ID-172

University of Kentucky
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An IPM Scouting Guide for Common Pests of Solanaceous Crops in Kentucky

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An IPM Scouting Guide for Common Pests of Solanaceous Crops in Kentucky

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The National IPM 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 when producing solanaceous crops (tomatoes, peppers, eggplant, and potatoes) in Kentucky.

This manual is not all-inclusive, and you may encounter a problem that you do not see here. Please contact your county Extension service for assistance. Also, for more complete growing information for vegetable crops in Kentucky, consult Vegetable Production Guide for Commercial Growers (ID-36), available from your county office or online at http://www2.ca.uky.edu/agcomm/pubs/ID/ID36/ID36.pdf.

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Physiological and Nutrient Disorders

Vivipary on tomato.

1. Vivipary can occur when fruit become overripe and the hormone controlling seed dormancy, known as abscisic acid, is exhausted. The seeds inside the fruit begin to germinate and the sprouting seeds can even poke through an uncut tomato. Vivipary can be avoided by not letting fruit become overripe. Do not leave tomatoes on the plant too long, and consume them within a few days after ripening. Tomatoes can be harvested before they are fully ripe. Storing tomato fruit below 55°F may also lead to vivipary. Peppers can also have vivipary.

2. Gold fleck starts as scattered small green spots on ripening fruit and quickly turns a gold color. The cause is unknown but is likely related to genetics. In some instances, damage from concentrated fertilizer sprays can resemble flecking but the affected tissue is usually brown (necrotic) and not gold in color. Although primarily thought to be genetic, flecking can appear more pronounced under certain environmental conditions. A similar look can also appear when thrips feed on tomato fruit.

Gold fleck on tomato fruit.

Catfacing on tomato.

Zippering on tomato.

3. Catfacing can be the result of poor pollination from extremely hot or cold temperatures or severe drought conditions. Certain herbicides that contain growth regulators may also be linked to catfacing. The best management strategy is to select varieties that have shown little tendency to catface in the past.

4. Zippering is characterized by the presence of brown tissue (resembling a zipper) running down the sides of tomatoes, often from the stem scar to blossom end. Zippering is the result of an anther remaining attached to newly forming fruit. It may also be associated with incomplete shedding of flower petals when fruit is forming. Little can be done to prevent zippering except selecting varieties that do not seem prone to zipper.

Cracking on tomato.

Sunscald on tomato.

5. Cracking generally appears near the stem scar and is the result of rapid fruit growth, usually brought on by periods of drought followed by heavy rains or irrigation events. Concentric cracking can often occur when standing water sits on the shoulders of fruit. There are large varietal differences in susceptibility to cracking. Cracking can be greatly reduced by choosing resistant varieties and managing irrigation.

6. Sunscald typically occurs on the shoulders of tomato and pepper fruit, though it can occur anywhere the fruit are unprotected from full sunlight. Nitrogen fertility and irrigation affect the amount of foliage that a plant produces, which will affect the chances for sunscald injury.

Blossom end rot on tomato (a) and pepper (b).

7. Blossom end rot is caused by inadequate translocation of calcium through the plant during fruit development. Kentucky soils are not typically deficient in calcium, and so this issue is usually not due to insufficient soil calcium levels but rather inadequate soil moisture to deliver the calcium to the plant and fruit. Once the condition has developed, it cannot be corrected on affected fruit; improved water management can prevent further loss.

8. Blotchy ripening can be caused by a number of factors, including inadequate potassium availability, cool and cloudy weather, and moisture stress. If blotchy ripening is a persistent problem, soil testing is recommended and check the Hartz Ratio (included on UK soil tests for tomato production). Applications of potassium nitrate during fertigation may help. Some tomato varieties are more susceptible than others.

Blotchy ripening on tomato.

Yellow shoulder on tomato.

White core in tomato.

9. Yellow shoulder is a ripening disorder in tomato fruit that causes distinct yellowing around the stem scar. It looks as though the fruit are not completely ripe, but the yellow color never turns red. It is caused by a lack of potassium in the fruit. This can be due to not enough available potassium in the soil. Soil and foliar testing can tell you if you have potassium in the soil that is just not being taken up by the plant. Check the Hartz Ratio. Varieties that lack the uniform ripening gene are more susceptible, as are varieties that produce less foliage to shade fruit.

10. White core is characterized by the presence of a thick, tough, large white core in tomatoes. Fruit with white core are often less juicy and flavorful. Excessively high temperatures and excessive nitrogen fertility can cause white core. Some varieties, including those that are not specifically bred for heat tolerance, are more susceptible than others. White core may occur more frequently in high tunnel tomatoes when temperatures are above 100°F and there is inadequate ventilation. If growing in a high tunnel, be sure to open end walls and side walls when air temperatures are consistently high. Consider installing overhead fans to increase air flow.

11. Magnesium deficiency symptoms are characterized by interveinal chlorosis (the leaf veins stay green while the regions between them turn yellow), typically on older leaves. As the deficiency progresses, the interveinal chlorosis will move up the plant. Some micronutrient deficiencies can have similar symptoms, but they generally appear on newer growth first. Magnesium sulfate (also known as Epsom salts) can help prevent or alleviate this deficiency.

12. Potassium deficiency often is associated with yellowing of the margins of the lower leaves. Potassium deficiencies are also associated with blotchy ripening in tomato fruit. Foliar testing can provide the status of potassium in plants. Be sure to follow the sampling instructions of the lab where you plan to send the foliar samples. You can also check the potassium status yourself using a Cardy Meter.

Magnesium deficiency shown in tomato leaves.

Potassium deficiency.

Boron deficiency in potato.

Bullishness in tomato.

13. Boron deficiency in potatoes results in necrosis (dieback) of the tuber tissue. Use boron-containing fertilizers to correct deficiencies. Be cautious to not over-fertilize with boron as it is a micronutrient, and much lower levels are necessary to correct deficiencies than with macronutrients, such as nitrogen, potassium, and phosphorus.

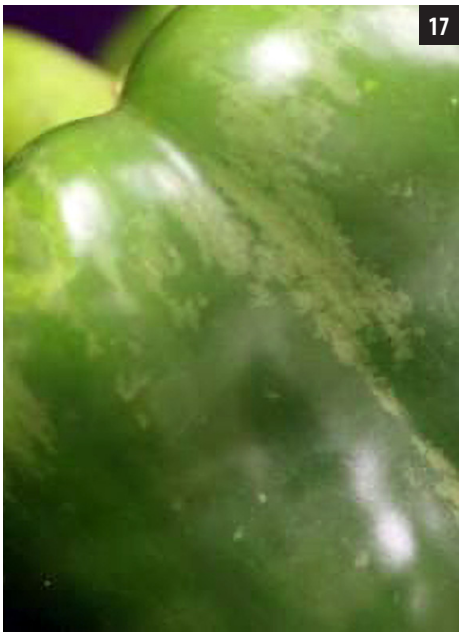
14. Bullishness is generally caused by excessive nitrogen fertilization resulting in overly "bullish" vegetative growth. Typical symptoms include a curling and distortion of leaves near the top of the plant. In some cases, it may resemble growth regulator injury. Poor fruit set is also associated with bullishness. It is more common during periods of cool, cloudy weather. Determinate, field-type varieties seem more affected than indeterminate varieties. Bullishness is common in greenhouse or high tunnel grown plants, particularly in late winter. Plants usually grow out of the condition once light levels and temperatures increase. Reduce nitrogen fertilization during periods of cool, cloudy weather to prevent bullish growth.

