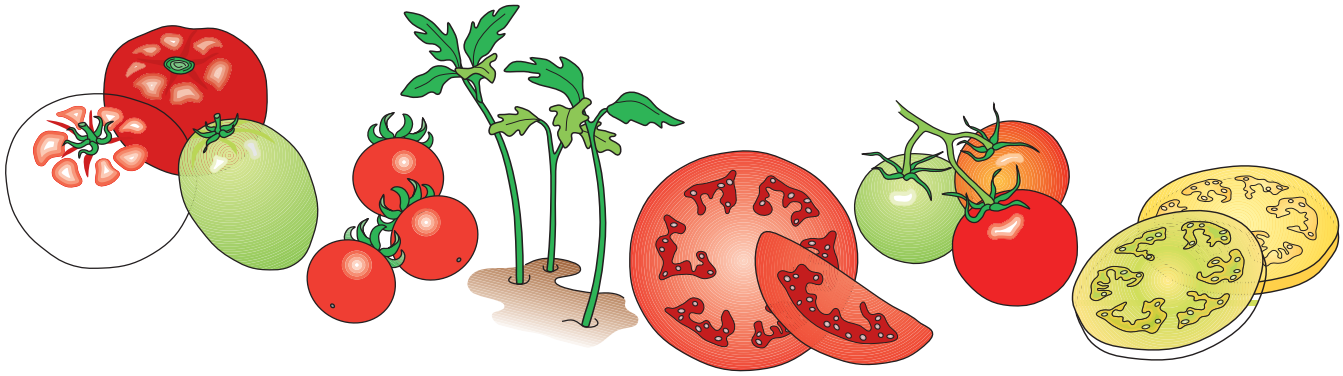

Tomato diseases and disorders

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Tomatoes are the most popular vegetable crop in Iowa. Many diseases and disorders can affect tomatoes during the growing season. This publication describes the symptoms and management of common problems found in gardens and greenhouses.

Diseases in outdoor production

This section looks at the diseases common in outdoor gardens.

Septoria leaf spot

Septoria leaf spot, caused by the fungus *Septoria lycopersici,* is the most common foliar disease of tomatoes in Iowa. It first appears as small, water-soaked spots that soon become circular spots about ⅛ inch in diameter (Figure 1). The lesions gradually develop grayish white centers with dark edges (Figure 2). The light-colored centers of these spots are the most distinctive symptom of Septoria leaf spot. When conditions are favorable, fungal fruiting bodies appear as tiny black specks in the centers of the spots. Spores are spread to new leaves by splashing rain. Heavily infected leaves turn yellow, wither, and eventually fall off. Lower leaves are infected first, and the disease progresses upward if rainy weather persists. Defoliation can be severe after periods of prolonged warm, wet weather (Figure 3). Infection can occur at any stage of plant development but appears most frequently after plants have begun to set fruit. The fungus survives the winter in tomato debris.

Figure 1. Septoria leaf spot symptoms

Figure 2. Septoria leaf spot; the light colored centers distinguish them from leaf spots caused by bacterial spot and speck

To control Septoria leaf spot a combination of cultural practices is often needed. These practices, which also will help to reduce the risk of many other diseases, include the following:

- Plant disease-free transplants far enough apart that the plants will not be crowded after they are full grown, in order to help the foliage dry rapidly.

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■ Water at the base of the plants, and in the morning rather than the evening, to minimize the amount of time that the leaves are wet.

■ Remove as much plant debris as possible in the fall and promptly plow under or bury the remaining residue.

■ Rotate crops so that tomatoes are grown in the same ground only every three or four years.

■ Avoid working with plants when foliage is wet to avoid spreading disease-causing microorganisms.

Fungicides also can help to control Septoria leaf spot. Consult ISU Extension bulletin *Insects and Diseases in the Home Vegetable Garden* (PM 230) for current fungicide recommendations.

