Tomato Disorders
Michigan State University Extension Service
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TOMATO Disorders

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Contents

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CONTROL

Extension Bulletin E-312, 1983 Control of Insects, Diseases and Nematodes on Commercial Vegetables, lists recommended fungicides for controlling the diseases identified in this bulletin. It is for sale at County Extension Offices at 75 cents per copy.

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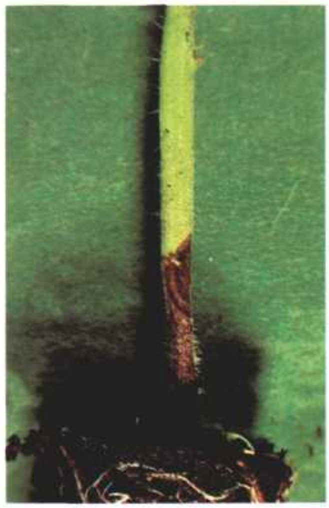
Damping Off

Damping off

Sclerotinia collar rot



Alternaria collar rot

SEVERAL FUNGI—especially *Rhizoctonia solani* and *Pythium* spp.—cause damping off of tomato seedlings. Some seedlings are lost to pre-emergent damping off before the seedlings have reached the soil surface. The seed rots either before or after sprouting. Seed rot is a major cause of uneven stands in fields or seedbeds.

In post-emergent damping off, the fungus penetrates the emerging seedling near the soil line, causing a water-soaked constriction of the stem. As a result, the plant wilts and topples over. More mature tomato seedlings will remain standing when attacked, but will be stunted and wilted, and often there will be sunken dark lesions on the lower stem (see **Collar Rot**). It is difficult to distinguish between Pythium and Rhizoctonia damping off.

Excess moisture and poor aeration are the greatest contributing factors to damping off. Low, wet areas or heavy soils that hold moisture should be avoided. Soil aeration and moisture-holding capacity can be improved by mixing field soil with sand or organic matter. In seedbeds, a thoroughly pasteurized well-aerated, light mix should be used. Good sanitation procedures, such as disinfestation of flats and other greenhouse items, reduces damping off. Seed treatment of direct-seeded tomatoes and fungicide drenches of seedbed-grown tomatoes aid in controlling damping off.

It is important to use both a Pythium and a Rhizoctonia-inhibiting fungicide in your spray program, as most of the fungicides used for this purpose are specific for one or the other fungus.

Collar Rot

COLLAR ROT occurs when several fungi invade the tomato stem at or near the soil line. Infection is followed by either a rotting or a cankering of the stem. If the stem becomes completely girdled, the plant will wilt and die.

Several fungi cause collar rot of tomato, including *Sclerotinia sclerotiorum, Alternaria solani* and *Rhizoctonia solani.*

Sclerotinia may initially cause a water-soaked, soft decay of the cortex and the pith. A cottony white mycelium will be visible on the affected plant parts.

Occasionally only a small lesion is present at the entry site of the fungus; but inside the stem, the mycelium will grow profusely. A plant affected by the soft decay phase may succumb rapidly; otherwise, the plant is apt to become stunted and decline slowly.

In addition to invasion near the soil line, plants are often attacked in branch crotches or points of injury and less frequently through old leaves or fruit.

If the stem of an affected plant is split open, black overwintering bodies called **sclerotia** ¼ to ½ inch in length are often evident. The fungus survives from year to year as sclerotia in the soil. Although small sclerotia may be blown from field to field, they are more often disseminated in seed or in diseased plant material.

Sclerotinia is favored by high moisture and is more of a problem in wet years or in low spots in the field. Infection occurs later in the season when a thick canopy develops, lower plant parts remain moist and air circulation is reduced. Although the pathogen can cause infection over a wide temperature range (32 to 82°F), 60 to 70°F is the optimum range for infection.

A tomato plant attacked by *Rhizoctonia* will often develop a condition called wirestem. The center of the stem decays and collapses, but the exterior part of the stem keeps the plant erect. The stem is wiry and slender at the point of infection, hence the name wirestem. On more mature plants, *R. solani* may cause cankers which often have alternating light and dark brown bands.