Frost damage on tomato foliage.

15. Frost injury. Tomato leaves injured by frost first appear water soaked, then turn to a necrotic browning, burned appearance.

16. Animal damage. Tomatoes are often damaged by crows, deer, coyotes, raccoons, voles, and a variety of other pests. Try to plant away from wooded areas and use deterrents if possible.

Crow-damaged tomatoes.



Silvering in bell pepper fruit.

17. Silvering occurs on bell peppers when cells adjacent to the cuticle in fruit separate causing a "silvered" appearance. It is considered a defect in fruit and can be a reason for fruit being rejected during times of excess supply. The severity of silvering can range from a small dime-size area on fruit to an area covering more than half of a fruit. It is related to variety; those varieties possessing strong resistance or tolerance to Phytophthora are more likely to exhibit this trait. There is also an environmental link to this disorder as it varies in severity from year to year.

18. Black spot. Irregular black or dark brown spots that are not raised on the pepper fruit. Spots will extend into the fruit as well. Rare, though previously documented in Texas. At this time the cause of this disorder is not known.

Black spot on pepper.

Flood damage to a pepper plant.

19. Flood damage. Prolonged exposure to flooding conditions can lead to a host of problems, including nutrient deficiencies, root death due to a lack of oxygen, and numerous soil-borne pathogens. Raised beds help improve drainage. Vegetables exposed to flood waters may need to be discarded to be in accordance with food safety regulations.

20. Ethylene injury may be difficult to diagnose, but symptoms can include: yellowing leaves, shedding leaves, dropping flowers or buds, stunted growth, and/or downward turned leaves that appear wilted but are still firm to the touch. Similar symptoms may be observed when plants are accidentally exposed to certain herbicides. Tomato plants are extremely sensitive to ethylene and the injury can be observed within 24 hours of exposure. Ethylene is a colorless, odorless gas that is a naturally occurring plant hormone and is present in many ripening fruit. However, ethylene can also come from the exhaust from a furnace when there is incomplete combustion. The injury is often observed in the late winter or early spring in greenhouses and heated high tunnels. Have heaters and furnaces checked annually before using them.

Ethylene damage on tomato (a&b).

Insect Pests

21. Aphids (various species). Common pests of all solanaceous crops. Pictured are the green peach aphid (*Myzus persicae*) on pepper and potato aphid (*Macrosiphum euphorbiae*) with white cast skins on tomato. Adult aphids are about ⅛ inch long and are a common pest of peppers and tomatoes in Kentucky. Aphids remove sap from plants through piercing and sucking mouthparts, and although large numbers can be tolerated, severe infestations such as this can lead to stunting and leaf curl in affected plants, honeydew accumulation on fruit, and sooty mold. Aphid outbreaks are often the result of overreliance on pyrethroid insecticides. Aphids pose a significant threat as a vector to spread viruses among crops.

22. Vegetable leafminer (*Liriomyza sativae*). Found on many vegetables, including tomato and pepper, vegetable leafminer larvae will make serpentine "mines" in leaves. Adults are 1/16 inch long black and yellow flies. Many natural enemies can control this pest. It is generally not an economic pest in Kentucky.

Potato aphids (a), green peach aphids (b).

Vegetable leafminer on tomato.

Greenhouse whitefly and eggs.

23. Greenhouse whitefly (*Trialeurodes vaporariorum*). About ⅛ inch in length, greenhouse whitefly is a common pest of tomato plants. Nymphs are pale yellow and often found on the underside leaves. The adult whitefly is white and often keeps its wings flat on its back. A generation of greenhouse whitefly can be completed in as short as three to four weeks, and an adult female can lay hundreds of eggs in just six to eight weeks. As with aphids, whiteflies can contaminate fruit with honeydew and promote sooty mold.

24. Silverleaf whitefly (*Bemisia argentifolii*). Silverleaf whitefly is a relatively new pest to Kentucky. Silverleaf whitefly will not overwinter in Kentucky, however it may be brought in via transplants or greenhouse plants. The silverleaf whitefly can be distinguished from the greenhouse whitefly by looking at how it holds its wings. The silverleaf whitefly will usually hold its wings to its side with a space visible between them; the greenhouse whitefly often holds its wings tight on its back. Silverleaf whitefly larvae inject toxins into tomato fruit when feeding, leading to irregular ripening that can cause significant losses. Affected fruit will not ripen completely.

Silverleaf whitefly (a) and damage on tomato (b).

Tobacco flea beetle.

25. Tobacco flea beetle (*Epitrix hirtipennis*). The tobacco flea beetle is about 1/10 inch long and yellowish brown with a dark band across its wings. They attack solanaceous crops, leaving small round holes in the leaves, and may destroy entire leaves. Potentially, they can be serious pests early in the season when the plants are less than 4 to 6 inches tall. As they grow, larger plants can withstand substantial flea beetle damage without loss of yield.

26. Potato flea beetle (*Epitrix cucumeris*). The potato flea beetle is about 1/16 inch long and feeds on tomato and potato plants. They differ from the tobacco flea beetle in that they are uniformly colored black to brown.

Potato flea beetles.

27. Margined blister beetle (*Epicauta pestifera*). Margined blister beetles are common in the Midwest and can be distinguished from other blister beetles by the orange striping on the wing margins. Only one generation is produced per year and they are generally not a major threat, though large numbers of adults can appear in swarms and rapidly defoliate plants.

28. Stink bugs (brown: *Euschistus servus*; green: *Acrosternum hilare*; brown marmorated: *Halyomorpha halys*). Stink bugs are about ½ to ¾ inch long and are common pests in Kentucky. They feed on plants and fruit by inserting their needle-like mouthparts into stems, leaves, or seed pods. While feeding, they inject materials into the plant to aid in digestion and sap removal. Adult stink bugs can be difficult to manage with insecticides. Stink bugs commonly feed on pepper and tomato fruit, causing significant damage that extends from the surface into the fruit. The brown marmorated stink bug is new to Kentucky and has the potential to build to high numbers on and cause extensive damage to many fruit and vegetables, including solanaceous crops. Penetration by the mouthparts can cause physical damage—much like stabbing the plant with a fine needle—and the materials injected can also damage plant tissues. A combination of mechanical and chemical damage may be responsible for the injury and symptoms seen in the field.

Margined blister beetle.