Early blight

Early blight, caused by the fungus *Alternaria solani,* is also known as Alternaria leaf spot or target spot. Like Septoria leaf spot, early blight is common in Iowa tomato plantings, and the two diseases may attack the same plants. Premature loss of lower leaves is the most obvious symptom of the disease (Figure 3). Brown to black spots, ¼ to ½ inch in diameter with dark edges, appear on lower leaves (Figure 4). Spots frequently merge, forming irregular blotches. Dark, concentric rings often appear in leaf spots, resulting in the "target" appearance suggested by the common name. Leaves turn yellow and dry up when only a few spots are present. The fungus occasionally attacks fruit at the stem end, causing large, sunken areas with concentric rings and a black, velvety appearance (Figure 5). Warm, wet weather favors rapid spread of early blight. *A. solani* also can infect potato. Like Septoria leaf spot, early blight can infect plants at any stage during the growing season but usually progresses most rapidly after plants have set fruit.

Cultural and chemical controls for early blight are the same as for Septoria leaf spot. In addition, avoid potato in rotations, and harvest all ripe fruit at every picking to avoid infecting other fruit. Resistant varieties of tomatoes in the Mountain series (Mountain Supreme, Pride, Gold, Fresh, and Belle) provide partial resistance to early blight.

Figure 3. Defoliation caused by both Septoria leaf spot and early blight

Figure 4. Early blight rot on foliage

Figure 5. Early blight symptoms on fruit

Anthracnose

Anthracnose, caused by the fungus *Colletotrichum coccodes,* is probably the most common fruit-attacking disease of tomato in Iowa. Symptoms first become visible on ripe or ripening fruit as small, circular, indented spots in the skin. As these spots expand, they develop dark centers or concentric rings of dark specks, which are the spore-producing bodies of the fungus (Figure 6). In moist weather these bodies exude large numbers of spores, giving diseased areas a cream to salmon-pink color. By this stage, decay has penetrated deeply into the tomato flesh. Spotted fruits often may rot completely because of attack by secondary fungi through anthracnose spots. Anthracnose appears most commonly on overripe fruits.

Figure 6. Anthracnose fruit rot

The fungus survives the winter on diseased tomato vines, in the soil, and in seeds. Weeks before the fruit ripens, anthracnose can become established on leaf spots caused by other fungi or by insect feeding injuries. Spores are spread largely by rain splash. Warm, wet weather causes the disease to spread and symptoms to develop. While insect or other wounds facilitate infection, tomatoes can also become infected in the absence of wounds.

Control measures for anthracnose are the same as for Septoria leaf spot. In addition, harvest at frequent intervals and pick all ripe fruit at each harvest.

Fusarium wilt

Fusarium oxysporum f. sp. *lycopersici,* the fungus that causes Fusarium wilt, attacks only certain tomato cultivars. Plants infected by this soil-dwelling fungus show leaf yellowing and wilting that progress upward from the base of the stem. Initially, only one side of a leaf midrib, one branch, or one side of a plant will be affected. The symptoms soon spread to the remainder of the plant (Figure 7). Wilted leaves usually drop prematurely.

Affected plants die early and produce few, if any, fruit. Splitting open an infected stem reveals brownish streaks extending up and down the stem (Figure 8). These discolored streaks are the water-conducting tissue, which becomes plugged during attack by the fungus, leading to wilting of the leaves. Plants are susceptible at all stages of development, but symptoms are most obvious at or soon after flowering.

Figure 7. Fusarium wilt

Figure 8. Vascular browning caused by Fusarium wilt

To minimize losses from Fusarium wilt, it is advisable to plant resistant varieties, and many resistant varieties are available. The letter "F" following the variety name indicates resistance to one or more races of the Fusarium fungus. Resistant varieties may become infected, but disease will not be as severe as with susceptible varieties and a reasonable yield should still be obtained. In addition, plant disease-free seed or transplants in well-drained, disease-free soil, rotate at least four years away from tomatoes to reduce populations of the fungus in soil, and remove and destroy infected plant residue. In greenhouse or seedbeds, disinfest soil by treating with steam.

