University of Kentucky
College of Agriculture, Food and Environment
Cooperative Extension Service

ID-219

An IPM Scouting Guide for Common Problems of Apple in Kentucky

An IPM Scouting Guide for Common Problems of Apple in Kentucky

This manual is the result of efforts of the University of Kentucky Fruit Integrated Pest Management team. Funding for this publication came from the University of Kentucky IPM Program and the USDA National Institute of Food and Agriculture Integrated Pest Management Program.

Cover photo: The blossom blight phase of fire blight is caused by the bacterium *Erwinia amylovora*.

Contents

Sponsored by Kentucky IPM

UK Fruit IPM Team
Nicole Ward Gauthier, Extension Plant Pathologist
Ric Bessin, Extension Entomologist
John Strang, Extension Horticulturist
Shawn Wright, Extension Horticulturist
Cheryl Kaiser, Editor

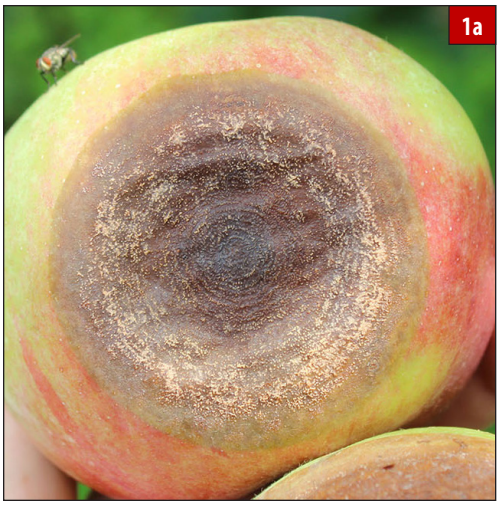
Acknowledgement
The authors would like to thank Dr. Michael Ellis, Department of Plant Pathology, Ohio State University, for his review and editorial comments.

The National Integrated Pest Management Network defines IPM as "a sustainable approach to managing pests by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health, and environmental risks." One of the key components of IPM is to continually scout and monitor crops to identify problems before they result in significant economic losses. Proper identification of pathogens and insect pests as well as nutritional and physiologic disorders and even herbicide drift is essential to determining the proper course of action. The pictures included in this guide represent some common pests or problems that growers may encounter during apple production in Kentucky. This manual is not all-inclusive, and growers may encounter a problem that is not included here. Please contact your county Extension service for assistance. Also, for more complete information on apple production and pest management in Kentucky, consult the following publications, available at county Extension offices or online:

Commercial Tree Fruit Spray Guide (ID-92): http://www2.ca.uky.edu/agcollege/plantpathology/ext_files/PPFShtml/MwTreeFruitSprayGuideID92.pdf

Midwest Tree Fruit Pest Management Handbook (ID-93): http://www.ca.uky.edu/agc/pubs/id/id93/id93.htm

Diseases



Bitter rot with spores (a) and internal decay symptoms (b).

1. Bitter rot (*Colletotrichum acutatum, C. gloeosporioides*) lesions begin as small, sunken localized areas on outer surfaces of fruit. As they mature, they remain sunken and circular, and develop red halos (outer rings). Under rainy conditions, salmon/pink spores appear in circular patterns. During arid conditions, black fruiting structures called acervuli are visible in lesions. Infected flesh develops cone-shaped rots that are brown and firm. **Management**—Sanitation (removal of infected fruit, cankers, and dead wood), resistant cultivars, and fungicides (applied soon after bloom).

2. Black rot (*Botryosphaeria obtusa*) affects leaves, fruit, and branches. Leaf spots (called "frog eye") appear a few weeks after petal fall. These purple-colored spots reach ¼ inch in diameter, and then spot centers turn tan and fall out. Fruit infections occur before or during bloom, resulting in rot of the calyx (blossom) end later in the season. Brown lesions remain firm and are not sunken. Black fruiting structures called pycnidia are produced across fruit lesions. Infected fruit shrivel and remain attached to trees (mummify). Branches may also become infected and cankers develop. **Management**—Sanitation (removal of mummified fruit and branch cankers), fungicide sprays.

3. Canker (non-pathogenic) caused by mechanical damage can result in plant decline, stunting, and other stress-related symptoms that are visible aboveground. Mechanical damage at soil level or on trunks may be caused by mowers, equipment, sun scald, or freeze damage. Young trees are most often affected by mechanical damage.

Black rot lesion with black fruiting structures.

Non-pathogenic canker.

Blossom blight stage of fire blight (a) and stem canker (b). Shepherds crook (c) and trunk canker (d) symptoms of fire blight.

4. Fire blight (*Erwinia amylovora*) is a bacterial disease with three distinct phases. Blossom blight occurs during bloom, causing collapse and rapid blackening of blossoms and/or spurs. This blossom infection stage is most severe when weather is warm and wet during bloom. Shoot blight occurs several weeks after bloom, with symptoms occurring on rapidly growing shoots. Infected shoots turn black from the tip, causing the tip to bend over forming a typical shepherd's crook at the tip of the branch. Canker phase begins at locations where spurs or infected branches intersect with larger branches. Advanced branch and trunk cankers usually contain black, sunken areas covered with loose, peeling bark.