External stink bug damage on red pepper (a), internal damage on green pepper (b), and external damage on tomato (c).

Brown stink bugs—adult brown marmorated (d) mature brown stink bug (e), and green stink bugs—immature (f) and mature (g).

A leaf-footed bug on tomatoes.

29. Leaf-footed bugs (*Leptoglossus* spp). Leaf-footed bugs get their name from the expanded tibia of the hind leg. They are closely related to stink bugs and also feed with piercing-sucking mouthparts but are not in the same family. Leaf-footed bugs are becoming more common, particularly on tomatoes, causing damage similar to that of stink bugs. Leaf-footed bugs may be observed after flowering through the fall.

30. Western flower thrips (*Frankliniella occidentalis*). Thrips of all types can feed on tomatoes. When they pierce the tomato, they leave behind small holes, leaving the fruit unmarketable. Thrips are extremely small (<1⁄16 inch) and often hard to detect. Thrips thrive in hot weather and can transmit tomato spotted wilt virus.

Western flower thrips (high magnification).

Thrip damage on tomato.

Two-spotted spider mite on tomato (a) and leaf damage (b).

31. Two-spotted spider mite (*Tetranychus urticae*). Two-spotted spider mites are small and difficult to see without the aid of a magnifying lens. Damage typically appears as a yellow flecking of leaves, which turns to a general browning of the leaves. Careful scouting for two-spotted spider mite is important as they are resistant to many classes of insecticide. Spider mites are more common in hot, *dry* weather.

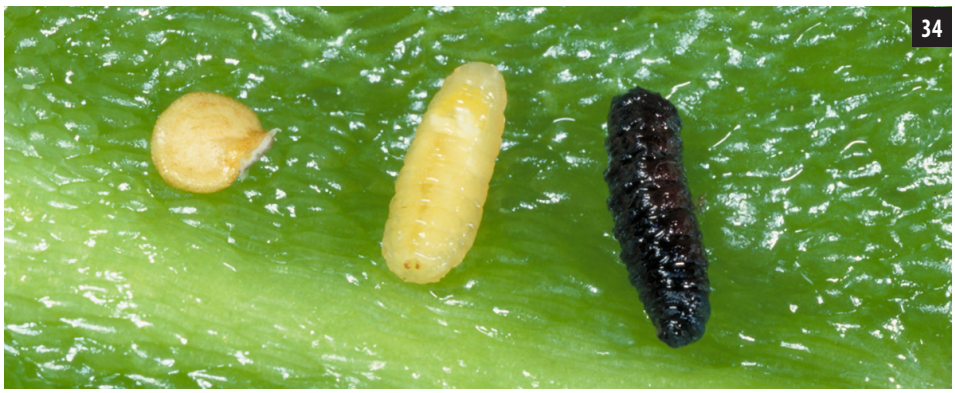
32. Colorado potato beetle (*Leptinotarsa decemlineata*). Colorado potato beetle can be a serious pest of tomato, eggplant, and pepper. Adult beetles are about 3⁄8 inch long with black and yellow stripes over its back. Each female can lay 500 or more eggs over a four- to five-week period. Eggs hatch in four to nine days and the larvae begin to feed on potato foliage. Larvae are humpbacked with two rows of black spots on each side. They usually feed in groups, and damage can be severe. The larval stage lasts two to three weeks. Full grown larvae burrow in the ground to pupate. In five to 10 days, the adult beetle emerges. This insect can go from egg to adult in as little as 21 days.

Colorado potato beetles (a), eggs (b), and larvae (c).

33. Tobacco hornworm (*Manduca sexta*). Tobacco hornworms are similar to tomato hornworms, and both cause significant foliar injury to tomato as well as peppers. Both can be several inches in length. Tobacco hornworms generally have a red "horn" and diagonal white stripes on their sides; tomato hornworms have a black horn and white v-shaped stripes. Both pests are common in Kentucky. The green hornworms may blend in and be hard to locate at first; however, they leave behind rather large black-brown frass deposits as evidence of their presence, and further scouting is warranted when such deposits are seen. Adult hornworms first appear as moths in late spring to lay eggs. Moths are quite large, approaching several inches in length. Often tobacco hornworms will be attacked by a parasitic wasp, *Cotesia* sp., which lays eggs inside tobacco hornworms. Wasp larvae grow internally and emerge in white cocoons.

Tobacco hornworm on pepper (a), attacked by beneficial wasp (b), tobacco hornworm moth (c), and tobacco hornworm frass (d).

34. Pepper maggot (*Zonosemata electa*). Pepper maggot larva (yellow) and pupa (black) are shown. They are about ½ inch long and will feed on actively growing peppers. Good sanitation and rotation are important.



Pepper maggot.

Beet armyworm larvae (a), mature larvae (b), moth (c), damage on pepper (d), and newly emerged beet armyworm larvae (e).

35. Beet armyworm (*Spodoptera exigua*). Beet armyworm is a serious pest of vegetables in Kentucky, often appearing in August or September. Mature larvae are about 1½ inch long and can rapidly defoliate plants. Female moths lay masses of up to 80 eggs under a covering of cottony-white scales, as many as 600 eggs over a three- to seven-day period. Eggs hatch in two to three days, with the larvae first feeding together in a group near the egg cluster. As the larvae grow, they gradually move away from the egg masses. In fresh market tomatoes, treatment is needed when 3% fruit feeding (shallow, dry cavities in the fruit) is noted. Beet armyworm is resistant to pyrethroid insecticides. Larvae often feed on pigweed, so when scouting take time to look at any pigweeds in the vicinity of your crop.

36. Yellow striped armyworm (*Spodoptera ornithogalli*). Yellow striped armyworms are similar to beet armyworms but are generally brown in color with a yellow strip and triangular black marks on their back. Management is the same as that for tomato fruitworm.

Yellow striped armyworm damaging tomato fruit (a) and small larvae on tomato foliage (b).

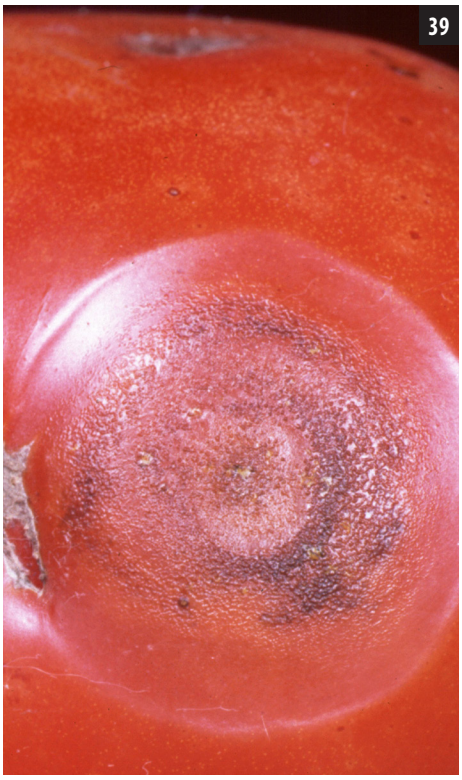
Tomato fruitworm (a) and moth (b).

