are critical for infection. These ascospores (primary spores) can infect all plant parts, including leaf tissue, blossoms, and fruit. Lesions begin as dull, olive-green circular spots that eventually turn brown to dark brown. Scab is best managed when the “primary” period is disrupted. Ascospores begin to be released at green tip, peak from late pink through petal fall, and end around second cover. Once infection becomes established, conidia (secondary spores) are produced and infection will continue throughout the tree during the season. Severe early leaf infection can cause premature defoliation. Typical fruit lesions are circular, rough-surfaced, olive-green spots. Heavily infected fruits are usually misshapen and might crack and drop prematurely.

Photos: K. Peter, T. Baugher, Penn State



Apple Scab

Cultural Disease Management

- Plant resistant cultivars where possible, especially for organic production.
- Orchard sanitation through leaf removal is highly effective in reducing inoculum. Leaves can be flail mowed or chopped. Alternatively, 5% urea (42 lb of feed grade urea per 100 gal of water) will aid in leaf breakdown if applied in the fall as leaves are falling onto the orchard floor.

Chemical Disease Management

- Dormancy: Apply copper (2 lb of metallic copper per acre).
- Green tip through tight cluster:
 - Use fungicides in Fungicide Resistance Action Committee (FRAC) Groups 3 and 9 (and their premixes); tank mix with a rainfast mancozeb (3 lb per acre). Rotate fungicides by FRAC Group to prevent fungicide resistance.
- Pink through petal fall:
 - Use fungicides in FRAC Group 7 (and their premixes); tank mix with a rainfast mancozeb. Rotate FRAC Group 7 fungicides with FRAC Groups 3 and 9.
 - If frequent rain events occur, it is sometimes necessary to spray during light rain or mist to keep trees covered. Use mancozeb, captan, or sulfur during these periods.
- Post petal fall through second cover:
 - Use fungicides in FRAC Groups 3, 9, and 11. Rotate fungicides as necessary.
- Alternative fungicides: Potassium bicarbonate, sulfur.

Apple Leaf – Rust Diseases

The most common rust diseases to affect apple are cedar apple rust, *Gymnosporangium juniperi-virginianae*, and quince rust. Both diseases must spend part of their life cycle on red cedar. Spores are initially discharged by winds from orange gelatinous galls on cedars, starting at the pink bud stage and lasting a few weeks. Warm (55° to 77 °F), wet conditions favor disease; lesions on leaves appear 10 to 14 days after infection. Fruit symptoms take much longer. Symptoms first appear as small, pale-yellow to orange spots on the upper leaf surface. The spots enlarge, and tiny, black fruiting bodies become visible, often with orange-yellow pustules. Fruiting bodies on the undersides of apple leaves produce spores. These spores can be carried back to the red cedar by wind and rain, where they germinate and produce galls that bear spores that eventually reinfect apple trees.

Photos: T. Baugher, K. Peter, Penn State



Rust Diseases

Cultural Disease Management

If possible, remove cedar trees located near orchards to disrupt the alternate host phase of the disease cycle.

Chemical Disease Management

- Apply mancozeb, ziram, or ferbam prior to an infection event at the beginning of the pink bud stage of apples and continue through first cover.
- Several FRAC Group 3 fungicides are labeled for rust control (refer to the label).
- Several FRAC Group 11 products are labeled for “suppression” only.
- Once rust lesions are observed on leaves and fruit, it is too late for control.
- Unfortunately, effective organic options are not available.

Apple Leaf – Marssonina Blotch

As with apple scab, spores of Marssonina blotch, *Marssonina caronaria*, overwinter in the previous year's leaves. Mature ascospores are found just before the bloom stage of bud development. Ascospore discharge usually lasts for three to four weeks. Rain is required for spore release. Primary symptoms appear in the middle of June, usually on mature leaves. Infection of leaves by conidia takes place most frequently at 68 to 77°F. Leaf spots first appear on the upper surface of mature leaves around the middle of June as small, black-purplish spots. Small, black acervuli are often visible on the surface. When lesions are numerous, they coalesce, the surrounding tissue turns chlorotic, and defoliation results. Severe defoliation may start in early summer. Fruit infection is uncommon and restricted to trees with numerous leaf infections.

Photos: K. Peter, Penn State



Marssonina Blotch

Cultural Disease Management

Sanitation through leaf removal is necessary to reduce inoculum from one year to the next.

Chemical Disease Management

- Fungicide applications used to control apple scab early in the season will help control for Massonina blotch. Broad spectrum fungicides such as mancozeb, ziram, and captan all work very well. Fungicides in FRAC Group 7 are the strongest. However, FRAC Group 3 and FRAC Group 11 fungicides are effective, especially when tank mixed with a broad spectrum fungicide.
- For organic management, sulfur is the best option to date.

Apple Leaf – Rosy Apple Aphid

The eggs of rosy apple aphid, *Dysaphis plantaginea*, begin to hatch in the spring when buds are at the silver tip stage. As soon as they hatch, the young seek out opening buds, seeming to prefer fruit buds. They feed on the outside of the bud clusters until the leaves begin to unfold. Then they work their way down inside the clusters to begin sucking the sap from the stems and newly formed fruits. Feeding causes the leaves to curl, affording the aphids protection from sprays and some natural enemies. If feeding on the leaves is not controlled, the nearby fruit will be small and misshapen (pygmy fruit).

Photos: G. Krawczyk, Penn State



Rosy Apple Aphid

Monitoring

Monitor fruit spurs for rosy apple aphid at early pink. Begin by inspecting blocks with a history of problems or sensitive varieties like Golden Delicious. Select five to ten representative trees, and for 3 minutes per tree, count the number of fruit spurs showing curled leaves due to aphid feeding. If more than one aphid-infested cluster is observed per tree, an insecticide treatment is justified to prevent fruit injury.

Cultural Management

Use pruning strategies that open up the tree canopy to make conditions less favorable for aphids and to improve spray coverage.

Chemical Management

Optimum timing for control of rosy apple aphid is at half-inch green and petal fall. Specific chemical recommendations are in the Penn State Tree Fruit Production Guide.

Apple Leaf – Tufted Apple Bud Moth

The tufted apple bud moth, *Platynota idaeusalis*, named for the tufted scales that can be seen on the tops of the wings, is a serious direct pest of apples. Bud moths deposit their eggs in an ovoid, apple-green mass consisting of as many as 150 eggs. After hatching, young larvae will cut the petiole of the leaf and cause the leaf to dry. Although the tufted apple bud moth belongs to a family of moths known as leafrollers, the leafrolling activity has little economic impact. It is when this insect webs a leaf onto the apple and feeds directly on the fruit that it becomes a pest. The importance of this pest has diminished in recent years due to the introduction of a number of codling moth control products providing excellent residual control of the tufted apple bud moth.

Photos: G. Krawczyk, L. Hull, Penn State



Tufted Apple Bud Moth

Monitoring

Install at least two or three plastic, delta-shaped sex pheromone traps in every block of apples of 5 acres or less. For blocks greater than 5 acres, use three or more traps. Attach each trap to a limb at a height of 5 to 6 ft in the outer third of the tree canopy. Place traps in the orchard by apple bloom time, and check traps every day until the first adult is caught. Record this date, and thereafter check the traps on the same day once a week.

Predicting Egg Hatch based on Degree Days

The number of accumulated degree days beginning with the first pheromone trap capture of an adult is closely related to egg hatch for both first and second brood. By monitoring orchard temperatures on a daily basis, a fruit grower can confidently predict the best time to apply an insecticide. The egg hatch period is a time when the larvae of this pest are most susceptible to insecticides.