Management—Sanitation (removal of infected limbs), resistant cultivars and rootstocks, and bactericide/antibiotic sprays during bloom.

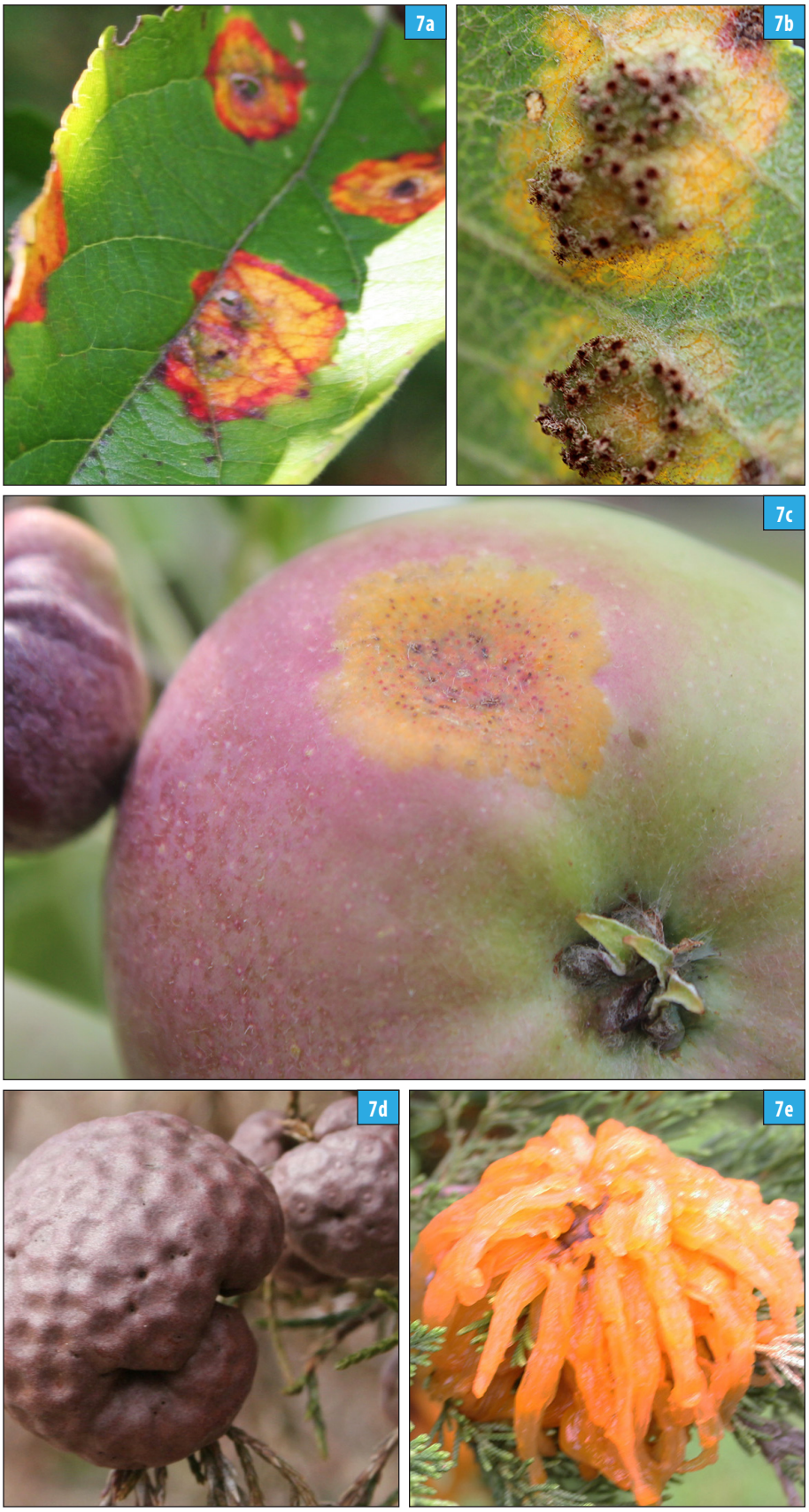
5. Frog eye leaf spot (*Botryosphaeria obtusa*). See black rot.

Frog eye leaf spot phase of black rot.

Lichen.

6. Lichen (mutualistic, not pathogenic) resembles simple plants, but are symbiotic organisms that consist of either algae or cyanobacteria combined with a fungus. They are primarily decomposers that grow on dead wood tissue and other organic debris. Severe lichen growth may indicate plant stress and decline.
Management—Eliminate plant stress (fertilize according to soil tests, mulch to conserve moisture, irrigation during dry conditions).