37. Tomato fruitworm (*Helicoverpa zea*). Tomato fruitworm is the same pest as corn earworm. Early fruitworm generations attack corn, particularly when it is silking. However, tomatoes are preferred for egg laying over corn when the silks turn brown and dry. Adult moths usually have light brown wings with a dark spot near the middle. Moths fly at night looking for a suitable place to lay their eggs.

38. European corn borer (*Ostrinia nubilalis*). European corn borer is a common pest of peppers in Kentucky. Corn borers overwinter as full-grown larvae in corn stubble. European corn borers enter pepper fruit near the calyx and destroy the inside of the pepper. If you have peppers with damage and entry holes near the calyx then corn borers are likely inside. Adults emerge in late spring to mate, and females will typically lay egg masses on foliage. Generally, there are two generations per year. Male moths are attracted to pheromone traps, which are effective tools to scout for European corn borer.

Adult female European corn borer (a), adult male (b), and damage on pepper (c, d).

Tomato Diseases



Anthracnose.

Fungi and Fungus-like Organisms

39. Anthracnose (*Colletotrichum* spp.), often referred to as "ripe rot," appears on ripening fruit as sunken, circular spots (lesions). Lesions enlarge and darken over time, and concentric patterns may be observed. Under humid conditions, salmon-pink masses of spores may exude from fungal bodies in lesions.

Management—Promptly remove and destroy diseased plant material; manage weeds and potential alternative hosts; avoid wetting fruit and leaves when irrigating; apply protectant fungicides at beginning of fruit set; rotate with non-host crops; promptly destroy crop residues after harvest; deep plow to bury residual inoculum.

40. Early blight (*Alternaria* spp.), *the* most common fungal disease of tomatoes in Kentucky, appears on leaves and stems as dark-brown lesions with concentric rings. Older leaves are usually affected first, but the disease spreads upward to newer growth under favorable conditions. Lesions enlarge and coalesce; extensive blighting (sudden death) and loss of leaves can result. Lesions may develop near the stem end of fruit during severe outbreaks. Fruit lesions become sunken and leathery; a thick mass of black spores may be present under humid or wet conditions.

Management—Promptly remove and destroy diseased plant material; manage weeds and potential alternative hosts; avoid wetting fruit and leaves when irrigating; apply protectant fungicides; rotate with non-host crops; promptly destroy crop residues after harvest; deep plow to bury residual inoculum.

Early blight on tomato foliage (a), severe early blight on tomato plant (b) and on fruit (c).

41. Fusarium wilt (*Fusarium oxysporum* f. sp. *lycopersici*) symptoms include stunting, yellowing of older leaves, and wilting. Wilting may initially occur on one side of plants and is often more severe during the hottest time of the day. Plants decline over a period of days or weeks, and eventually die. Vascular tissue (xylem) in infected stems turns brown—a key diagnostic feature. Disease can be problematic when conditions are hot and dry and is usually more severe if associated with infestations of root-knot nematode.

Management—Rotate to non-host crops for at least three years if disease is severe; select resistant cultivars (effective only if disease pressure is low). Plant pathogen-free seed and transplants; manage nematodes (see No. 56); promptly remove and destroy diseased plant material; destroy crop residues after harvest; deep plow to bury residual inoculum; avoid movement of infested soil to clean fields.


41a


41b


42

Fusarium root and crown rot.


41c

Fusarium wilt vascular browning.

42. Fusarium crown rot (*Fusarium oxysporum* f. sp. *radicis lycopersici*) symptoms include yellowing or stunting; plants can become diseased at any growth stage. Wilt may occur during the hottest time of the day but recover at night; plants eventually die. Crown symptoms include a dark brown girdling lesion that extends to the taproot; dark brown vascular discoloration is common in the lower portion of the stem. Fungal infection typically occurs through wounds.

Management—Rotate to non-host crops for at least three years if disease is severe; select resistant cultivars (effective only if disease pressure is low). Plant pathogen-free seed and transplants; promptly remove and destroy diseased plant material; destroy crop residues after harvest; deep plow to bury residual inoculum; avoid movement of infested soil to clean fields.

Gray mold Botrytis stem (a), fruit (b), and ghost spot (c).

43. Gray mold (*Botrytis cinerea*) is characterized by a distinctive gray to light-brown, fuzzy, moldy growth that appears on diseased leaves, stems, and blossoms. Occasionally, infections to green fruit may result in "ghost spots" that make fruit unmarketable. Gray mold more commonly occurs on tomatoes produced in greenhouses and high tunnels. Cool temperatures and high humidity favor disease.

Management—Provide adequate ventilation and plant spacing; promptly remove and destroy diseased plant material; apply protectant fungicides during cooler conditions.

44. Late blight (*Phytophthora infestans*) symptoms may be observed on leaves, stems, and fruit. On leaves, individual lesions begin as water-soaked areas that can enlarge quickly and result in extensive blighting (sudden death) of leaves. Under cool, humid conditions, sporulation (whitish-gray downy-type growth) can be observed on the undersides of affected leaves. Fruit exhibit darkened, water-soaked spots that coalesce, often covering much of the fruit. Severely infected fruit are invaded by secondary organisms, resulting in a rapid, soft decay. Late blight is relatively rare in Kentucky, and most likely to occur during periods of cool, wet weather (often in autumn).

Management—Rotate to non-host crops for at least three years; purchase pathogen-free seed and transplants; immediately remove and destroy infected plants; apply protectant fungicides to non-infected plants after an outbreak or when outbreaks are reported in the area; promptly destroy crop residues after harvest; deep plow to bury residual inoculum; avoid movement of infested soil to clean fields.

Late blight leaf (a), stem (b), and fruit (c).

Leaf mold upper leaf (a) and sporulation (b).

45. Leaf mold (*Fulvia fulva,* syn *Passalora fulva*) develops mainly on leaves in the form of light green or yellow spots on upper leaf surfaces. As lesions mature, a green, velvet-like layer of sporulation can be visible on lower leaf surfaces. Affected leaves eventually die and drop from the plant. Wet conditions and high humidity (greater than 85% relative humidity) favor disease. Leaf mold is found primarily on greenhouse-grown tomatoes.

Management—Select resistant cultivars; provide adequate ventilation in structures; promptly remove and destroy diseased plant material; apply protectant fungicides beginning at fruit set.

46. Powdery mildew (*Leveillula taurica*; *Golovinomyces* spp.) results in a white, powdery fungal growth on upper and lower leaf surfaces. Over time, tissues become necrotic, resulting in death of affected leaves. Stems may be infected in severe outbreaks. This disease primarily occurs in greenhouses and high tunnels.

Management—Provide adequate plant spacing and ventilation in structures; apply protectant fungicides.

Powdery mildew.