R. solani causes infection over a wide temperature range (40 to 94°F) and pH range, and is favored by high relative humidity. Although the pathogen is most active in soil with a high moisture level—above 80% water saturation—poor aeration restricts the growth of the pathogen.

Alternaria causes small, dark, sunken areas on the stem, which enlarge to form elongated spots with concentric rings. Usually the center of the lesion is light. When these lesions occur near the soil line, the plant becomes partially girdled. Affected stems often break, or the plant is so weakened that it dies at transplant. Those plants that survive transplant are often stunted and unthrifty. Additional information on *Alternaria solani* is listed under **Early Blight.**

Control—Use of disease-free transplants is most effective in controlling collar rot.

Anthracnose

ANTHRACNOSE (*Colletotrichum coccodes*) causes rotting of ripe fruit, which reduces yield and fruit quality. Anthracnose also causes a high mold count in canned tomatoes.

Early symptoms appear on the fruit, as small, slightly depressed, water-soaked circular spots. The lesions increase in size (up to 1/2 inch), become further sunken and often contain a pattern of concentric rings. The lesions generally darken, and small, black, fruiting bodies called **acervuli** appear in the center. In smaller lesions, the central portion may turn dark because of numerous fruiting structures just below the surface. In moist, warm weather these fruiting bodies exude masses of slimy tan or salmon-colored spores. As the fungus spreads within the fruit, a semi-soft decay is evident.

Lesions often coalesce, resulting in large rotted areas on the fruit. Fruit is more susceptible as it ripens; and although green fruit may be infected, disease symptoms will not occur until the fruit begins to ripen. The organism can penetrate the fruit cuticle directly, but may enter through wound sites also. On a ripe fruit, a lesion can develop within 5 to 6 days of spore contact.

Lesion development is most rapid at 80°F, although the pathogen can cause infection over a range of temperatures (55 to 95°F). Spores are disseminated by water splashing, so disease development is greatest during wet rainy weather.

Anthracnose fruit rot

Anthracnose lesion

Control—The organism overwinters in infected plant debris but is also capable of surviving in soil. A 2- or 3-year crop rotation and avoidance of sandy soil sites to minimize injury from blowing sand particles will reduce anthracnose. A chemical spray program beginning no later than blossom set and consisting of recommended fungicides applied weekly up to harvest reduces disease incidence.

Septoria Leaf Spot

Septoria leaf spot

Septoria lesion

SEPTORIA LEAF SPOT (*Septoria lycopersici*) causes defoliation and premature leaf drop. Severe leaf loss reduces the size, quality and quantity of fruit. The organism is not known to affect fruit; however, exposure of fruit by the loss of foliage can result in sunscald damage.

Septoria survives in the soil on plant debris for up to 3 years. Solanaceous weeds (Jimson weed, horsenettle, ground cherry and nightshade) are hosts and may harbor the pathogen for long periods.

Small, water-soaked circular spots first appear on the undersides of older leaves. As the spots mature, they enlarge to about 1/4 inch in diameter. These spots are generally gray or tan with a dark brown margin. In the center of these spots, small black "pimple-like" structures (fruiting bodies of the fungus) appear, which are just large enough to be seen with the unaided eye. Heavily infected leaves turn yellow, dry up and drop.

When conditions are wet, spores are exuded from the fruiting body and disseminated by wind-blown water. If the environment is ideal for disease development, spots can appear with 5 days of spore contact, and fruiting bodies may appear within 6 days. The fungus is most active when temperatures range between 60 and 80°F and during a rainy season. Since free moisture is necessary for spore infection, long-lasting dews and rainy days are both favorable for disease development.

Although tomato plants may be attacked at any stage of growth, they are most susceptible after fruit set. Lush green, rapidly growing plants are the most susceptible to rapid disease development. Resistance varies among cultivars; however, most varieties are susceptible.