Photo: G. Krawczyk, Penn State



Apple Foliage – European Red Mite

European red mite, *Panonychus ulmi*, causes injury to apple foliage by removing nutrients during feeding. A characteristic brown foliage that, in severe cases becomes bronze, results from heavy infestations. Several predators (described under “beneficials”) help control mites and reduce the use of pesticides.

Photos: K. Peter, D. Biddinger, Penn State



European Red Mite

Management

Predatory Mites

Pennsylvania's integrated mite management program for apples depends largely on the phytoseiid predatory mites *Typhlodromus pyri* (Scheuten) and *Neoseiulus fallacis* (Garman) to regulate pest mites to low levels during the cooler spring and late summer/fall months. Once established, *T. pyri* is capable of maintaining pest mite populations at very low levels if not disrupted by the use of toxic pesticides.

Scouting for Beneficial Mites

- Sample several trees in each block by examining the underside, mid-veins of 25 leaves per tree for fast-moving, tear-drop shaped mites with a hand lens (10 to 15x lens).
- The predatory mites will appear to be clear or slightly reddish, but not red or bright yellow in color or with spots.
- If you have a ratio of predator to prey of at least 1:10, biocontrol will suffice.

Apple Foliage – Honeycrisp Yellows

The Honeycrisp variety is sought-after by consumers, but it is one of the more challenging varieties to grow. Calcium-related disorders are discussed in the apple fruit section of this guide. A foliar symptom growers



will notice in mid- to late summer is a yellow mottling of leaves often referred to as “Honeycrisp yellows.” This is believed to be a physiological disorder associated with a build-up of carbohydrates from photosynthesis. It appears to be more severe on trees with light crops of fruit.

Photos: R. Crassweller, Penn State

Honeycrisp Yellows

Management

Honeycrisp yellows is a genetic characteristic of Honeycrisp believed to be caused by an excessive buildup of carbohydrates in the leaves. Since it is greatest on lightly cropped trees, maintaining crop loads of 4 to 6 fruit per square centimeter of trunk cross-sectional-area can help reduce the problem.

Other Leaf Disorders

In very rare cases you may see similar symptoms on other cultivars. Generally you will find that the symptoms are due to the presence of potato leaf hoppers, however, especially if the trees are young.

Another insect pest to monitor is Japanese beetle, since Honeycrisp is one of the first varieties to which Japanese beetle are attracted. Feeding causes leaves to become skeletonized. Inspect your Honeycrisp blocks first as Japanese beetles are emerging.

Apple Foliage – Necrotic Leaf Blotch

Sometimes confused with magnesium deficiency, necrotic leaf blotch is a physiological disorder seen on Golden Delicious and any cultivar where Golden Delicious is a parent, e.g., Gala. It appears to be most severe in seasons with widely fluctuating moisture and temperature conditions. Symptoms develop abruptly, and in waves, generally in late summer.

Photo: T. Baugher, Penn State



Necrotic Leaf Blotch

Management

Although no bacteria or fungi have been associated with necrotic leaf blotch, the disorder has been reduced where the fungicide ziram is used in the summer spray program. Foliar applications of zinc oxide also have been effective in reducing the severity of the disorder.

Careful Observation of Symptoms

The disorder is characterized by irregularly shaped necrotic blotches on the leaves, limited by the veins. These necrotic areas do not have spores, unlike necrotic spots caused by pathogens resulting in frogeye leaf spot, Marssonina blotch, and Alternaria spot.

Necrotic leaf blotch –
blotch confined by veins



Marssonina blotch –
blotches cross veins



Photos: K. Peter,
Penn State

Apple Flower/Fruit – Fire Blight

Fire blight bacteria, *Erwinia amylovora*, overwinter in the margins of cankers on branches and trunks. When the temperature reaches about 65°F, bacteria begin to multiply and are spread to blossoms, primarily by rain and insects. Blossoms are the most vulnerable to infection and need protection. Bacterial ooze appears on the new infections, providing additional sources of bacteria for new infections, primarily to young shoots. For blossom infections to occur, four criteria need to be met in the following order:

1. Open blossoms
2. An accumulation of at least 198 degree hours above 65°F
3. A wetting event such as dew or rain
4. An average daily temperature of 60°F

Photos: T. Baugher, K. Peter, J. Travis, Penn State



Fire Blight

Disease Management

- During dormancy, prune out all cankers, cutting apple limbs at least 8 to 12 inches below external evidence of the canker.
- At green tip, apply a copper spray aiming to have 2 lb per acre of metallic copper equivalent to kill bacteria on tree surfaces.
- When daily temperatures average 60°F or higher during bloom through petal fall, make at least two complete applications of a streptomycin formulation.
- For semi-dwarf trees and older dwarf trees that have filled their tree space, applications of prohexadione calcium (Apogee, Kudos) beginning at bloom are effective for mitigating shoot blight that may occur during the season.
- For newly planted or young dwarf trees, combining streptomycin with a product that stimulates the plant's immune system at bloom will help mitigate blossom blight and will offer some protection of growing shoots shortly after bloom. (Example: Actigard)
- Another option to mitigate shoot blight on young dwarf trees is low-rate copper applications. To prevent fruit injury, use in every other spray and be mindful of slow-drying conditions and the pH of the spray solution since acidic conditions increase copper phytotoxicity. (Example: Cueva)
- During the season, control piercing-sucking insects and scout regularly post-petal fall for fire blight infections. Prune out infections as soon as they are observed, cutting 8 to 12 inches beyond the visible site of infection.

Apple Flower/Fruit – Powdery Mildew of Apple

The fungus causing powdery mildew on apple, *Podosphaera leucotricha*, overwinters as mycelium (the body of the fungus) inside infected buds. During the growing season, the fungus attacks buds, blossoms, leaves, new shoots, and fruit. It interferes with the proper functioning of leaves, reduces shoot growth and fruit set, and produces a netlike russet on the fruit of some varieties. The spores are easily windblown. Fruit infection takes place during and shortly after the blossom period. Leaf and shoot infection may continue as long as shoot growth continues. Buds can become infected as they begin to form until they have matured for overwintering. Infections occur at temperatures of 65° to 80°F when relative humidity is high, such as at night. No moisture is required for spore germination to occur. Consequently, powdery mildew is often called the “dry weather disease.”

Photos: K. Peter, Penn State



Powdery Mildew of Apple

Disease Management

- There are no effective cultural management strategies to limit powdery mildew from one season to the next season.
- Where the disease is severe, mildew sprays should begin at the tight cluster bud stage and continue until new shoots stop growing (about fourth cover spray).
- Sterol inhibitor (SDHI) fungicides (FRAC Group 3 fungicides) applied to control apple scab are very effective in controlling powdery mildew. SDHI fungicides (FRAC Group 7) vary in their efficacy in mitigating powdery mildew; however, premix fungicides, such as those mixed with FRAC Group 11, have shown efficacy.
- Sulfur and potassium bicarbonate are alternative control options.

Apple Fruit – Black Rot and Frogeye Leaf Spot

The black rot and frogeye leaf spot fungus, *Diplodia seriata*, attacks the fruit, leaves, and bark of apple trees. The first signs of black rot are small, purple spots appearing on the upper surfaces of leaves and enlarging into circles $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter. Multiple small, black pycnidia may appear in the centers and can be viewed easily using a hand lens. Infected areas of branches and limbs are reddish brown and are sunken slightly below the level of surrounding healthy bark. Pycnidia form on dead wood of the cankered areas. Fruit rot generally appears at the calyx end of the fruit. There is usually one spot per fruit, a characteristic that distinguishes black rot from bitter rot. Another difference from bitter rot is that when cutting through the lesion, the decayed flesh will not be in the shape of a cone.