Verticillium wilt

Verticillium albo-atrum and *Verticillium dahliae,* the fungi that cause Verticillium wilt, can attack more than 200 plant species, including potato, pepper, eggplant, strawberry, watermelon, and radish. Like Fusarium wilt, this disease appears first on the lower leaves and progresses upward. Yellow blotches develop on lower leaves; the leaves rapidly turn completely yellow, wither, and drop off (Figure 9). Unlike Fusarium wilt, symptoms of Verticillium wilt do not progress along one side of a leaflet, branch, or plant. Infected plants may survive through the growing season, but are stunted and yield is reduced. Verticillium wilt, like Fusarium wilt, causes internal browning of the water-conducting tissue in stems (Figure 9). The discoloration is most pronounced near the soil line and seldom extends more than 10 to 12 inches above this point.

Control measures are similar to those for Fusarium wilt. Names of Verticillium-resistant tomato cultivars are followed by the letter "V." Rotate away from all crops in the tomato family (Solanaceae), including tomato, pepper, potato, and eggplant, for at least four years. Corn and beans are suitable rotation crops in the home garden.

Figure 9. Verticillium wilt foliage symptoms and cut stem showing browning

Late blight

Late blight, caused by the fungus *Phytophthora infestans,* rarely occurs in Iowa but can devastate tomato plantings during periods of cool, rainy weather. Late blight may infect either young (upper) or old (lower) leaves. It first appears as water-soaked areas that enlarge rapidly, forming irregular, greenish black blotches (Figure 10), giving the plant a frost-damaged appearance. The undersides of the leaves often show a downy white growth in moist weather. Infection of green or ripe fruit produces large, irregularly shaped brown blotches (Figure 11). Infected fruits rapidly deteriorate into foul-smelling masses. Late blight usually appears in mid- or late August during persistent cool, wet weather, or when cool night temperatures cause frequent heavy dews. *P. infestans* causes similar symptoms on potatoes and can spread from potatoes to tomatoes.

Control measures for late blight are the same as for Septoria leaf spot. In addition, avoid rotating with potato.

Figure 10. Late blight symptoms on leaflet

Figure 11. Fruit rot caused by late blight

Bacterial spot

Bacterial spot, caused by the bacterium *Xanthomonas campestris* pv. *vesicatoria,* infects both tomato and pepper. Spots that appear on leaves and stems are small (up to ⅛ inch across), circular to irregular in shape, and have a slightly greasy feel. Unlike similar-sized spots caused by the fungus *Septoria lycopersici,* those caused by the bacterial spot pathogen do not develop grayish brown centers. As lesions enlarge, they often become surrounded by a yellow halo. If spots are numerous, they begin to grow together (Figure 12), and leaves wither and turn brown (Figure 13). Fruit symptoms are more distinctive than leaf or stem symptoms. Spots on green fruit first appear as black, raised, pimple-like dots surrounded by water-soaked areas. As the spots enlarge to ¼ to ½ inch, they become gray-brown and scabby with sunken, pitted centers (Figure 14). The bacterium overwinters on the surface of seeds, in infected debris, and in soil. It is commonly brought into fields on infected transplants. Warm, rainy weather favors rapid spread of bacterial spot.

Control measures are essentially the same as for Septoria leaf spot. However, obtaining disease-free transplants is particularly crucial for controlling this and other bacterial diseases, since the bacteria can be transmitted to seedlings from contaminated seeds. Avoid rotating with peppers. It is advisable to avoid handling plants (pruning and tying, for example) any more than is necessary, because wounds caused by handling allow bacteria to enter plants. Sprays of a fixed copper product can reduce spread of the disease in the garden if applications begin when first symptoms appear. Refer to *Insects and Diseases in the Home Vegetable Garden* (PM 230) for current spray recommendations.

Bacterial speck

This disease, caused by the bacterium *Pseudomonas syringae* pv. *tomato,* does not affect pepper or other solanaceous crops but may survive on nonhost plants. Tiny, 1/16-inch-diameter, dark spots appear on leaves, surrounded by yellow halos (Figure 15). However, as with bacterial spot and bacterial canker, the fruit symptoms are most characteristic. The numerous specks that develop on young green fruit are slightly raised, 1/32 to 1/16 inch in diameter, and have well-defined margins (Figure 14). The specks are considerably smaller than the spots caused by bacterial spot, do not penetrate the fruit deeply, and can be scraped off with a fingernail. Although bacterial speck seldom reduces yields greatly, it can harm fruit quality. Infection is favored by cool (less than 70° F), wet conditions. Epidemics often follow rainstorms that cause abrasion of leaves and splash soil onto the foliage.