47. Septoria leaf spot or **Septoria leaf blight** (*Septoria lycopersici*) symptoms are usually first observed in lower plant canopies but can spread upward to newer growth. Circular lesions with darkened borders and tan-brown centers can be numerous; under favorable conditions, severe blighting (sudden death) occurs. Small, black specks (pycnidia) are often found in the centers of older lesions. Disease is favored by moderate temperatures and high humidity/rainfall.

Management—Promptly remove and destroy diseased plant material; manage weeds (potential alternative hosts); avoid wetting leaves when irrigating; apply protectant fungicides; rotate with non-host crops; promptly destroy crop residues after harvest; deep plow to bury residual inoculum.

Septoria leaf spot.

48. Southern blight (*Athelia rolfsii*, syn *Sclerotium rolfsii*) initially results in a sudden yellowing or browning and wilting, followed by plant death. Lesions or cankers develop at the base of infected stems near the soil line, often extending up several inches aboveground. When humidity is high, a dense, white fungal growth (mycelium) may be present on affected plant parts and surrounding soil. Eventually, numerous small (1 to 2 mm in diameter), round, tan-to-reddish brown fungal survival structures (sclerotia) develop on the surface of the mycelium. Low-hanging fruit and those that touch infested soil can become infected, resulting in a wet rot and rapid decay. Disease is favored by warm, wet conditions.

Management—Rotate to non-host crops for at least three years if disease is severe; promptly remove and destroy diseased plant material; destroy crop residues after harvest; deep plow to bury residual inoculum; avoid movement of infested soil to clean fields. Limited fungicides are available, and efficacy of these fungicides can be variable.

Southern blight lower stem (a), stem (b), and fruit (c).

Timber rot stem (a) and sclerotia (b).

49. Timber rot or **white mold** (*Sclerotinia sclerotiorum*) primarily affects the main stem; lesions can occur at the soil line or several inches above ground. Under favorable conditions, lesions elongate and become tan with a faint zonate pattern within the symptomatic area. Eventually, stems become girdled and entire plants wilt or collapse suddenly. Infected plants rarely survive. Splitting the stem of symptomatic plants longitudinally reveals one or more irregular-to-cylindrical, black fungal survival structures (sclerotia), a key diagnostic feature of this disease. Timber rot is more common in late spring during periods of cool, wet weather.

Management—Provide adequate spacing and good drainage; deep plow or bury crop debris at the end of the growing season; rotate with non-host crops avoid movement of infested soil to clean fields.

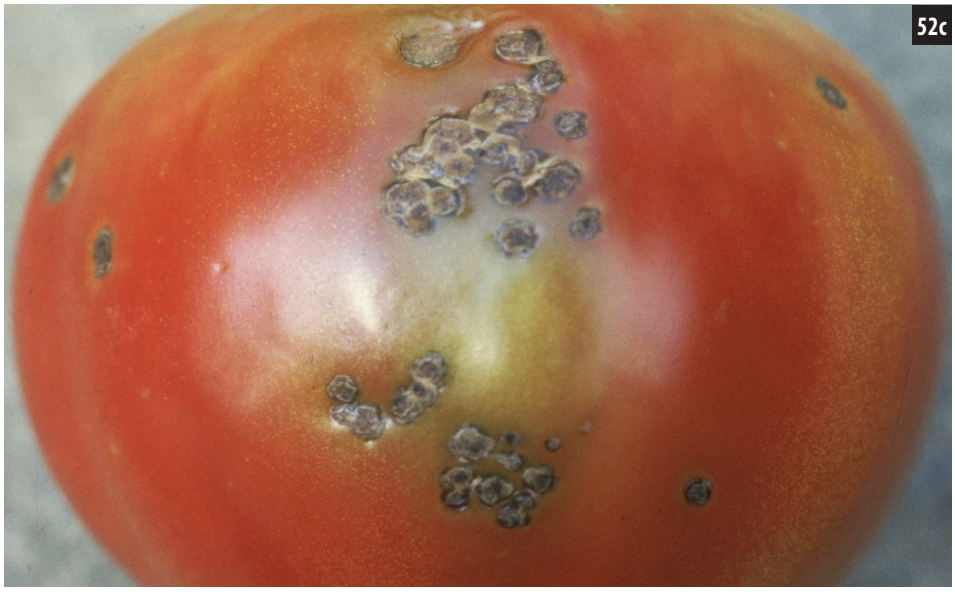
Bacteria

50. Bacterial canker (*Clavibacter michiganensis* subsp. *michiganensis*) may occur on all aboveground plant parts. On mature plants, wilting is often the first symptom observed; later, infected stems split, resulting in open cankers. When stems are split lengthwise, the vascular system has a reddish-brown discoloration, and the pith may be grainy or pitted. Some infections can result in marginal browning or necrosis of older leaves, referred to as "firing." Necrotic tissue may be surrounded with a yellow border, and affected leaves tend to curl upward. Infected seedlings may appear stunted and often wilt and die. On fruit, raised spots with a white margin, roughly 1⁄16 inch in diameter (called "bird's eye"), may appear. This disease can be devastating in structures or fields. Warm temperatures and high humidity or rainfall favor disease.

Management—Plant pathogen-free seed and transplants; disinfect tools and implements; avoid overhead irrigation or working with plants when leaves are wet; promptly remove and destroy diseased plant material; rotate with non-host crops. Destroy crop residues after harvest; deep plow to bury residual inoculum.

Bacterial canker stem canker (a), firing (b&c), and fruit (d).

Bacterial speck leaf.



Bacterial spot leaf (a&b) and fruit (c).

51. Bacterial speck (*Pseudomonas syringae* pv. *tomato*) can affect leaves, stems, and fruit. On leaves, lesions are small, circular, and brown in color; spots may be surrounded by a yellow border or "halo." Over time, lesions coalesce and form large blighted (suddenly dead) areas in the plant canopy. Defoliation may occur in severe cases. Differentiating leaf symptoms of bacterial speck and bacterial spot (see No. 52) can be difficult. On green fruit, lesions are small (specks) and tend to be somewhat sunken. Disease is more likely to occur when conditions are cool and rainy.

Management—Plant pathogen-free seed and transplants; disinfect tools and implements; avoid overhead irrigation or working with plants when leaves are wet; apply a bactericide; promptly remove and destroy diseased plant material; rotate with non-host crops. Destroy crop residues after harvest; deep plow to bury residual inoculum.

52. Bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) leaf lesions are small, circular, and brown in color; spots infrequently have a yellow halo. Lesions can coalesce and form large blighted (suddenly dead) areas in the plant canopy. Defoliation may occur in severe cases. Differentiating leaf symptoms of bacterial spot and bacterial speck (see No. 51) can be difficult; however, bacterial spot lesions tend to have a wet or greasy appearance. On green fruit, bacterial spot lesions begin as raised blisters and reach a maximum size of about ¼ inch. Fruit lesions tend to have a scabby appearance and can be slightly raised or depressed in the center. Disease is most likely to occur when conditions are warm and humid or rainy.