Photos: T. Baugher, K. Peter, Penn State;
A. Biggs, West Virginia University



Black Rot and Frogeye Leaf Spot

Cultural Disease Management

- Conduct dormant pruning to remove cankered wood, dead branches, and twigs that serve as inoculum sources and dispose of dead wood. This should be an important component of both current-season and long-range management.
- Prune and remove cankers at least 15 inches below the basal end; properly dispose of prunings by burial or burning.
- Remove all mummified fruit.
- Control fire blight during the growing season.
- Maintain healthy trees and prevent tree stress.

Chemical Disease Management

- Mancozeb, captan, and fungicides containing a strobilurin (FRAC Group 11) as an active ingredient are effective in controlling black rot on fruit. Begin applications during bloom.

Apple Fruit – Bitter Rot

Bitter rot on apple and pear fruit is caused by the pathogenic fungi in the *Colletrotrichum* genus. The fungus can penetrate the unbroken fruit skin. When a spore penetrates the skin, the infection will then go dormant (quiescent phase) for a period. During this time, the spore does not grow and is not susceptible to fungicides. Consequently, fungicides need to be applied prior to the initial infection by the spore. Bitter rot typically manifests in July and August, and fruit susceptibility increases as it begins to mature. By the time brown spots are $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter, they are distinctly sunken or saucer shaped. When they reach $\frac{1}{2}$ inch in diameter, small black dots, the fruiting bodies of the fungus, appear in the sunken lesion. These may be arranged in concentric rings. Later, they ooze a gelatinous, salmon-pink mass of spores, washed by rains to other fruit. When cutting through the lesion on the horizontal axis of the apple, the flesh is light brown and watery in a cone-shaped area, with the small end of the cone toward the fruit center. As a fruit ripens, it decays rapidly and finally shrivels into a mummy.

Photos: K. Peter, Penn State



Bitter Rot

Disease Management

- Cultivars vary in their susceptibility with the most susceptible being Rome, Honeycrisp, Jonagold, Empire, Nittany, McIntosh, and Liberty.
- Sanitation is important for any kind of fruit rot management. This includes removal of old cankers, dead wood, and mummified fruit and encouraging breakdown of brush.
- Full season management is necessary to prevent bitter rot. During bloom, closely monitor orchards for warm temperatures and frequent wetting events, which cause prolonged wetness hours.
- To date, the most effective products for managing bitter rot include mancozeb, captan, and pyraclostrobin (found in Merivon and Pristine). Aprovia and Fontelis (used at 20 fl oz per acre) have also shown efficacy.
- The pathogen is not sensitive to trifloxystrobin (Flint Extra and Luna Sensation), kresoxim-methyl (Sovran), thiophanate methyl (Topsin-M), FRAC Group 3 fungicides, FRAC Group 9 fungicides, and most FRAC Group 7 fungicides (except Aprovia and Fontelis).
- Tank mixtures of Merivon, Aprovia, or Fontelis and mancozeb are recommended for application from bloom through first cover (as at least two complete applications).
- Closely monitor rain events and prolonged wetness hours in the summer as well. During summer cover sprays, regular captan (3 lb per acre) applications are necessary. To control late season infections and postharvest rots, another application of Merivon is recommended near harvest.

Apple Fruit – White Rot

White rot is caused by a relatively weak fungal pathogen, *Botryosphaeria dothidea*, and is only problematic when the tree is stressed, such as due to drought, winter injury, insect damage, or fire blight. The fungus can cause fruit rot. New infections on twigs and limbs start to become evident by early summer, appearing as small circular spots or blisters, sometimes with an orange tint. As the lesions expand, the area becomes slightly depressed. Cankers stop enlarging in late fall and can be indistinguishable from black rot canker, making isolation of the pathogen necessary for correct identification of the causal organism. By spring small, black pycnidia, the spore-containing structures of the fungus, appear on the smooth surface of new cankers. Cankers exhibit a scaly, papery outer bark that is often orange. The scaly, papery bark can be easily peeled off the tree. Tissues beneath the canker surfaces are watery or slimy and brown. Most cankers are not deep, extending at most to the wood. As fruit infections, symptoms first appear as small, slightly sunken, brown spots that can be surrounded by a red halo. As the decayed area expands, the entire fruit may become rotten.



White Rot

Cultural Disease Management

- Conduct dormant pruning to remove cankered wood, dead branches, and twigs that serve as inoculum sources and dispose of dead wood. This should be an important component of both current-season and long-range management.
- Prune and remove cankers at least 15 inches below the basal end; properly dispose of prunings by burial or burning.
- Remove all mummified fruit.
- Control fire blight during the growing season.
- Maintain healthy trees and prevent tree stress.

Chemical Disease Management

- Mancozeb, captan, and fungicides containing a strobilurin (FRAC Group 11) as an active ingredient are effective in controlling black rot on fruit. Begin applications during bloom.

Apple Fruit – Sooty Blotch and Flyspeck

Sooty blotch and flyspeck are separate diseases, but both are normally present on the same fruit. Sooty blotch (a disease complex caused by several unrelated fungi) appears on fruit surfaces as sooty or cloudy blotches with indefinite borders. These blotches, which are olive green to black, can be removed by rubbing vigorously. Flyspeck, *Zygothiala jamaicensis*, looks like true “flyspecks” characterized by sharply defined, small, black, shiny dots in groups of a few to nearly 100 or more. Both fungi overwinter on the twigs of many woody plants as well as apple and pear. Fruit infection can occur any time after petal fall but is most prevalent in mid- to late summer.

To use the Brown and Sutton disease prediction model, count leaf wetness greater than four hours starting ten days after petal fall. The threshold to start treatment begins approximately at 220 hours of leaf wetness. Disease outbreaks are favored by extended periods of above-normal summer temperatures combined with frequent rainfall and high humidity. New infections can be observed as late as September.

Photo: K. Peter, Penn State



Sooty Blotch and Flyspeck

Cultural Disease Management

- Remove alternate hosts such as brambles from the orchard and surrounding hedgerows.
- Use dormant and summer pruning practices that open up the tree canopy and facilitate air movement and the drying of fruit after rainfall.
- Thin to separate fruit clusters to prevent disease development.
- Cool fruit after picking to slow disease development.

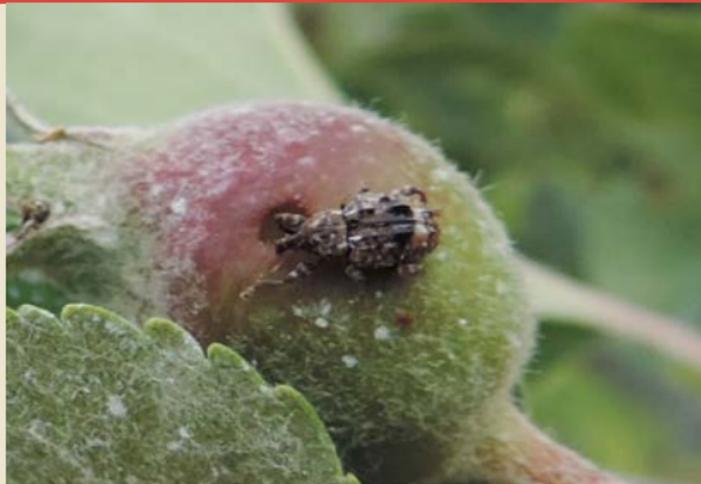
Chemical Disease Management

- Routine fungicide sprays normally control this disease in Pennsylvania. Summer fungicide applications should not be extended beyond 14-day intervals.
- Frequently reapply fungicides during persistent rain events occurring late in the season (July through September).