7. Rust (*Gymnosporangium juniperi-virginianae, G. clavipes, G. globosum*). Three different rust diseases (cedar-apple, cedar-quince, and cedar-hawthorn) have similar symptoms. Small yellow spots develop on upper leaf surfaces in spring, shortly after apple bloom (soon after teliospores are released from galls on cedars). Leaf spots on apple enlarge, turning orange to yellow. Black fruiting structures called pycnia (not pycnidia) appear in spots on upper sides of leaves, and then in in late summer, cylindrical tubes (aecial cups) form on undersides of leaves. Fruit infections are usually near calyx ends of fruit and resemble leaf lesions. The fungus does not cause repeated infections on apple later in the growing season.
Management—Resistant cultivars, removal of nearby hosts (cedar, hawthorn, and quince) when possible, fungicides (beginning at bloom).



Cedar-apple rust on upper (a) and lower (b) leaf surfaces and on fruit (c). Immature (d) and sporulating (e) telial galls on red cedar.

Early (a) and advanced (b) stages of apple scab on foliage and fruit lesions (c).

8. Scab (*Venturia inaequalis*) primary lesions appear on undersides of leaves as early as flowering. Symptoms begin as velvety, brown or olive spots with feathery, undefined edges. Later, spots appear on both sides of leaves, become more distinct, and turn black and corky or scab-like with age. Fruit lesions resemble those on foliage. Secondary infections occur if primary infections are not properly controlled and spores (conidia) from these infections infect healthy tissue.

Management—Sanitation (removal of infected leaf debris and fruit), resistant cultivars, and fungicide sprays beginning at bloom.

9. Sooty blotch/flyspeck (*Geastrumia polystigmatis, Zygophiala jamaicensis*) are two separate diseases that often occur together on fruit surfaces during summer and fall. Sooty blotch causes black-brown to olive-colored irregular blotches. Fruiting structures called pycnidia appear in darker spots. Flyspeck symptoms appear as sharp, black, shiny dots grouped into clusters. These specks are fruiting structures called pseudothecia. Both pathogens are superficial and are restricted to fruit surfaces and do not penetrate into the flesh.

Sooty blotch and flyspeck.

Management—Sanitation (removal of bramble hosts, removal of diseased fruit), pruning to increase rapid drying, and fungicides during summer months.

White rot.

10. White rot (*Botryosphaeria dothidea*) affects both fruit and branches. Fruit rot originates as small circular spots on fruit initiating when fruit begin to mature, expanding outward and inward as temperatures warm. As diseases advances, each rotten area develops a cylindrical rot to the fruit core. Rotten fruit drop as disease progresses. Conidia (fungal spores) may also infect branches of unhealthy or stressed trees, entering through wounds or through lenticels. The fungus also colonizes dead wood, especially those killed by fire blight.
Management—Sanitation (removal of branch cankers and infected limbs), fungicides during summer months.

11. Root/collar rot (*Phytophthora cactorum, Phytophthora* spp.) is first noticed by aboveground symptoms. Stunting or unhealthiness of trees may begin with small yellow leaves that turn reddish-purple later in the season. Cankers develop at the soil line but may not be noticeable without removal of bark. Bark may be dark-colored and soft, and underlying wood is reddish-brown and often slimy. This decay girdles trees, and trees often die within 1 to 3 years. Infections are more widespread and lesions develop more rapidly in damp, saturated soil.
Management—Site selection (well-drained soil or improving drainage), disease-resistant rootstock.

Collar-rot symptoms above ground (a) and on young tree (b). Trunk canker (c).

Insects

Apple maggot larva (a) and adult (b).

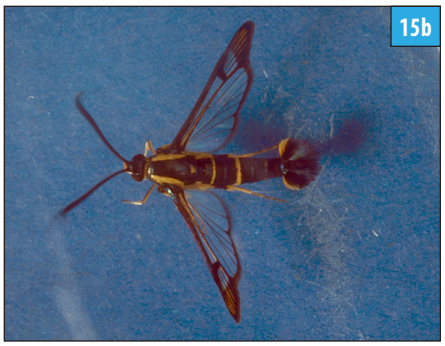
12. Apple maggot (*Rhagoletis pomonella*) adults are active in midsummer. Adults, which are small flies (about ¼ inch), have a dark thorax with a white spot on the tip, a dark abdomen with white cross bands, and four dark streaks on wings. Full-grown larvae are ⅓ inch long, cream-colored, legless, and without a distinct head.
Management—Proper insecticide timing (monitor using red spheres and yellow sticky cards).

13. Brown marmorated stinkbug (*Halyomorpha halys*) is nearly ¾ inch long, mottled brown in color, with two light bands on each antenna, and a smooth edge between eye and 'shoulder.' There are alternating white and brown spots on abdomen edge beyond wings. Nymphs have white bands on their tibia. Damage caused by this insect can be mistaken for cork spot.
Management—Insecticide as needed, scout border rows.

14. Codling moth (*Cydia pomonella*) adults are about ⅜ inch and gray with distinct bronze areas on the bottom third of wings. Larvae are found in apple cores, are pinkish in color with brown heads, and can reach ¾ inch. Single scale-like eggs are laid on fruit or adjacent leaves.
Management—Pheromone traps, insecticide timing based on weather monitoring and degree day models, mating disruption.