Management—Plant pathogen-free seed and transplants; disinfect tools and implements; avoid overhead irrigation or working with plants when they are wet; apply a protectant bactericide; promptly remove and destroy diseased plant material; rotate with non-host crops. Destroy crop residues after harvest; deep plow to bury residual inoculum.

Viruses

53. Cucumber mosaic virus (CMV) symptoms on tomato are varied but can include stunting and yellow/green mottling (light and dark areas in irregular patterns) on leaves. Leaves may become "strappy" or have a "shoestring" appearance; this is the symptom most identified with CMV. Few fruit are produced on infected plants. CMV is vectored by aphids.

Management—Promptly remove and destroy diseased plant material. Plant barrier crops and manage weeds (potential alternative hosts). Attempts to manage the insect vector has yielded inconsistent results.

54. Tobacco mosaic virus (TMV) and **tomato mosaic virus** (ToMV) primarily cause mottling (light and dark areas in irregular patterns) of leaves. Stunting and leaf curling may also occur. External symptoms on fruit include uneven ripening, mottling, and reduced size. Internal discoloration (called "brownwall") can occur in some cases. TMV and ToMV are mechanically transmitted and easily spread.

Management—Plant disease-free seed and transplants; select resistant cultivars; promptly remove and destroy diseased plant material; disinfect tools and implements; wash hands after handling tobacco products or infected plants; manage weeds (potential alternative hosts).

Cucumber mosaic virus.

Tobacco mosaic virus foliage (a) and yellow strain fruit (b).

55. Tomato spotted wilt virus (TSWV) can cause a number of symptoms, including stunting, wilting, stem lesions, and root necrosis. Leaves may have ringspots or show bronzing. Fruit may display mottling (light and dark areas in irregular patterns), ringspots, and irregular growth.

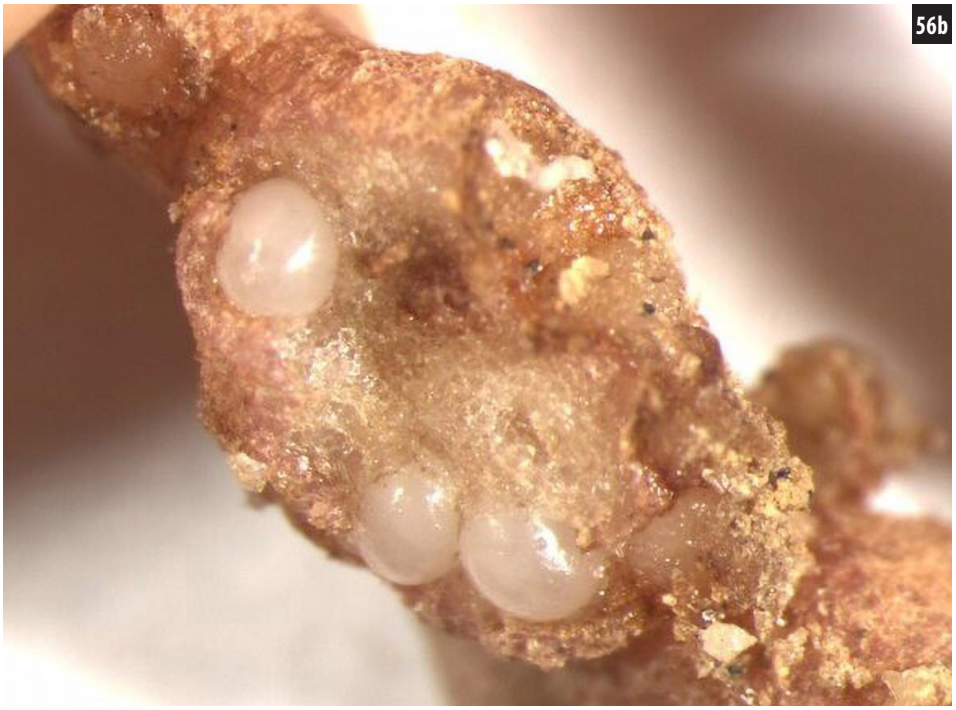
Management—Promptly remove and destroy diseased plant material. Select resistant cultivars; use reflective mulches.


56a


55b


55c

Tomato spotted wilt virus leaf (a & b) and fruit (c).


56b

Root-knot nematodes (a) and female (b).

Nematodes

56. Root-knot nematodes (*Meloidogyne incognita, M. hapla*) aboveground symptoms include stunting, uneven growth, and nutrient deficiencies. Numerous galls form on roots, a characteristic symptom of this disease.

Management—Select resistant cultivars; manage weeds (potential alternative hosts); rotate with non-host crops; avoid movement of infested soil to clean fields. Nematicides and soil fumigants are generally not recommended due to their temporary effect, cost, regulations, and limited number of licensed commercial applicators available for small growers.

Pepper Diseases

Fungi and Fungus-like Organisms

57. Anthracnose (*Colletotrichum* spp.) appears on ripening fruit in the form of sunken, circular spots (lesions), but may also develop on immature fruit. Lesions enlarge and darken over time, and concentric patterns may be observed. Under humid conditions, salmon-pink masses of spores may be visible oozing from fungal fruiting bodies (acervuli).

Management—Purchase pathogen-free seed and transplants; manage weeds (potential alternative hosts); avoid overhead irrigation; apply protectant fungicides; rotate with non-host crops; promptly destroy crop residues after harvest; deep plow to bury residual inoculum.

58. Phytophthora blight (*Phytophthora capsici*) leaf infections result in water-soaked, pale green to yellow lesions. Infected fruit develop water-soaked lesions and a thin layer of white fungal growth may be visible on infected tissues when humidity is high. More advanced symptoms are commonly present and include rotting or necrosis of roots and crowns and darkened cankers on stems; plants eventually die. Phytophthora blight is an aggressive, fast-moving disease under ideal conditions (warm, wet weather) and can cause extensive losses.

Management—Select resistant cultivars; promptly remove and destroy diseased plants; eliminate standing water; avoid overhead irrigation; apply fungicides; rotate with non-host crops; promptly destroy crop residues after harvest.

Anthracnose fruit.

Phytophthora blight (a) and rot-detached fruit (b).

59. Southern blight (*Athelia rolfsii,* syn *Sclerotium rolfsii*) initially results in a sudden yellowing/browning and wilting of affected plants, followed by death. Lesions or cankers develop at the base of infected stems near the soil line, often extending several inches aboveground. When humidity is high, a dense, white fungal growth (mycelium) may be present on affected plant parts and surrounding soil. Eventually, numerous small (1 to 2 mm in diameter), round, tan-to-reddish brown fungal survival structures (sclerotia) develop on the surface of the mycelium. Low-hanging fruit and those that touch infested soil can become infected, resulting in a wet rot and rapid decay of fruit. Disease is favored by warm, wet conditions.