Apple Fruit – Plum Curculio

The plum curculio, *Conotrachelus nenuphar*, is usually more abundant on fruit trees adjacent to woods, fencerows, and trashy fields. Adults can be found in orchards for five to seven weeks after bloom. When a fruit is approximately ½ inch in diameter, it provides abundant food and a suitable place for egg laying. The crescent-shaped oviposition scars are being observed more frequently in Pennsylvania, as a result of selective insecticides being widely used after bloom.

Photos: G. Krawczyk, Penn State



Plum Curculio

Monitoring and Management

The critical period for controlling plum curculio is during the first few days of warm and humid weather following petal fall, when maximum temperatures remain approximately 70°F. Control is more difficult when feeding is greatly reduced by low temperatures and moderate rains because spray deposits are washed from fruit and foliage. Low temperatures also extend the period during which curculio is active in orchards.

Important considerations in blocks with a history of plum curculio injury

1. Shorten the interval between sprays during peak curculio activity (this may be necessary on outside rows only).
2. Increase the insecticide rate during peak activity.
3. Select the most effective insecticides without sacrificing control of other pests or interfering with the integrated pest management program.

Apple Fruit – San Jose Scale

San Jose scale, *Quadraspidiotus perniciosus*, produce living young called crawlers, while most other scales produce eggs. Scales on new growth and fruit produce deep purplish-red coloration in the tissue. When scales are removed from the fruit, a light-colored bull's eye is evident. Additional injury to the tree is caused by loss of plant sap, which depletes vigor and reduces yield. Prolonged attack causes cracking and splitting of the wood; if the scale is not controlled, the tree may die. Once established, most scale insects are difficult and expensive to control.

Photos: G. Krawczyk, D. Biddinger, Penn State



San Jose Scale

Monitoring

Pheromone traps are available for monitoring male adult emergence. Later in the season, usually early to mid-June, the crawlers can be monitored by wrapping petroleum jelly-coated electrical tape (sticky side out) around infested branches.

Cultural Management

Prune out infested branches to reduce the scale population. Open up the tree canopy with judicious thinning cuts during dormant pruning to improve spray penetration.

Chemical Management

The secret to successful control is coverage with high water volume. If live scales are present, apply oil at the dormant or delayed dormant period. Where populations are high, an insecticide can be applied at early petal fall to control males before they mate with the females. Later in the season, usually from early to mid-June, the crawlers can be targeted with chemical spray applications if the oil sprays were less than effective.

Pear Fruit – Pear Psylla

Pear psylla, *Cacopsylla pyricola*, adults look like small cicadas. They overwinter on trees and become active any time the temperature is above 40°F. Females begin laying tiny, pear-shaped, yellowish eggs in cracks in the bark and around the buds. Eggs hatch in two to four weeks, and the yellowish, wingless nymphs move to succulent stems and developing leaves to feed on plant sap. The pear psylla secretes large amounts of honeydew, which runs down over foliage and fruit and in which a sooty fungus grows. This causes the skin of the fruit to become blackened and scarred and the foliage to develop brown spots. Heavy infestations can cause defoliation of trees, reducing vitality.

Photos: G. Krawczyk, T. Baugher, Penn State



Pear Psylla

Monitoring

Monitor for the presence of pear psylla nymphs in the early season and again for the summer generations.

Cultural Management

An overabundance of new growth provides more feeding sites for psylla. Minimize heavy pruning and nitrogen fertilization. Remove water sprouts during late June and early July.

Chemical Management

In orchards with a history of psylla infestations, insecticidal control begins with a strong prebloom spray program designed to eliminate as many overwintering adults as possible before they have the opportunity to lay eggs. Good coverage is critical for control of this pest. Make applications to both sides of the trees and in a volume of water high enough to thoroughly wet and cover the entire tree.

Apple Fruit – Brown Marmorated Stink Bug

Adult brown marmorated stink bugs, *Halyomorpha halys*, are shades of brown on both the upper and lower body surfaces. They are the typical “shield” shape of other stink bugs, almost as wide as they are long. To distinguish them from other stink bugs, look for lighter bands on the antennae and darker bands at the rear of the front pair of wings. The name “stink bug” refers to the scent produced by glands located on the underside of the insect. Feeding on tree fruits such as apple results in corky spots that render the fruit unmarketable as a fresh product. Stink bug injury may be distinguished from bitter pit (calcium deficiency) by the presence of a feeding wound that you may need a lens to see.

Photos: G. Krawczyk, Penn State



Brown Marmorated Stink Bug

Monitoring and Management

With a constant threat of new adults migrating into the orchard from surrounding vegetation such as woods or field crops, monitoring traps are the most practical tools to detect the presence of brown marmorated stink bug. Commonly used products with various modes of action can effectively control this pest.

For the most effective and accurate detection of migrating stink bugs, traps should be placed on the edges of orchards bordering woods or other possible sources of brown marmorated stink bug.

Photo: G. Krawczyk, Penn State



Apple Fruit – Codling Moth

Codling moths, *Cydia pomonella*, overwinter as full-grown larvae within a cocoon under leaf litter, loose bark scales, or any other sheltered place they may encounter. Pupation occurs at about first pink, with first flight occurring about full bloom. First-generation eggs are laid on leaves near fruit or on the fruit and hatch in about 6 to 10 days. Newly hatched larvae bore through the fruit surface and feed near the surface for a short time before boring to the core, leaving frass exuding from the point of entry. When full grown, larvae exit the fruit, seek shelter, and spin a cocoon. Mating disruption (use of pheromone dispensers to confuse males) is a valuable alternative to insecticide treatment for isolated orchards with low codling moth populations.

Photos: G. Krawczyk, D. Biddinger, Penn State



Codling Moth

Monitoring

Place codling moth pheromone traps at a density of at least one trap per five acres (but no less than two traps per block) by the pink stage and situate them on the outside of the tree, preferably in the upper fourth of the canopy.

The codling moth trap should be placed in the upper fourth of the tree canopy, while most other traps should be placed at 5 to 6 feet (eye level). A bamboo or metal pole can be used for codling moth trap placement.

Mating Disruption

Mating disruption represents a valuable alternative to insecticide treatment for isolated orchards with a low codling moth population. Hand-applied pheromone dispensers and various forms of sprayable pheromones are commercially available.

Photo: G. Krawczyk, Penn State



Apple Fruit – Bitter Pit and Cork Spot

Bitter pit and corking are physiological disorders associated with low fruit calcium and sometimes high levels of nitrogen in the fruit flesh. Practices that improve soil conditions, encourage uniform annual cropping, and encourage moderate tree vigor will decrease calcium-related fruit disorders. Since the vegetative portions of a tree have relatively high concentrations of calcium, excessive tree vigor may deplete calcium that otherwise might be available for fruit. When trees bear a light crop of apples, the fruits are normally very large and low in calcium.

Season-long application of calcium tree sprays is the most cost-effective cultural practice for reducing calcium disorders.