15. Dogwood borer (*Synanthedon scitula*) adults are a clearwing moth (both fore and hind wings are mostly clear), resembling a small wasp. Thorax and abdomen are dark blue, almost black with yellow bands. Mature larvae are ⅗ inch long, cream-colored with reddish-brown heads and two brown spots on the upper surface of the front thoracic segment.
Management—Trunk sprays applied after peak flights (monitor using pheromone traps, remove tree guards for monitoring larval activity).

Codling moth larva (a) and damage to fruit (b).



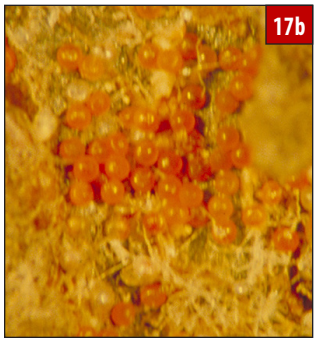
Dogwood borer larva (a), male adult (b), and damage to trunk (c).

Brown marmorated stinkbug (a) and damage to fruit (b).

Eastern tent caterpillar (a) and with egg case (b).

16. Eastern tent caterpillar (*Malacosoma americanum*) larvae are hairy, black with a white stripe down backs. Caterpillars have brown and yellow lines along sides, as well as a row of oval blue spots. Masses of 150 to 400 eggs are covered with shiny, black varnish-like material. Masses encircle branches that are about pencil-size or smaller in diameter. Moths are reddish-brown with two pale stripes running diagonally across each forewing.
Management—Insecticide sprays for codling moth and oriental fruit moth usually manage tent caterpillars.

17. European red mite (*Panonychus ulmi*) adult females are brick-red with white spots at the base of six to eight hairs on their backs. Male mites are more slender and lighter in color than females, with a more pointed abdomen. Eggs are red, globular, and somewhat flattened with a slender stalk on their upper side. European red mite feeding causes leaves to turn pale and then a bronze color.
Management—Dormant and summer oils; minimize insecticide sprays to help minimize effects on predators.



European red mite (a) and eggs (b).

18. Flatheaded appletree borer (*Chrysobothris femorata*) adult beetles are about a half-inch long, brown to gray, and flattened. The body is blunt at the head and tapers to a rounded point at the posterior end. Wing covers appear to be finely corrugated. Borers are about 1 inch long, legless, yellow-white, and slender except for a broad, flat enlargement of the thorax directly behind the head. Borers leave a 3⁄16 of an inch D-shaped hole when emerging from a tree.
Management—Reduce stress, sanitation (remove weak and dead wood).

19. Green June beetle (*Cotinis nitida*) adults are about 1 inch long with dull metallic green wings and bronze to yellow margins on head and sides. Undersides are shiny green. Larvae are cream-colored, up to 2 inches long, crescent-shaped, crawl on their backs, and project legs upward when moving.
Management—Insecticide with short pre-harvest interval (PHI) as needed, just before and during harvest.

Flatheaded apple tree borer larva (a) and adult (b).

Green June beetle larva (a) and adult (b).

Japanese beetle grub (a) and adults (b).

Adult Oriental fruit moth (a) and damage (b).

20. Japanese beetle (*Popillia japonica*) adults are ⅜ inch long metallic green beetles with copper-brown wing covers and five small white tufts of hair projecting from under wing covers at the tip of the abdomen. Mature larvae are crescent-shaped grubs about 1 inch long with a brown head and grayish-black end. The pattern of hairs on the last body segment (raster) form a V-shape near the anal opening.
Management—Insecticide should target adults as needed.

21. Oriental fruit moth (*Grapholita molesta*) is a ¼ inch , charcoal-colored moth with fine alternating bands of light and dark lines giving it a mottled appearance. Oriental fruit moth (OFM) eggs are flat and oval, initially opaque and white in color but turning brownish-red as they mature. Larvae are pinkish-white with brown heads and ½ inch long when full-grown. OFM larvae and codling moth (CM) larvae are very similar, but OFM has a small hidden four-prong comb on the end of their abdomen.
Management—Pheromone traps, insecticide timing based weather monitoring and degree day models, mating disruption.

22. Plum curculio (*Conotrachelus nenuphar*) adult is a typical snout beetle, a ¼ inch long, dark brown with patches of white or gray, and four prominent humps on wing covers. Injury will appear as a ⅛ of an inch crescent-shaped cut on fruit surface. Larvae are legless, grayish-white grubs with brown heads, and ⅓ inch when full grown.
Management—Insecticides when damage is first observed or at first-cover.

23. Ribbed cocoon maker (*Bucculatrix pomifoliella*) adults are small (1⁄10 inch) light-brown moths with a dark spot on each front wing. Early-stage larvae form narrow leaf mines and are greenish-brown. Partially-grown larvae emerge from the leaves to spin a molting cocoon, later emerging again to resume feeding while exposed on leaf surfaces. Pupal cocoons (¼ inch) will appear longitudinally ribbed and are attached to twigs or fruit. Damage is caused by young larva destroying foliage.
Management—No sampling procedures or thresholds have been established.