Management—During the season, remove and destroy symptomatic plants if relatively few are affected. Deep plow or bury crop debris at the end of the growing season; rotate with non-host crops; avoid movement of infested soil to clean fields. Limited fungicides are available, and efficacy of these fungicides can be variable.

Southern blight mycelium (a) and stem with sclerotia (b).

Bacteria

60. Bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) may affect leaves, stems, and fruit. On leaves, lesions are circular and brown in color and infrequently have a yellow halo. Lesions can coalesce and form large blighted (suddenly dead) or yellowed areas in the plant canopy. Loss of leaves may occur in severe cases, exposing fruit to sunscald injury. On green fruit, lesions begin as raised blisters that reach a maximum size of about ⅛ inch. Fruit lesions tend to have a rough, scabby appearance and may crack over time. Disease is most likely to occur when conditions are warm and humid/rainy.

Management—Plant pathogen-free seed and transplants; disinfect tools and implements; avoid overhead irrigation or working with plants when leaves are wet; apply a protectant bactericide; promptly remove and destroy diseased plant material; rotate with non-host crops. Destroy crop residues after harvest; deep plow to bury residual inoculum.

Bacterial spot leaf (a) and fruit (b).

Alfalfa mosaic virus pepper.

Viruses

61. Alfalfa mosaic virus (AMV) leaf symptoms typically include a bright yellow mosaic or white discoloration. The virus is transmitted by aphids and can survive in a number of plant species.

Management—Promptly remove and destroy diseased plant material. Use reflective mulches. Insecticide sprays are not reliable. Do not plant peppers within or next to alfalfa plantings.

62. Cucumber mosaic virus (CMV) leaf symptoms are variable and include chlorosis, mosaic (distinctive dark and light green areas), distortion, ringspots, necrosis, and "oakleaf" patterns around veins. Infected fruit may be pale in color and exhibit ringspots or necrotic areas; fewer fruit may be produced. CMV is vectored by aphids.

Management—Promptly remove and destroy diseased plant material. Plant barrier crops; manage weeds (potential alternative hosts). Attempts to manage the insect vector have provided inconsistent results.

Cucumber mosaic virus leaves (a & b).

63. Tobacco etch virus (TEV) leaf symptoms commonly include mottling (light and dark areas in irregular patterns) or distortion. Root necrosis and plant stunting may also occur. Fruit may show mottling or mosaic (distinctive dark and light green areas) symptoms. Aphids vector TEV.

Management—Promptly remove and destroy diseased plant material. Select resistant cultivars; apply mineral oils; use reflective mulches.

Tobacco etch virus leaf.

64. Tomato spotted wilt virus (TSWV) symptoms include plant stunting and stem lesions. Leaves may be distorted, have ringspots, and exhibit bronzing. Fruit may display mottling (light and dark areas in irregular patterns), ringspots, and irregular growth.

Management—Promptly remove and destroy diseased plant material. Select resistant cultivars; use reflective mulches.

Tomato spotted wilt virus leaf (a), stem (b), and fruit (c).

Eggplant Diseases

Fungi and Fungus-like Organisms

65. Phomopsis blight (*Phomopsis vexans*) most commonly affects fruit, although symptoms may also appear on leaves and stems. On fruit, small, circular lesions appear and enlarge rapidly; lesions often coalesce, covering a large portion of the fruit surface. Darkened rings may be evident in older lesions, giving them a zonate appearance. These rings are comprised of numerous fungal fruiting bodies (pycnidia) embedded in the diseased tissue. Infected fruit are unmarketable and often invaded by secondary organisms that cause rapid fruit decay. Disease can be problematic during warm and wet conditions

Management—Rotate with non-host crops; promptly destroy crop residues after harvest; deep plow to bury residual inoculum.

Phomopsis blight (a & b).

Potato Diseases

Fungi and Fungus-like Organisms

66. Early blight (*Alternaria* spp.) appears on leaves and stems as dark-brown lesions with concentric rings. Older leaves are usually affected first, but the disease spreads upward to newer growth under favorable conditions. Lesions enlarge and coalesce; extensive blighting (sudden death) and loss of leaves can result. Tubers are affected in severe outbreaks resulting in small, sunken, brown spots.

Management—Select resistant cultivars; purchase pathogen-free seed stock; apply protectant fungicides; promptly destroy crop residues after harvest; rotate with non-host crops.

Early blight leaf (a) and tuber (b).

67. Late blight (*Phytophthora infestans*) symptoms may be observed on leaves, stems, and tubers. On leaves, individual lesions begin as water-soaked areas, which can enlarge quickly and result in extensive blighting (sudden death) of leaves. Under cool, humid conditions, sporulation (whitish-gray downy growth) can be observed on the undersides of affected leaves. Severely infected tubers are invaded by secondary organisms, resulting in a soft rot. This disease is relatively rare in Kentucky, and most likely to occur during periods of cool, wet weather (often in autumn).

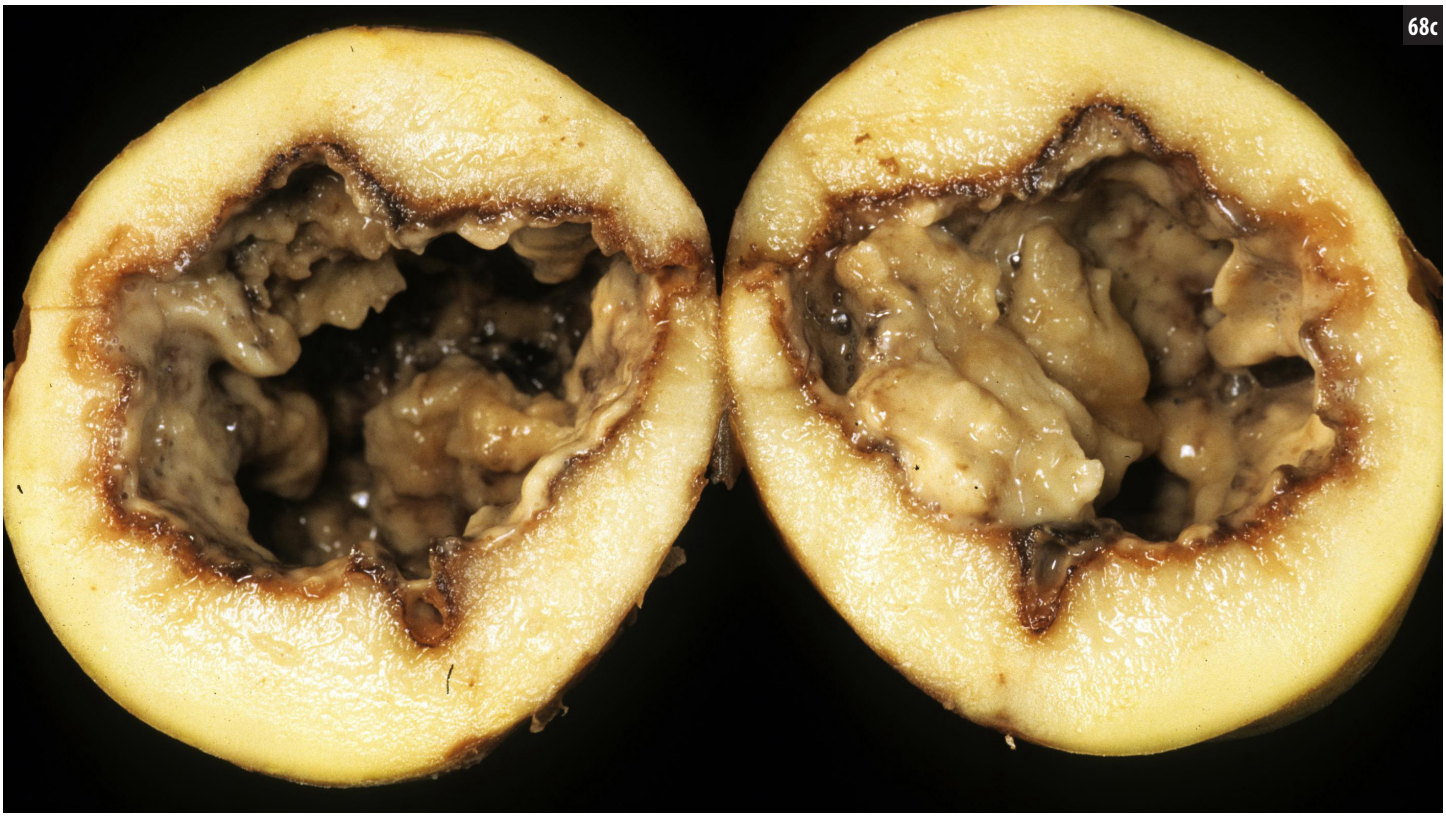
Management—Plant pathogen-free seed pieces; provide adequate plant spacing; maintain proper fertility; apply protectant fungicides; promptly destroy crop residues after harvest; avoid movement of infested soil to clean fields.