Photos: T. Baugher, Penn State



Bitter Pit and Cork Spot

Calcium Sprays

Cultivars prone to corking and bitter pit should receive 9 to 11 lb of actual calcium per acre per season in six to eight cover sprays. This is 30 to 40 lb of calcium chloride, which has proven effectiveness and lower cost. Other products that supply calcium are available; however, not all are labeled at rates that supply enough calcium. It is important to compare the cost per pound of actual calcium and the amount of formulation needed to achieve the desired level of actual calcium per season.

Cultural Conditions to Balance

Soil Moisture	Plant on well-drained soils. Carefully monitor irrigation.
Nutrition	Maintain a pH of 6.5. Follow leaf and fruit analysis recommendations to prevent excessive levels of nitrogen, potassium, and magnesium relative to calcium.
Tree Vigor	Avoid excessive pruning or nitrogen fertilization.
Fruit Density	Plant on frost-free sites, provide adequate pollinizers for cross pollination, manage crop load with chemical and/or hand thinning.

Lime by itself will not prevent bitter pit and cork spot!

Apple Fruit – Freeze Injury

The temperature at which fruit buds are injured depends primarily on their stage of development. As flowers begin to swell and expand into blossoms, they become less resistant to freeze injury. For example, at green tip, 90% of the flowers may be killed by a low temperature of 10°F, whereas at full bloom, the critical temperature for 90% kill is 25°F. Resistance to freeze injury varies within trees as it does between orchards, varieties, and crops. Late season freeze injury to developing fruitlets may result in a ring of russet (left) or “pumpkin-like” striping of fruit (right).

Photos: T. Baugher, R. Crassweller, Penn State



Freeze Injury

Critical Temperature for Apples

The table below shows the average temperatures required to kill 10% and 90% of buds if they are exposed for 30 minutes. Consideration should also be given to weather conditions preceding cold nights. Prolonged cool weather tends to increase bud hardiness during the early stages of bud development. (Adapted from WSU Bulletin EBO419)

Stages of Development	10% kill (°F)	90% kill (°F)
Silver tip	15	2
Green tip	18	10
1/2 inch green	23	15
Tight cluster	27	21
First pink	28	24
Full pink	28	25
First bloom	28	25
Full bloom	28	25
Post bloom	28	25

Peach Wood – *Cytospora* Canker

Cytospora canker, caused by various *Cytospora* species, is one of the most destructive diseases of peaches and other stone fruit. The fungus attacks the woody parts of stone fruit trees through bark injuries, pruning cuts, dead shoots, and buds. Visible first is the exudation of gum at the point of infection. The canker forms from a small area of necrotic (dying and turning brown) tissue that slowly enlarges with the collapse of the inner bark. Older cankers are oval to elongated in outline. *Cytospora* cannot infect actively growing trees. New infections usually start in the late fall or early spring when the tree is dormant. Colonization begins slowly around 36 to 46°F and can also occur at 50 to 59°F. Increased duration of wetness and high humidity (90%) increase disease incidence.

Photo: T. Baugher, Penn State



Cytospora Canker

Disease Management

Cytospora canker control involves total orchard management. Since no stone fruit tree is immune and fungicide treatments alone are ineffective, management efforts must be aimed at reducing tree stress and preventing injuries where infection could begin.

- Conduct soil analysis prior to planting and adjust soil pH and nutrient status by thorough incorporation of lime and fertilizers.
- Maintain balanced plant nutrient levels by conducting annual leaf analysis and following fertilizer recommendations. Adjust nitrogen fertilization based on shoot length and level of pruning. Ensure adequate potassium levels, since this nutrient is associated with resistance.
- Delay pruning until late winter or early spring since spores are lowest March through May. This will greatly reduce risk of infection of wounds created by pruning.

Cherry Wood – Bacterial Canker

Bacterial canker is caused by *Pseudomonas syringae* pv. *syringae* (PSS). Freeze damage makes plants more susceptible to diseases caused by PSS since this injury creates an open door for the bacterium to enter the plant and destroy plant cells. Consequently, when spring freezes or frosts occur, there is usually an increase in bacterial canker. Bacterial canker affects branches, twigs, buds, leaves, and fruit. On twigs, cankers are darkened areas often located at the base of buds. On limbs or trunks cankers are frequently darker than normal bark, sunken in their centers, and may extend for a considerable distance. Gumming is frequent in the spring and fall when the disease is most active. Leaves and shoot growth beyond the canker may wilt and die during the growing season when cankers girdle a branch or the trunk. Leaves may also develop water-soaked lesions, which turn brown and become surrounded by a yellow halo. The center of the spot will drop out, leaving a “shot-holed” appearance.

Photos: K.Peter, Penn State



Bacterial Canker

Cultural Disease Management

- For trees with a known history of bacterial canker, pruning is best completed after harvest during the summer when conditions are hot and dry. Bacterial populations will be at their lowest during this period and the risk for infection is reduced.
- PSS can be transmitted by pruning tools, so these should be disinfected between pruning cuts if bacterial canker is present. Affected limbs should be pruned several inches below the canker, such that an “ugly stub” remains in order to limit the spread into the tree.

Chemical Disease Management

- Sprays during the growing season have not been effective in controlling the disease.
- Michigan research has shown that using copper hydroxide or copper sulfate at 0.5 to 0.7 lb of metallic copper per acre up to the white bud or popcorn stage of cherry can reduce bacterial populations. However, this will not persist, and bacterial populations can increase after a few days. In addition, the research showed copper was not effective in significantly reducing PSS populations if temperatures fall to 26°F.
- Some benefit has been achieved from copper applications made when most of the leaves have dropped in the fall and just before bud swell in the spring. For maximum benefit on susceptible trees, these sprays should be continued for several years.

Peach Wood – Lesser Peachtree Borer

Lesser peachtree borers, *Synanthedon pictipes*, overwinter as larvae and mature during April and May. Larvae eat an exit hole nearly through the bark, spin a cocoon, and pupate in a small cavity. In three to four weeks, a clear-winged moth emerges, leaving an empty pupal skin projecting from the burrow. The female moth is capable of laying several hundred eggs in cracks, under bark scales, and in cankered areas of branches. Moths are attracted to trees that have been injured or previously infested. Eggs hatch in a week to ten days, and young worms move to the inner bark and continue to feed.

Photos: G. Krawczyk, D. Biddinger, Penn State



Lesser Peachtree Borer

Monitoring

An early sign of lesser peachtree borer injury is the presence of wood chips, sawdust, and frass produced by feeding borers in the gum in cankered areas of branches. If the gum does not contain this particulate material, the injury is probably not caused by borers. Treat at peak flight, usually toward the end of June, if there is an average of more than two borers per tree, and again in late summer. If fewer than two pupal skins are found in each tree, target only the second generation in late summer.

Cultural Management

Any horticultural practice that prevents canker and maintains good tree development will help prevent borer damage.