Ribbed cocoon maker (a, b) and leaf damage (c).

Plum curculio feeding damage (a, b), larva (c) and adult (d).

Rosy apple aphid (a) and foliar symptoms (b).

24. Rosy apple aphid (*Dysaphis plantaginea*) can be distinguished by its greenish-rose color and the damage it causes. Rosy apple aphid injects a toxin in its saliva, causing severe leaf curling and fruit distortion. Young aphids found with adults will change from dark green to purple as they grow. Curled leaves will need to be unfurled to determine if colonies are still present. Honeydew or sooty mold on leaves or fruit is a common indication of aphid presence.
Management—Apply delayed dormant oil as well as pre-bloom or petal-fall sprays when infestations exceed 5 percent of terminals or fruit clusters. Once leaves are tightly curled, adequate spray coverage and control is more difficult.

San Jose scale damage to fruit (a), on branch (b), and injury under bark (c).

Speckled green fruitworm.

25. San Jose scale (*Quadraspidiotus perniciosus*) is minute (1/20 of an inch), flattened, gray, circular with concentric rings, and a tiny knob in the center. Crawlers are yellow, only 1/200 inch in size, resemble spider mites in shape and are visible only with a hand lens. Red flecking on fruit at harvest or under bark on new growth (caused by toxic saliva injections) are indications of San Jose scale infestation.
Management—Scouting, dormant oil applications, spring insecticide spray (either at pre-bloom or early summer targeting the crawler stage). Use a piece of black tape (sticky side out) on an infested limb to detect crawlers.

26. Speckled green fruitworm (*Orthosia hibisci*) larvae are green with numerous white or blue flecks, a thin light colored stripe down the middle of the back and a wider stripe along each side of the body. Larvae are robust and can reach 1¼ to 1½ inches when fully grown. Eggs (1/15 of an inch diameter) are grayish white and hemispherical with ridges that radiate out from the center.
Management—Insecticide at first cover.

27. White apple leafhopper (*Typhlocyba pomaria*) feeding is evident by whitish spots or stippling on upper leaf surfaces. Adults are long and slender, wedge-shaped, with light yellow body and slightly darker head. Juveniles are generally pale white, wingless and will scurry about when disturbed.
Management—Insecticide if an average of three or more nymphs per leaf is detected.

28. Wooly apple aphid (*Eriosoma lanigerum*) differs from other apple aphids in appearance, life cycle, and type of damage it inflicts. Unlike other aphids, it feeds on all parts of the tree, above and below ground. Wooly apple aphid (WAA) colonies appear as cottony masses, generally clustered in wounds and leaf axles toward tree centers. WAA is purple and surrounded by white, cottony, thread-like secretions. Honeydew or sooty mold on leaves or fruit are a common indication of aphid presence.
Management—Higher volume sprays due to insect's protective waxy covering, semi-resistant rootstocks (M.111 and M.106).

White apple leafhopper nymph (a), juveniles and adult (b).

Wooly apple aphids covering a branch (a) and on roots (b).

Weeds

Honeyvine milkweed.

Johnsongrass.

Marestail foliage (a) and flowers (b).

29. Honeyvine milkweed (*Cynanchum laeve* or *Ampelamus albidus*) is a vining weed that is difficult to control because of its large perennial taproot, rapid growth rate, large annual production of seeds, and minimal treatable surfaces. This weed rapidly grows up through trees, making it difficult to manage with post-emergent herbicides.
Management—Pre-emergence herbicide; post-emergent herbicide applied persistently and repeatedly after germination.

30. Johnsongrass *(Sorghum halepense)* may reach a height of 3½ feet and competes heavily with trees for nutrients and water. It reproduces by seed and perennial rhizomes, making it difficult to control.
Management—Pre-emergence herbicides applied persistently and repeatedly after germination. Herbicides selective for grasses can also be applied.

31. Marestail/horseweed (*Conyza canandensis*) is becoming more commonly glyphosate-resistant. Seed that germinates throughout spring and early summer will mature and set seed the same year, while seed that germinates in fall overwinters in the rosette stage. Plants reach heights of 3 to 6 feet, and one plant may release 200,000 seeds that disperse easily by the wind.
Management—Pre-emergent herbicides, burn-down herbicides during seedling or rosette stages.

32. Palmer amaranth (*Amaranthus palmeri*) is an extremely competitive invasive weed that is very adaptive. It has developed resistance to glypohosate and ALS herbicides; amaranth has also shown resistance to HPPD inhibitor and dinitroanaline herbicides in other areas. One plant can produce 100,000 to 500,000 seeds that may remain viable for 5 years. Under ideal conditions, amaranth can set seed as early as 4 weeks from germination. Older leaves of *A. palmeri* differ from other amaranth species in that the petiole is as long as or longer than the leaf blade and the plant lacks hairs.
Management—Use herbicides before plants reach 4 inches in height. Use a combination approach of a pre- and post-planting herbicide. Note, some populations may have developed resistance to certain herbicides.