Control—Four-year crop rotation with legumes or cereals, deep plowing of plant debris and weed control help reduce Septoria leaf spot. Chemical control is also effective. Recommended fungicides should be applied starting shortly before or at blossom set on a 7-day spray schedule up to harvest.

Early Blight

EARLY BLIGHT (*Alternaria solani*) is a serious defoliator and fruit rotter of tomatoes in the Midwest. It also can cause extensive leaf rotting of potato, another member of the solanaceous family, and is also known to attack eggplant, horsenettle and nightshade.

The fungus can be destructive to both immature seedlings and mature tomato plants. On seedlings, it causes damping off, leaf spotting and collar rot (see **Collar Rot**).

Alternaria leaf spot

Alternaria fruit rot

When clean tomato transplants are set out in the field, they usually remain free of leaf spot until blossom. If present on transplants, the disease will continue to develop under conditions of high moisture.

Leaf symptoms are dark brown to black spots ranging in size from 1/32 to 1/2 inch. First symptoms appear on older leaves. Within the lesion target or bullseye, rings appear which are a result of growth flushes of the fungus. Lesions often coalesce to form large dead areas in the leaf. When the leaf is covered with many lesions, the leaf yellows and drops off, leaving the fruit susceptible to sunscald. Lesions can also occur on the stems and blossoms. Blossom infection will cause blossom drop.

Fruit become infected in the green and ripe stages. Infection generally occurs at the point of attachment to the stem but can occur through growth cracks and wounds on the fruit. On fruits, early blight causes dark brown, leathery sunken spots with concentric rings. When attacked, young fruits often drop off prematurely.

In humid weather, infected areas on the fruit become covered with a black, velvety coat of spores. Crowded, poorly nourished plants with a heavy fruit set, early-maturing varieties and varieties that concentrate their fruit set are most susceptible.

The fungus overwinters in plant debris and seed. Although spore production and lesion enlargement are greatest in cool weather (less than 70°F), infection is greatest in warm weather (above 75 to 85°F). Heavy dews, extremely humid weather and abundant rainfall are essential for heavy disease pressure.

Control—Crop rotation of 3 to 4 years will eliminate the fungus from the soil. Chemical sprays of recommended fungicides are essential in a good control program. Sprays should begin at disease appearance (blossom set at the latest) and be continued weekly up to harvest.

Late Blight

LATE BLIGHT caused the historic Irish potato famine in the 1840s. Late blight can devastate fields of both potatoes and tomatoes if not properly controlled. In northern states, the disease occurs only sporadically on tomatoes, but losses can be heavy.

Late blight leaf lesion

Late blight fruit rot

Initial leaf symptoms are pale green to brown spots, usually with a purplish cast. Affected areas rapidly enlarge, become water soaked, turn dark brown to purple-black, shrivel and die. Often pale yellow or green halos encircle the enlarging lesion.

All above-ground parts are susceptible. If a lesion appears on the stem, it can rapidly girdle and kill it. Early in the morning, white to purplish mold can be observed on the advancing edge of the lesion. The mold is only present under conditions of high relative humidity and abundant free moisture.

Fruit rot usually begins near the stem end and is more frequent on the upper half of the fruit surface. Greyish green to brown irregularly shaped blotches appear on the fruit surface and rapidly enlarge. The rotted portion, which may eventually cover the whole fruit surface, is wrinkled but remains intact and is often covered by a white mold.

Late blight is caused by *Phytophthora infestans*, a fungus that grows most actively in cool (55 to 65°F), moist weather. The fungus produces spores between 50 and 80°F, but more spores are produced in the lower end of the temperature range. These spores are disseminated from affected tissue by water movement. Under favorable weather conditions, the pathogen can blight the foliage so rapidly that it appears the plants were hit by frost. Decaying vines may be recognized by a foul odor. The fungus overwinters in undecomposed debris from previously diseased tomato or potato plants or in potato tubers in the soil or in cull piles of rotted tomatoes or potatoes. These overwintering sites serve as an inoculum source in the spring. Infected transplants may also serve as the original source of the disease.