Figure 12. Bacterial spot on leaflet

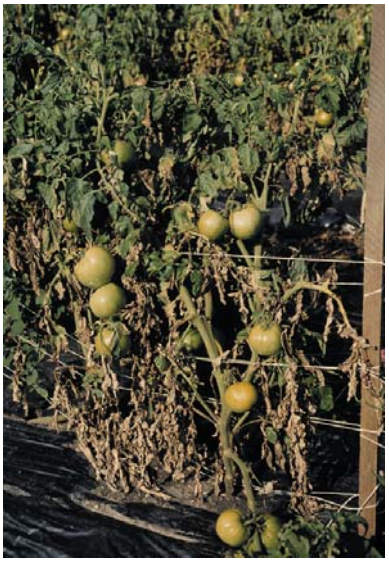


Figure 13. Wilting caused by bacterial spot

Figure 14. Fruit spots caused by bacterial speck (left) and bacterial spot (right)

P. syringae pv. *tomato* overwinters in seed, in plant debris, in soil, and on many other plants.

To control bacterial speck, follow the same cultural measures as for Septoria leaf spot. Plant only disease-free transplants. Destroying weeds around a tomato field or garden will help to reduce survival of the causal bacterium. A fixed copper product can help control spread of bacterial speck if applications begin when the first symptoms appear.

Figure 15. Bacterial speck on leaflet

Figure 16. Wilting of a young transplant (center) caused by bacterial canker

Figure 17. Marginal browning of leaves caused by bacterial canker

Figure 18. Fruit spots caused by bacterial canker

Bacterial canker

Bacterial canker, caused by the bacterium *Clavibacter michiganensis* subsp. *michiganensis,* has caused serious losses in some tomato plantings in the North Central states, including Iowa, during the last few decades. Young transplants may wilt suddenly and completely (Figure 16). On older plants, leaflets begin to turn brown at the edges, then die back progressively toward the leaf midrib (Figure 17). Often only one side of a leaflet or a plant develops symptoms first, but symptoms eventually spread. Rarely, cavities may develop within stems, sometimes splitting open into brown, longitudinal cankers. Spots on fruit are quite distinctive: white and slightly raised at first, then raised, dark-colored centers with white halos 1/16 to 1/8 inch in diameter (Figure 18). These spots are sometimes termed "bird's-eye" lesions. The white halo turns brown as the spot becomes older.

Control measures for bacterial canker are the same as for bacterial speck, except that copper sprays have minimal impact on slowing the spread of bacterial canker.

Figure 19. TSWV ringspots on a fruit

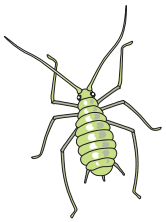
Figure 20. Purplish discoloration of tip leaves caused by TSWV

Figure 21. Dwarfing of plant (left) by TSWV

Viruses

The most common virus disease in Iowa is tomato spotted wilt virus (TSWV), but others can occur. TSWV causes distinctive yellow ringspots on mature fruit (Figure 19). Foliage also can be affected; plants are usually stunted and tip leaves show a purplish discoloration (Figure 20). Thrips, which are small (¼ inch long) green-brown insects, spread the virus. Plants can be affected as transplants while growing in a greenhouse; after transplanting, stunting and failure to set fruit may be the most noticeable symptoms (Figure 21).

Other viruses are spread by aphids or leafhoppers and can cause leaf curling, yellow or green mosaic patterns on the leaves, "shoestringing" of leaves, or a bronzing appearance. Fruits also are affected with mosaic patterns, streaking, or mottled areas.



Planting only certified virus-free transplants is the best technique for managing viruses. It is helpful to verify that the greenhouse used to produce transplants conducts a vigorous program to control aphids and thrips. There is no way to "cure" a virus-infected plant. However, removing the infected plant as soon as symptoms are found can help prevent spread by insects to healthy plants. Many viruses that infect tomato also infect peppers and potatoes; so, avoid planting these crops next to each other. Insect control may also be beneficial in the transplant and early-season phases. Consult *Insects and Diseases in the Home Vegetable Garden* (PM 230) for current insecticide recommendations.