Palmer amaranth foliage (a) and stems (b).

Wildlife

Deer horn rubbing damage.

Rabbit injury to tree base.

Vole injury (a), damage to root stock (b), and tunnels at the base of a tree (c).

33. Deer can cause problems in a number of ways: By using young flexible trees to rub the velvet off of their horns, causing trees to be destroyed in the process; feeding on young shoots and foliage making it very difficult to train and develop a productive tree structure; and their presence in the orchard during summer and fall causes fruit *E. coli* contamination concerns.
Management—Repellent for low populations, hunting and/or high-tensile electric fences for high populations. The most effective deterrent is a 10-foot tall woven wire fence.

34. Rabbit feeding may girdle and kill trees. Injury typically occurs while the trees are dormant and rabbit food sources are reduced.
Management—Destroy fallen fruit; keep area beneath trees bare or relatively vegetation-free during winter; maintain grassy areas and fence rows to eliminate over-winter cover and additional food sources. Protect young trees with hardware cloth.

35. Vole feeding damage occurs during winter and is particularly intense when there is a snow, weed, or mulch cover that hides voles from predators. Injury to trees results when voles eat bark off roots and lower tree trunks. Three different vole species damage and kill fruit trees in Kentucky: pine vole, meadow vole, and prairie vole. All have short tails which differentiates them from longer-tailed mice. Voles have a high reproductive capacity, allowing populations to build very rapidly.
Management—Commercial baits or covered snap traps. Destroy fallen fruit; keep area beneath trees bare or relatively vegetation-free during winter; maintain grassy areas and fence rows to eliminate over-winter cover.

36. Yellow-bellied sapsucker injury is apparent as one or more rows of horizontal or vertical holes penetrating trunk bark. Injury usually occurs in spring on older trees when birds feed on inner tree bark and sap. Sapsuckers often revisit trees to feed on sap that collects in the holes they created.
Management—Yellow-bellied sapsuckers are protected by federal law so they may not be killed. Noise or visual frightening devices and/or wrapping trunks with screening may be of limited success.

Yellow-bellied sapsucker damage to trunk.

Physiological Disorders

Blackheart injury to trunk.

Frost injury (left) and uninjured (right) flowers (a). Frost ring (b). Pumpkin apple symptom of freeze injury (c).

37. Blackheart results from freeze damage to xylem (vascular) tissue. Tree decline often results if large amounts of tissue are killed. Damage can occur when trees have not hardened off properly in fall and during particularly cold winters. Excessive nitrogen availability late in the growing season and/or a hard early fall freeze before trees develop their hardiness may be factors. Some less hardy varieties and rootstocks are more prone to blackheart.
Management—Avoid late season nitrogen applications. Begin pruning in February after coldest winter temperatures have passed; prune youngest trees in late March as they are more susceptible to winter injury.

38. Frost injury can affect flowers or small fruit. Injury to ovaries of flowers occurs when temperatures drop below critical levels. Browning is apparent almost as soon as flowers thaw. Most fruit with seeds killed by frost drop from the tree prematurely. Frost rings develop on fruit when ice forms beneath the fruit epidermis, separating the epidermis from the fruit flesh. Cork cells form in response, resulting in russeting. Frost rings typically occur at the calyx end of the fruit. Pumpkin fruit symptoms are another manifestation of severe cold injury to outer portions of fruit. Affected fruit are unmarketable except for use in cider.
Management—Proper site selection (good air drainage); reduce orchard freezing using equipment such as wind machines (air inversion), overhead irrigation (sprinklers), and supplemental heat source.

39. Fruit cracking, stem-end splitting and internal ring cracking are caused by rapid fruit expansion. They can occur following excess rainfall or irrigation. Internal ring cracking is a concentric crack found internally at the stem base. 'Stayman Winesap' is particularly prone to fruit cracking, while 'Gala' and 'Fuji' are prone to stem-end splitting and internal ring cracking.
Management—Apply growth regulators during summer to reduce fruit cracking; harvest promptly when fruit ripen.

40. Necrotic leaf blotch affects only mature leaves and is characterized by the development of irregular necrotic spots that usually appear within a 24-hour period. Most affected leaves turn yellow and drop prematurely within 4 to 7 days. This disorder is restricted to 'Golden Delicious' and 'Golden Delicious' crosses. Necrotic leaf blotch is associated with 4 to 5 days of cool, wet, cloudy weather followed by sunny hot days.
Management—Apply ethylenebisdithiocarbamate fungicides (e.g. mancozeb) beginning a month after petal fall or apply zinc oxide every 14 days from bloom to harvest.

Fruit cracking.

Necrotic leaf blotch at various stages.

Russet.

Sunscald injury to fruit.

41. Russeting is a wound healing response associated with frost injury or with rain, high humidity, and fluctuations in temperature during early fruit development. Pesticide sprays, such as fixed copper, can also injure fruit when applied after quarter green leaf stage, particularly when temperatures are cool and drying conditions are slow. 'Golden Delicious' and 'Hudson's Golden Gem' are susceptible to russeting.
Management—Cultivar selection, four sprays of growth regulator (beginning at petal fall).