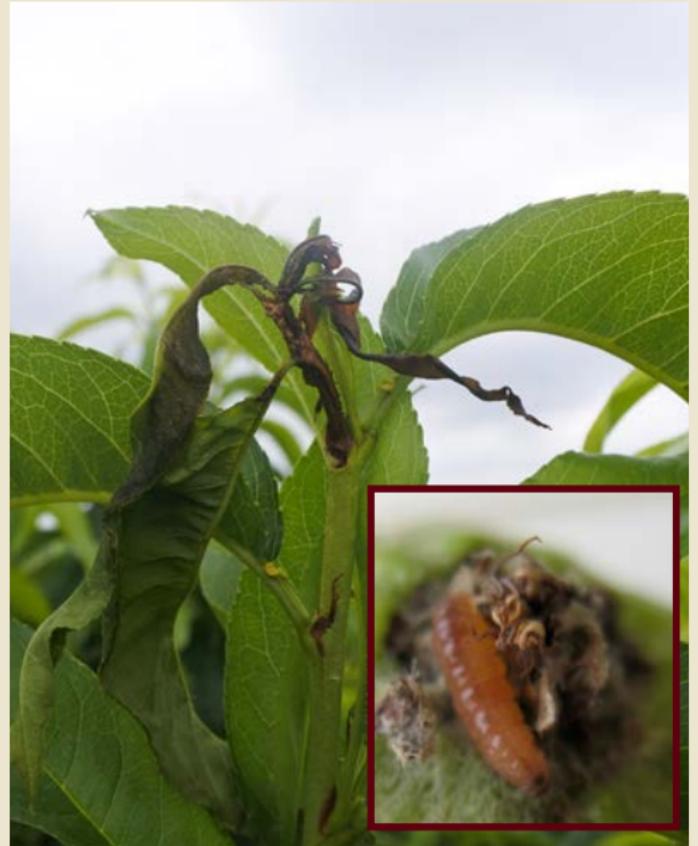
Mating Disruption

Lesser peachtree borer mating disruption dispensers release pheromones for 100 to 120 days and should be placed in the orchard before moth emergence in the spring. Use the recommended number of pheromone dispensers per acre and distribute uniformly throughout the entire block.

Peach Branch/Shoot – Oriental Fruit Moth

Oriental fruit moths, *Grapholita molesta*, overwinter as larvae, pupate, and emerge as adults during April. Females lay eggs and a first-generation larva enters at a leaf axil (angle between leaf and stem) near the tip of a shoot and bores down the central core, causing the terminal to “flag.” Later generation larvae may enter the fruit near the stem end and make feeding burrows that can extend to the pit.

Photos: G. Krawczyk, Penn State



Oriental Fruit Moth

Monitoring

Use pheromone traps to establish a biofix (i.e., first sustained capture of two or more moths per trap) and then calculate and record degree days to determine the percent egg hatch for each generation. Place the traps in stone fruit and/or apple orchards in early April and check daily until biofix is established. Then monitor traps weekly throughout the season.

Mating Disruption

Place mating disruption dispensers in the upper level of the tree canopy at label rate at the pink stage. If codling moth is also a problem in the same block, select an option that controls both species. The sprayable pheromones can be applied together with routine pesticide applications. Their effective time depends on pheromone formulation, rate, and weather conditions.

Ideally, orchards should be at least 5 acres in size for mating disruption to be effective.

Peach Branch/Shoot – Spotted Lanternfly

Spotted lanternfly, *Lycorma delicatula*, is an invasive planthopper, native to Asia, that was first detected in southeastern Pennsylvania in 2014. It feeds using a piercing-sucking mouthpart and can potentially cause injury such as oozing sap, wilting, leaf curling, and tree dieback. The secretion of honeydew can also be damaging. Penn State researchers are studying potential consequences of direct feeding damage to young peach trees, although commercial damage in orchards has not yet been observed. Spotted lanternfly is a plant stressor that, in combination with other stressors (e.g., diseases, weather), can cause gradual tree decline. Spotted lanternfly is very mobile and management actions must be continuous to keep it controlled.

Photo: E. Smyers, Penn State



Steps of Spotted Lanternfly Management

1. Stop the spread
2. Scrape eggs
3. Band trees to catch nymphs
4. Remove tree-of-heaven
5. Apply insecticides

Spotted Lanternfly

Frequently Asked Questions

Q. How are they spreading so fast?

A. Because spotted lanternfly lays eggs on almost any surface, including vehicles like rail cars and trailers, as well as outdoor equipment and patio furniture, the pest is easily spread by people. Before you travel within or out of the quarantine zone, check your belongings, yourself, and your vehicle for spotted lanternfly!

Q. How can I help?

A. Report your sightings of spotted lanternfly by calling 1-888-4BAD-FLY. Make sure you are not moving any life stage of spotted lanternfly when traveling within or out of the quarantine zone.

Q. What about truck drivers and people making deliveries? Do they know about spotted lanternfly?

A. All businesses that are moving material within the quarantine zone or in and out of the quarantine zone in Pennsylvania are required to hold a spotted lanternfly permit. This permit ensures that the businesses and employees are checking for spotted lanternfly before they travel.

Peach Foliage – Peach Leaf Curl

Peach leaf curl is caused by *Taphrina deformans*, a fungus that destroys young peach leaves. Although new leaves develop, their growth weakens the tree. Infected leaves, which begin appearing in mid-May, are easily distinguished from healthy leaves in that they are puckered and thicker than normal. Deformed areas are red to yellow at first and then turn brown. Eventually the infected leaves fall from the tree. After the deformed and discolored leaves fall, they produce powdery gray spores that are blown by winds to peach twig surfaces and remain there for the winter. Once the fungus enters the leaf, the disease cannot be controlled, but it does not spread later in the season.

Photos: K. Peter, Penn State



Peach Leaf Curl

Cultural Disease Management

Where peach leaf curl is severe, it is very important to maintain tree vigor by:

- thinning fruit to reduce demand on the tree,
- irrigating to reduce drought stress, and
- fertilizing trees with nitrogen (budbreak to mid-June, being careful not to overstimulate trees).

Chemical Disease Management

- A single fungicide (copper, chlorothalonil, sulfur, or ziram) application made in the fall after all leaves have dropped or in spring before bud swell will control the disease. If spring applications are made, temperatures must be monitored closely. Unusually warm weather during late winter months can encourage bud swell, thereby making fungicide sprays ineffective. Once the fungus enters the leaf, the disease cannot be controlled.
- The fungicide kills the spores on twig surfaces. For either the spring or the fall spray to be effective, application must be thorough. Complete coverage of the twigs, branches, and trunks is essential. Applications made from one side of the tree or with highly concentrated sprays may not be effective.

Peach Foliage – Bacterial Spot

Bacterial spot, *Xanthomonas arboricola* pv. *pruni*, first appears as small, grayish, water-soaked areas on the undersides of leaves. Mature spots are angular and are most numerous at the tip ends and along the midribs of leaves. The infected areas may drop out, giving the infected leaves a “shot- holed” appearance; leaves will turn yellow and fall. Other leaf spot diseases and spots due to spray injury tend to be more circular in outline and not confined by the leaf veins. Leaf spots due to nitrogen deficiency are normally red. The bacteria overwinter in twigs and buds and, in the spring, are spread by rain to leaves, shoots, and fruit. Warm rains and temperatures above 65°F are needed for the bacteria to multiply and be disseminated. Peach fruit infected by bacterial spot early in the season develop unsightly blemishes and may exhibit gumming. Pits or cracks on the fruit surface extend into the flesh and create large, brown to black depressed areas on the fruit surface. Shallow pitted lesions that develop after pit hardening are usually superficial and give the fruit a mottled appearance. On plum, the fruit symptoms are likely to be quite different in that large, black, sunken areas are most common.

Photos: K. Peter,
Penn State



Bacterial Spot

Cultural Disease Management

- Planting resistant cultivars is the most effective control measure. An increasing number of good peach cultivars are highly resistant to bacterial spot. Resistance in plums, nectarines, and apricots is not as common.
- Maintain good tree vigor.