Diseases in greenhouse production

High humidity and warm temperatures in greenhouses provide a favorable environment for development of certain diseases. The diseases listed below are much more likely to occur inside greenhouses than outdoors.

Gray mold

Gray mold, caused by the fungus *Botrytis cinerea,* is a common disease of greenhouse-grown tomatoes. This disease is characterized by a light-gray fuzzy growth that appears on stems and leaves. Soft rot of the stem end of the fruit can also occur (Figure 22). Botrytis infections are most severe in greenhouses with moderate temperatures, high humidity, and stagnant air. Increasing ventilation and air circulation to reduce humidity levels can be helpful, as well as timely fungicide applications.

Figure 22. Gray mold on fruit

Leaf mold

Leaf mold, caused by the fungus *Fulvia fulva,* can cause problems in humid greenhouses with poor air circulation. This fungal disease appears on lower leaves as yellow spots on the upper surface (Figure 23) and fuzzy masses of buff-colored spores on the underside (Figure 24). These leaves drop prematurely as the disease progresses upward on the plant. Lowering greenhouse humidity, planting resistant varieties, and applying fungicide promptly can be helpful in leaf mold management.

Figure 23. Yellow spots caused by leaf mold on upper leaf surface

Figure 24. Buff-colored spore masses of leaf mold on underside of leaflet

Powdery mildew

Powdery mildew, caused by the fungus *Oidium neolycopersici,* is also common in humid Iowa greenhouses with poor air movement. Characterized in the early stages by white patches on the upper surface of leaves, this disease can cause defoliation as the spots develop into brown lesions (Figure 25). Increasing air circulation and spacing between plants will reduce powdery mildew problems. Fungicide sprays also can be effective if used when symptoms are first noticed.

Good control of powdery mildew can be achieved by using several fungicides. Fungicides are most effective when sprays begin as soon as the first symptoms are noticed, rather than after the disease is already well established.

Figure 25. Blighting of leaflet by powdery mildew

Physiological disorders

The following problems are not caused by infectious microorganisms but rather by environmental stresses on the plant. These disorders occur primarily in field-grown rather than greenhouse-grown tomatoes.

Blossom end rot

Blossom end rot is a very common problem on green and ripe tomatoes. It first appears as a sunken, brownish black spot ½ to 1 inch in diameter on the blossom end of the fruit. These spots may gradually increase in size (Figure 26). Although blossom end rot itself causes only local injury, secondary organisms frequently invade the lesion and cause complete rotting of the fruit. It often occurs in rapidly developing fruit during periods of hot, dry weather and tends to have the greatest impact on the earliest-maturing fruit.

Figure 26. Blossom end rot

Blossom end rot is caused by a calcium deficiency that is related to wide fluctuations in available moisture. Iowa soils contain plenty of calcium, so the addition of calcium will not solve the problem. To prevent blossom end rot, maintain a steady rate of plant growth without stress. A consistent and ample supply of moisture can reduce the problem by helping to maintain a steady flow of calcium from the soil to the fruit. Mulching also will help by conserving soil moisture. Blossom end rot is more serious when an excess of nitrogen fertilizer has been applied. Staking and pruning tomato plants also may increase the incidence of blossom end rot. If blossom end rot occurs, remove the affected fruit so that later-maturing fruit will develop normally. Mulching and avoiding heavy applications of nitrogen fertilizer may help reduce fruit cracking.

Fruit cracking

Two types of cracks may develop on tomato fruit. Radial growth cracks radiate from the stem (Figure 27), and concentric cracks encircle the fruit, usually on the shoulders (Figure 28). Similar to blossom end rot, cracking is associated with rapid fruit development and wide fluctuations in water availability to the plant. Fruit that has reached the ripening stage during dry weather may show considerable cracking if the dry period is followed by heavy rains and high temperatures. Tomato varieties differ considerably in the amount and severity of cracking under climatic conditions. Supersonic and Jetstar are two varieties that show relatively low incidence of cracking. As with blossom end rot, mulching and avoiding heavy applications of nitrogen fertilizer should help reduce fruit cracking.