42. Sunburn or sun scald injury to the fruit is often associated with high temperatures and intense sunlight when skies are clear. It may occur when the weight of fruit results in a branch adjustment so that previously protected portions of fruit become exposed to direct sunlight. It frequently shows up on the southwest side of trees of light-skinned varieties (e.g. 'Granny Smith') when trees are under water stress.
Management—Follow proper tree pruning and training practices; avoid water stress; spray fruit with white wash or Surround crop protectant; wash and brush protectant off after harvest.

43. Sunscald injury to the lower trunk occurs on the southwest side of trees in and on older upward facing branches in winter. It occurs when the sun heats up the bark after it has begun to slip. A rapid drop in temperature produces a contraction of the bark, causing it to separate from the tree. These wounds are slow to heal and provide an entrance for insects and diseases.
Management—Protect young tree trunks with white plastic wrap around tree guards or apply a white indoor paint late in fall. Retain some leaf cover over older limbs when pruning and/or paint the tops of horizontal exposed limbs with indoor latex paint.

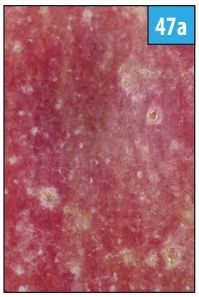
44. Watercore appears as water-soaked areas within fruit as a result of over-ripening (high sorbitol content). It is associated with cool night temperatures close to harvest, large fruit size, high nitrogen levels, and high sunlight exposure. It also occurs when there are few fruit on the tree and the many leaves produce sugars that have only a few sites to be stored.
Management—Harvest before fruit become overripe. Mild to moderate watercore usually disappears in storage.

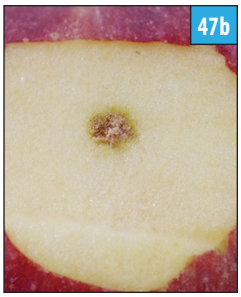
Watercore.

Sunscald injury to trunk (a) and upper branch surface (b).

Nutrient Disorders

Bitter pit internal and external symptoms.





External (a) and internal (b) symptoms of cork spot.

Iron deficiency.

45. Bitter pit is characterized by small dark pits located around the calyx end of fruit that show up late in the season or in storage. This condition is caused by a fruit calcium deficiency.
Management—Maintain soil pH at approximately 6.5; avoid excessive nitrogen; apply calcium chloride in cover sprays to move calcium through fruit skin; dip fruit in a calcium solution prior to storage.

46. Boron deficiency is found relatively frequently in Kentucky apple foliar analyses, but symptoms are not readily apparent because trees are generally only slightly deficient. Symptoms first show up in fruit as an increase in corking and/or cracking. In more severe cases, fruit size is reduced and fruit may be malformed. Corking from boron and calcium deficiency symptoms are difficult to separate. Severe deficiency symptoms on high pH soils in the western U.S. include death of shoot tips, reduced leaf size and rosette growth on terminal shoots.
Management—Annual foliar sprays of Solubor at pink and petal fall. Borax applications may be made to soil.

47. Cork spot (aka York spot) shows up as a slight depression at the fruit surface or it may be internal. The area is darkened in color and corky. This condition is a fruit calcium deficiency often appearing in seasons when the fruit are very large. All the calcium that moves into the fruit accumulates within 30 days after bloom. In larger apples the calcium is diluted and a deficiency occurs. Some varieties, such as 'York,' are more prone to this problem.
Management—Maintain soil pH at about 6.5; avoid excessive nitrogen; apply calcium chloride in cover sprays to move calcium through fruit skin.

48. Iron deficiency on apple is rare in Kentucky. Symptoms show up first on the youngest leaves, which turn yellow. Initially the fine leaf veins are dark green, but as the deficiency progresses the entire leaf turns uniformly yellow. This deficiency occurs when the soil pH is too high and iron is chemically bound in the soil so it is unavailable to the tree.
Management—Applications of iron chelate to foliage and/or soil provide a temporary solution; lower soil pH for long-term control.

49. Magnesium deficiency symptoms typically show up on older leaves as light green blotches between veins, progressing toward the leaf margins. Blotches turn tan and then brown in color; most affected leaves drop from trees.
Management—Monitor tree magnesium levels through foliar analysis and apply dolomitic lime to soil if a pH increase is needed. Apply magnesium sulfate (Epsom salt) to foliage and/or soil, or apply magnesium chelate or magnesium oxide to foliage.

50. Manganese bark necrosis or measles is manifested as an uneven bark surface with purplish raised pimples and dark deposits below. It is caused by an excessive uptake of manganese from the soil. A low soil pH of 5 or below makes manganese much more available and leads to this disorder. Symptoms show up primarily in 'Red Delicious.'
Management—Apply lime prior to establishing orchards to attain a soil pH of 6.5. Maintain soil pH as a preventative measure.