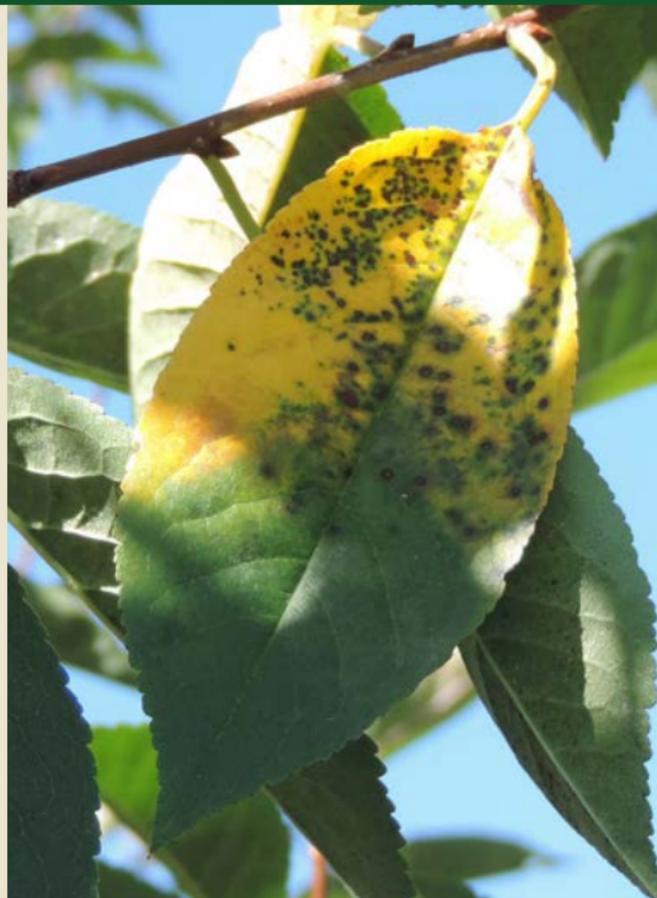
Chemical Disease Management

- Chemical sprays with a copper-based bactericide and the antibiotic oxytetracycline (FireLine, MycoShield) have moderate efficacy but must be used preventatively.
- Copper-based sprays are applied from the dormant to shuck-split phenology stages to reduce initial inoculum. Because of high sensitivity of peach foliage to copper, rates are reduced progressively in successive sprays during this period. For the cover sprays that start at shuck-off, copper can be used at 0.5 to 1.0 oz per acre of metallic copper.
- Other products to include in a spray rotation with copper and oxytetracycline are bacterial-based products (Serenade, Double Nickel) and Regalia.
- If crop loss results from severe winter temperatures or early spring freezes, bacterial spot must still be managed on susceptible varieties during the season to prevent defoliation and inoculum buildup for the next year.

Cherry Foliage – Cherry Leaf Spot

The cherry leaf spot fungus, *Blumeriella jaapii*, overwinters in diseased leaves on the ground and around bloom, spores are discharged. Like apple scab, the infections are favored by warm, wet conditions. The disease is most severe on leaves and can cause them to drop prematurely. Buds and wood become susceptible to winter injury, which might show the next season as dead spurs and limbs. Leaves are susceptible throughout the season, but with age, they become less susceptible. Each succeeding wave of infection becomes heavier, and severe defoliation begins. High humidity and rainfall increase the spread of the disease.

Photo: T. Baugher, Penn State



Cherry Leaf Spot

Cultural Disease Management

Rotary mowing of the orchard after leaves drop in the fall will hasten leaf decay and reduce overwintering inoculum.

Chemical Disease Management

- Fungicide applications are the primary means of control beginning at the bract leaf stage during bloom time and continuing throughout the season as disease conditions persist.
- Two postharvest fungicide sprays are recommended to prevent premature defoliation. The goal is to have the trees hold onto their leaves through September. Premature defoliation in July and August can cause trees to be more susceptible to winter damage, which ultimately could lead to tree death.

Peach Foliage – Copper Injury

Copper is a general biocide and will kill fungi, bacteria, and plant cells. The leaves of stone fruit trees are more sensitive to copper injury than apple leaves. Stone fruit varieties can vary in sensitivity to copper (some are more sensitive than others). When copper is sprayed, the particles will persist on the plant surface after the spray dries; copper ions are gradually released from copper deposits each time the plant surface becomes wet (with water/rain). The gradual release of copper ions from the copper deposits provides residual protection against plant pathogens. Copper sprays act as protectant fungicide/ bactericide treatments but lack post-infection activity.

Copper injury appears as different sizes of round holes on leaves, resembling a spray pattern. In contrast to bacterial spot, the holes are random and do not follow the veins, e.g., the angular symptoms of bacterial spot. Yellowing is not always associated with lesions caused by copper injury. Very injured leaves can remain on the tree although sometimes the leaves will turn yellow and fall off.

Photo: K. Peter, Penn State



Copper Injury

Management

- Copper injury worsens under slow drying conditions. Slow drying time (e.g., rainy conditions) increases solubility of copper, release of copper ions, and thereby phytotoxicity of copper fungicides.
- Copper sprays will become more phytotoxic if they are applied in an acidic solution: beware of adjuvants, phosphorus acid fungicides (Rampart, Phostrol, ProPhyt), and mancozeb that lower pH of tank mixes. Growers may add lime to reduce potential for plant damage.
- Do not mix copper with foliar fertilizers.

Peach Foliage – Herbicide Injury

Herbicide injury is sometimes mistaken for a disease symptom or insect injury. Damage may occur from spray drift due to windy conditions during spray application, improper dosage or sprayer calibration, or in the case of auxin-type herbicides, volatilization or drift from adjacent fields or farms. Auxin-type herbicides are members of the Herbicide Resistance Action Committee (HRAC) Group 4 and include 2,4-D, clopyralid, and fluroxypyr.

Photos: R. Crassweller, Penn State

Sollicam Injury



Goal Injury



2,4-D Injury



Herbicide Injury

Avoiding Damage

Herbicides are the primary tools used to manage vegetation under the tree row, but they also have risks. Young trees can be especially sensitive to herbicides, and drift onto green bark or foliage can stunt or kill the tree.

Since most damage from auxin herbicides occurs due to either volatilization of the material or drift from adjacent fields, attention to environmental conditions is important. Volatilization can occur when auxin herbicides are applied at temperatures greater than 75°F and/or when the soil is dry. Only apply these materials when temperatures are less than 70°F. Certain formulations such as amine forms of 2,4-D have lower volatility compared to ester formulations. Therefore be sure to use the less volatile materials. Ester formulations should not be used in orchards.

Drift can occur when herbicides are applied under windy conditions. Do not apply herbicides if wind speeds are at or above 10 mph. Use nozzles that produce a coarse spray of large droplets, as fine mists of small droplets are prone to greater drift.

Peach Foliage – Nitrogen Deficiency

Peach trees deficient in nitrogen have reddish leaves. As the condition worsens, the leaves exhibit a “shot-holed” appearance. Prevention of nitrogen deficiency requires a combination of timely fertilization, good weed control, and balanced pruning.

Photo: T. Baugher, Penn State



Nitrogen Deficiency

Nutrient Management

Soil applications of nitrogen are generally applied to fruit trees as close to bud break as possible. Calcium nitrate is highly soluble and will be taken up quickly at this stage. Avoid use of urea when temperatures are warm enough to cause volatilization. If there is a possibility the crop will be reduced by freezing temperatures, apply half of a normal rate at bud break and adjust the rate of a second application based on estimated crop load.