Late blight leaf (a), stem (b), and tuber (c).

Bacteria

68. Black leg (*Erwinia carotovora*) infections most often occur after plants have emerged; however, disease can also occur in seed pieces, preventing them from sprouting. On plants, a black to brown decay extends from the seed piece to several inches or more aboveground. Infected tubers can rot in storage (bacterial soft rot phase). The bacterium can survive in infected seed pieces, leading to the development of black leg in a subsequent crop. High temperatures and wet soils greatly increase the risk of black leg.

Management—Plant only pathogen-free seed pieces; avoid planting potatoes in fields with a history of black leg; do not over-irrigate; promptly destroy crop residues after harvest; deep plow to bury residual inoculum.



Black leg (a) and bacterial soft rot (b & c).

Scab.

69. Scab (*Streptomyces scabies*) symptoms on tubers include rough, raised lesions that are variable in shape and size. Lesions (scabs) may have a corky texture and range from superficial to those that extend deep into tubers. This disease is most problematic where soil pH is above 5.5.

Management—Select resistant cultivars; plant pathogen-free seed pieces; maintain proper soil pH (between 5.0 and 5.2); provide adequate soil moisture; rotate to non-host crops; promptly destroy crop residues after harvest; deep plow to bury residual inoculum.

Nematodes

70. Root-knot nematodes (*Meloidogyne incognita, M. hapla*) aboveground symptoms include stunting, uneven growth, and nutrient deficiencies. Numerous galls form on roots and tubers, which may range from tiny bumps to larger swellings. Necrotic spots may develop under the skin.

Management—Manage weeds (potential alternative hosts); rotate with non-host crops; avoid movement of infested soil to clean fields. Nematicides and soil fumigants are generally not recommended due to their temporary effect, cost, regulations, and limited number of licensed commercial applicators available for small growers.

Root-knot nematode potato.

Herbicide Injury

Roundup (glyphosate) damage to tomato foliage.

71. Roundup (glyphosate) **injury to tomato.** Labeled for postemergence non-selective control of broadleaves and grasses. Due to the high risk of drift injury, it is not recommended to spray in row middles.

2,4-D (2,4 dichlorophenoxyacetic acid) damage to tomato foliage.

72. 2,4 D (2,4 dichlorophenoxyacetic acid) **injury on tomato.** For nonselective control of broadleaf weeds in grasses, cereals, and rights of way. 2,4-D is a synthetic plant hormone that leads to abnormal growth in broadleaf plants. Typical injury symptoms include stem curling. Take care to situate vegetable plantings away from other crops or areas where 2,4 D drift could be a problem.

73. Gramoxone (paraquat) **injury.** Labeled for preplant application for nonselective contact control of grasses and broadleaves. Leaf burn and necrosis is a common injury associated with paraquat and other contact herbicides. Typical injury symptoms include necrotic regions on leaves where contact with the herbicide was made.

Gramoxone (paraquat) damage to tomato (a) and pepper foliage (b).

Command (clomazone) damage to eggplant foliage.

74. Command (clomazone) **injury.** Not labeled for use in eggplant or tomato in Kentucky. However, it is labeled for several other vegetables, including cabbage, and for preplant control of weeds. Injury typically appears as a distinct bleaching of affected leaves.

75. Callisto (mesotrione) **injury.** Callisto is not labeled for use on solanaceous crops in Kentucky. However, it is labeled for postemergence control of annual broadleaves in sweet corn. If spraying on sweet corn, be aware of the possibility of drift injury in other vegetables. Callisto injury to broadleaves generally will appear as a bleaching of leaves.

Callisto (mesotrione) damage to pepper (a) and tomato (b).

For more information:

Aphids
Tomato Insect IPM Guidelines (ENTFACT-313)
https://entomology.ca.uky.edu/ef313

Aphids (ENTFACT-103)
https://entomology.ca.uky.edu/ef103

Greenhouse whitefly
Whiteflies in Gardens (ENTFACT-303)
https://entomology.ca.uky.edu/ef303

Tobacco flea beetle
Tomato Insect IPM Guidelines (ENTFACT-313)
https://entomology.ca.uky.edu/ef313

Brown and green stink bugs
Stink Bug Damage to Corn (ENTFACT-305)
https://entomology.ca.uky.edu/ef305

Colorado potato beetle
Colorado Potato Beetle Management (ENTFACT-312)
https://entomology.ca.uky.edu/ef312

Pepper maggot
Pepper Maggot in Kentucky (ENTFACT-316)
https://entomology.ca.uky.edu/ef316

Beet armyworm
Beet Armyworm in Kentucky (ENTFACT-308)
https://entomology.ca.uky.edu/ef308

Tomato fruitworm
Tomato Insect IPM Guidelines (ENTFACT-313)
https://entomology.ca.uky.edu/ef313

European corn borer
Predicting European Corn Borer Development (ENTFACT-106)
https://entomology.ca.uky.edu/ef106

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