Boron deficiency internal and external symptoms.

Magnesium deficiency.

Manganese bark necrosis.

Production Problems

Burr knot (a) and girdling limb (b).

51. Burr knots result from adventitious root development on aboveground portions of trees. Development is favored by low light, high humidity, and warm temperatures. Some apple varieties (e.g. 'Lodi') and rootstocks (e.g. M.7 and MM.111) are particularly prone to this problem. Burr knots provide areas for wooly apple aphids, borers, fire blight bacteria, and wood rot fungi to colonize trees. Large numbers of burr knots weaken trees, and resulting wood rot infections may girdle limbs.
Management—Treat galls with Gallex, select rootstocks and varieties that are less prone to this problem.

52. Graft union breakage is common on dwarf apple trees if no support is provided. Dwarf tree graft unions are brittle and prone to breakage, particularly as trees begin to bear fruit and put more stress on the graft union.
Management—Support dwarf trees with a trellis or post.

Graft union breakage.

Poor pollination (fruit).

53. Poor pollination occurs when there are insufficient numbers of bees. This is often associated with too few hives and/or cold, windy, wet conditions during bloom. Normal fruit will have 10 developed seeds which mobilizes carbohydrates into the fruit during growth. Fruit with low seed numbers are typically smaller in size and may be unsymmetrical or lopsided.
Management—Provide adequate bee numbers; thin fruit to remove those with low seed numbers. Honey bees may be more efficient pollinators than orchard bees and more economical than bumble bees.

Herbicide Injury

Leaf distortion from 2,4-D herbicide.

Clomazone injury to apple foliage.

54. 2,4-D (2,4 dichlorophenoxyacetic acid) **injury.** Leaf twisting, malformation, and curling are common symptoms of 2,4-D herbicide exposure from spray drift, volatilization, or sprayer contamination. Spraying 2,4-D under dry, low humidity conditions and at temperatures above 85°F or using ester formulations of this product can lead to volatilization and movement from the application area.
Management—Use labeled products; avoid applications when temperatures are above 85°F; use a coarse spray at a low spray pressure to avoid volatilization and drift.

55. Clomazone (e.g Command) **injury** to apple leaves. Command is a volatile pre-emergence herbicide used on vegetable crops and soybeans. Contact from small amounts of this herbicide through drift or volatilization will bleach young leaves.

56. Glyphosate (e.g. Roundup) **injury** symptoms can become evident in spring following a late summer application the previous season. Trees are much more susceptible to injury when this herbicide drifts onto or is inadvertently applied to trees after about July 15. Glyphosate translocates within the tree, moving down to roots in late summer and fall. It is then moved up into the foliage the following spring to produce small willow like leaves. The herbicide may repeat this cycle within the tree for several years. Late season drift is more likely to be lethal to trees than early season drift. The surfactant in Roundup often affects the development of tree winter hardiness, leading to trunk cracking and tree death.
Management—Avoid contact with apple; minimize drift (shielded sprayers, low pressure spray, calm days).

Localized (a) and foliar (b) symptoms of glyphosate injury.

Photo Credits

Many of the images in this manual came from the personal collections of the UK IPM Fruit Workers Team. However, in some instances images were used from outside sources. Credits for those images are listed as follows:

Bugwood
Mary Ellen (Mel) Harte, Bugwood.org—31b
Robert Videki, Doronicum Kft, Bugwood.org—31a

Clemson University
Clemson-USDA CES, Bugwood.org—2

Illinois Wildlife Action Plan
Chris Evans, Bugwood.org—30

Michigan State University
Mark Longstroth—3, 11a, 11b, 11c, 56a, 56b
William Shane—40c

Ohio State University
Bruce Ackley, Bugwood.org—32b

University of Georgia
Plant Pathology Archive, Bugwood.org—27a
Rebekah D. Wallace, Bugwood.org—32a

University of Illinois
Mohammad Babadoost—40a, 40b
Mosbah Kushad—49

University of Kentucky
Cheryl Kaiser—6
Dwight Wolfe—33
John Strang—4d, 5, 7a, 7d, 7e, 8b, 8c, 10b, 15c, 16a, 16b, 29, 34, 35b, 35c, 36, 37, 38a, 38c, 39, 41, 42, 43a, 44, 45, 47a, 47b, 48, 50, 51a, 51b, 52, 53, 54, 55
Nicole Ward Gauthier—cover, 1a, 1b, 4a, 4b, 4c, 7b, 7c, 8a, 9, 10a, 38b, 43b
Paul Bachi—35a
Ricardo Bessin—12a, 12b, 13a, 13b, 14a, 14b, 15a, 17a, 17b, 18b, 19a, 19b, 20a, 20b, 21a, 21b, 22a, 22b, 22c, 22d, 23a, 23b, 23c, 24a, 24b, 25a, 25b, 25c, 26, 27b, 28a, 28b

USDA
James Solomon, Bugwood.org—15b, 18a

Virginia Polytechnic Institute
Mary Ann Hansen, Bugwood.org—46

Issued 5-2014