Orchard floor management practices also affect nitrogen availability, and deficiency symptoms are common in young peach trees when a 4 ft-plus weed-free strip is not maintained.

Leaf analysis provides a general indication of nitrogen status of peach trees, with the optimum level being 2.50 to 3.40% (compared to 1.80 to 2.80% for apple trees). Young, nonbearing trees should grow up to 26 inches annually and mature, heavily bearing trees, 18 to 24 inches.

Peach/Cherry Flower/Fruit – Brown Rot

Brown rot, *Monilinia fructicola*, first affects blossoms, which wilt and turn brown (referred to as “blossom blight”). The infected blossom parts serve as a source of the fungus for future fruit infections. Blossom infections can extend into and eventually girdle a twig, causing a canker to form. The fungus overwinters in mummies, blighted twigs, and cankers. Decay from brown rot occurs as fruits ripen. The infections begin as small, brown spots and the entire fruit can rot within a few hours under favorable conditions. Rotted fruits dry out, become mummified, and either remain attached to the tree or fall to the ground. Warm, wet, or humid weather is very favorable for disease development.

Photos: J. Travis, B. Lehman, K. Peter, Penn State



Brown Rot

Cultural Disease Management

- Removing all mummies after harvest is important in reducing the amount of fungus overwintering in the orchard.
- Remove dead or cankered wood while pruning.
- Summer pruning will increase air circulation, allowing faster drying and fewer fruit infections.

Chemical Disease Management

- Apply fungicide sprays during bloom and at 18 days, nine days, and one day before peach harvest.
- Captan used as a cover spray has been shown to decrease the available spore load leading up to harvest.
- To reduce the risk of resistance, alternate fungicides by FRAC Group, especially during preharvest.

Peach Fruit – Rusty Spot

Rusty spot of peach is characterized by the presence of rust-colored spots. The cause is uncertain, although many believe it to be the apple powdery mildew fungus, *Podosphaera leucotricha*. Peach orchards with rusty spot are often next to apple orchards that are infected with powdery mildew. Young peach fruit become infected and exhibit white nonpowdery lesions that are small, spherical, and later turn orange-tan in color. Leaves and stems are not affected.

Photos: K. Peter, Penn State



Rusty Spot

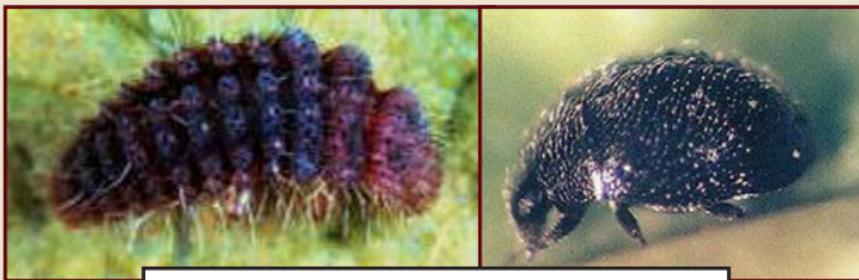
Disease Management

- Routine fungicides control this disease.
- Controlling mildew in adjacent apple orchards reduces rusty spot incidence in peach orchards.

Beneficial Insects and Arachnids

Beneficial insects provide biological control of insect and mite pests. The black ladybird beetle (*Stethorus punctum*) suppresses populations of spider mites. Lacewing larvae (Family *Chrysopidae*) eat soft-bodied pests like aphids. These beneficial insects and others are part of the natural fauna of an orchard.

Photos: D. Biddinger, L. Hull, Penn State



Stethorus punctum larva and adult



Green lacewing eggs, larva, and adult

Natural Enemies/Biological Control in Orchards

Biological Control Principles

Biological control of pest species by predators, parasitoids, and pathogens has been a cornerstone of IPM since its inception. The best results are most often achieved where a complex of many species of natural enemies each contribute to reducing pest populations at different times of the season and on different developmental stages.

Biological Control of Mites

The most successful biological control programs have centered on the conservation of native species of mite predators to control the European red mite. The use of pheromone mating disruption, horticultural oils, and some of the more selective reduced-risk insecticides and miticides will allow a natural increase of predators capable of regulating pest mite populations to tolerable levels without the use of miticides. Mite control through biological control has the additional advantage of stopping the development of miticide resistance and, once established, is sustainable long-term if the use of certain harmful pesticides is avoided.

Beneficial Insects and Arachnids

Predatory mites (e.g., *Zetzellia mali*, *Typhlodromus pyri*) also provide biological control of spider mites. Some parasitoid wasps lay eggs on insect pests and the developing young wasps kill their host.

Photos: D. Biddinger, A. Surci a, Penn State



Parasitoid sand wasp



Stink bug
host



Zetzellia mali



Typhlodromus pyri



Natural Enemies/Biological Control in Orchards

Typhlodromus pyri

Discovered in Pennsylvania for the first time in 2003, this predatory mite is currently the most reliable and effective mite predator in eastern U.S. apple orchards. Pear shaped and slightly larger than a European red mite adult, they are white/translucent until they feed. When feeding on adult red mites or apple rust mites, its abdomen may appear reddish. *T. pyri* is very active and moves rapidly to consume up to 350 mite prey in a lifespan of about 75 days. Females may lay up to 70 eggs each and have several generations per season. Populations, therefore, can build rapidly in response to pest mite populations. Most effective in the cooler weather of the spring and fall, *T. pyri* is somewhat less effective in the summer months. It overwinters on the apple tree under the bark where it is less susceptible to dormant oil applications and is very tolerant of Pennsylvania's winters.

Inoculating an Orchard with Beneficial Mites

You can inoculate your orchard with beneficial mites by bringing in spur leaves from an orchard with well-established populations, such as the Penn State Fruit Research and Extension Center. May to June is the best time to do this. Place two sets of spur leaves on every sixth tree in high density plantings and every third tree in medium density plantings.

Beneficial Insects – Native Pollinators

Wild bees contribute significantly to fruit tree pollination. On a bee-per-bee basis, wild bees can be more effective pollinators than honey bees, so they do not need to be as abundant to provide quality pollination. Almost 120 species of wild native bees can be found in fruit orchards during the growing season.



Metallic sweat bee

Image by Alex Surciã



Small carpenter bee

Image by Alex Surciã



Mason Bee



Photos: A. Surciã, D. Biddinger, Penn State

Beneficial Insects – Native Pollinators

Supporting a diversity of bees has advantages over relying on a single species (such as the honey bee) to provide stable pollination. If bee diversity is high in an orchard, when populations of one or several species fluctuate due to parasites or disease, other species continue to provide stable pollination.

Wild bees that fly in the early spring are better adapted for flying under poor weather conditions than most other bees. They visit flowers and pollinate in cool and cloudy conditions when honey bees are less active. In warm, sunny weather, wild bees often begin foraging earlier in the morning and fly later into the afternoon.

Research indicates that habitat near or on farms is the key to sustaining pollinators. Hedgerows, shelterbelts, and windbreaks containing native flowering trees and shrubs can offer multiple farm benefits. While reducing erosion and providing screening, they also provide nesting habitat and food for bees.

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Plant protection product registrations may change from what was recommended at the time this guide was printed. Always read the product label prior to making any pesticide applications.

Fungicide Resistance Action Committee (FRAC), Insecticide Resistance Action Committee (IRAC), and Herbicide Resistance Action Committee (HRAC/WSSA) Groups are listed in the most recent Penn State Tree Fruit Production Guide.

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