Figure 27. Radial fruit cracking

Figure 28. Concentric fruit cracking

Catfaced fruit

Catfacing is a term used to describe misshapen fruit with irregular bulges at the blossom end and bands of leathery scar tissue (Figure 29). Cold weather at the time of blossom set distorts and kills certain cells that should develop into fruit, resulting in the deformities. The disorder is most often observed among first-formed fruit. Catfacing is most common in the large-fruited "beefsteak" type tomatoes.

Sunscald

Sunscald occurs on green tomato fruit exposed to the sun. The initial symptom is a whitish, shiny area that appears blistered. The killed, bleached tissues gradually collapse, forming a slightly sunken area that may become pale yellowish and wrinkled as the fruit ripens (Figure 30). The killed tissue is quickly invaded by secondary organisms and the fruit decays.

Fruits most subject to sunscald are those that have been exposed suddenly to the sun because of pruning, natural spreading of the plant caused by a heavy fruit load, or loss of foliage from diseases. The extent of the injury is more serious during periods of abnormally high temperatures. To prevent sunscald on tomato fruit, control foliar diseases and avoid heavy pruning or shoot removal.

Blotchy ripening

This physiological disorder is indicated by the absence of normal red pigment on localized areas of the fruit. These areas appear as yellow or gray-green patches on otherwise normal-colored ripening fruit (Figure 31). When these fruits are sliced open, brown discoloration is often apparent.

Climatic, nutritional, and cultural problems may contribute to blotchy ripening. Low levels of potassium in plants and prolonged cloudy periods or inadequate light intensity have been associated with the disorder. Other possible contributing factors are high soil moisture, high humidity, low temperature, soil compaction, and excessive fertilization. These environmental factors can contribute to nutrient deficiencies or other imbalances that impede development of red pigment in the fruit. To minimize incidence of blotchy ripening, follow proper cultural practices to maintain nutritional balance and plant vigor. If commercial fertilizers are used, select balanced formulations and avoid over-application.

Figure 29. Catfaced fruit

Figure 30. Sunscald

Figure 31. Blotchy ripening

Physiological leafroll

Figure 32. Physiological leafroll

Physiological leafroll occurs when the edges of the leaves roll upward and inward (Figure 32). Sometimes the curling continues until the leaf margins from either side touch or overlap. Some leaves on the plant may not exhibit rolling. Leafroll does not reduce plant growth, yield, or fruit quality. It is believed to result from irregular water supply, and may be intensified following pruning. The symptoms are sometimes temporary, disappearing after a few days, but can persist throughout the growing season.

Failure to set fruit

High summer temperatures can reduce the number of tomato fruit harvested in several ways. High day and night temperatures will reduce flower production on tomato plants. If the night temperatures are above 70° F, flower production and pollination are reduced. High temperatures for several consecutive days, coupled with drought conditions, will lead to poor pollination and cause flowers to drop from the plants. Hot drying winds may intensify the problem. Plants sometimes drop their flowers when night temperatures are lower than 55° F. The most favorable night range for tomato fruit set is between 58 and 68° F. Commercially available blossom-set hormones should not be relied upon because they do not give consistent results.

Herbicide injury

This malady is caused by misapplication or drift of 2,4-D, MCPP, and other growth regulator herbicides. Tomato plants are highly sensitive to these chemicals throughout the growing season. The first symptom is downward curling of leaves and tips of growing points. Leaves often become narrow and twisted toward the tip, with prominent, light-colored veins. The symptoms are most pronounced on portions of the plant that were actively growing when the exposure occurred. In severe cases, stems and petioles become thick, stiff, and brittle with warty outgrowths (Figure 33). Affected plants usually recover. However, the fruit may become catfaced or develop in a plum shape, and may be hollow and seedless.

To avoid herbicide injury, do not spray when wind may carry spray drift toward tomatoes or other sensitive crops. In addition, spray at low pressures, use a coarse-spray nozzle, and apply the spray as close to the ground as possible. Avoid applying other pesticides in sprayers that have previously contained herbicide because traces of herbicide are likely to remain in the sprayer even after thorough rinsing.

Figure 33. Herbicide damage