Control—Control is achieved by 1) use of disease-free transplants, 2) destruction of overwintering sites and volunteer plants, and 3) following a thorough spray program when needed. Spraying should commence at disease appearance and continue through periods of cool, wet weather.

Buckeye Rot

Buckeye rot

BUCKEYE ROT caused by the fungus *Phytophthora parasitica* appears infrequently in northern tomato-growing areas, although it occurs commonly in the south. Fruit rot is the most common symptom, although the pathogen can produce irregular, brown necrotic lesions on stem and leaves and cause seedling damping off. The pathogen can attack fruits of eggplants and peppers as well as tomatoes. Both green and red fruit, especially those in contact with the soil surface, may become infected.

The initial symptom is a small grayish-brown spot which appears at the point of fruit/soil contact. The spot gradually enlarges, forming a pattern of concentric rings of wide, light-brown and narrow, dark-brown bands. The lesion becomes leathery in texture and is slightly sunken. Under very moist conditions, a cottony, white fungal growth appears on the lesion.

Buckeye rot is most common during long periods of excess soil moisture and soil temperatures between 64 and 80°F. Under extremely favorable environmental conditions, losses can be heavy if spread is left unchecked.

Control—Tomatoes should not be planted on heavy, poorly drained soils. Low areas of the field are most likely to suffer losses first from Buckeye rot. Rotation with hosts outside the solaneaceous family as well as staking and mulching will reduce losses. Several control materials are recommended for use on a weekly basis.

Tomato Wilts

SEVERAL FUNGI, including *Verticillium albo-atrum*, *V. dahliae* and *Fusarium oxysporum f. lycopersicae*, cause wilting due to blockage of the water-conducting vessels. The Fusarium fungus attacks only tomato, while the Verticillium fungus infects many species of plant, including potatoes, peppers, cucumbers and rhubarb as well as a number of weeds. Both fungi can infect many plants without causing symptoms.

Fusarium and Verticillium wilts cause a yellowing of older leaves. In Fusarium-infected plants, leaf yellowing often occurs only on one side of the plant and is followed by the leaves turning brown, dying and dropping off. Fusarium-infected plants often die before reaching maturity whereas Verticillium-infected plants generally survive the growing season but are stunted and low yielding. If the stem of a diseased plant is cut longitudinally, dark brown streaking of the vascular system is evident, especially at the nodes. The discoloration generally extends farther up the plant in Fusarium-infected plants. Both organisms are commonly found in many soils and are capable of persisting in the soil for several years.

The Fusarium wilt pathogen is most active between 80 and 90°F, so the disease is usually prevalent late in the season and tends to cause serious losses in years of high soil and air temperatures.

Conditions that predispose plants to Fusarium infection are: succulence and rapid growth, unthriftiness, low levels of nitrogen and phosphorus, and high levels of potassium. The Verticillium wilt pathogen grows best when soil temperatures are in the 60 to 70°F range. High temperatures slow the growth of wilt. Infected plants, however, may be more evident in hot weather because of water stress.

Control—Use resistant cultivars. That is the best way to control Fusarium and Verticillium wilt. A long (4 to 6 year) rotation will reduce, but not totally eliminate, the fungus from the soil. When Verticillium wilt is present in a field, do not plant other susceptible hosts in the rotation. Disease-free transplants and hot water-treated seed will reduce the spread of these wilt organisms into clean fields.

Fusarium leaf wilt

Vascular discoloration of wilt-infected plant

Walnut Wilt

THE BLACK WALNUT and butternut contain large amounts of juglone, a toxin, which is excreted from the root system into the soil. When walnut or butternut trees are growing in or along the border of tomato fields, symptoms of walnut wilt will appear on plants up to a distance of 50 feet from the tree(s). The toxic materials remain active in the soil for several years after trees are removed. The disease usually appears after midseason. Wilting of all plants in an area may appear suddenly, or long-term stunting of plants may occur. Symptoms of this disorder

Walnut wilt

are easily confused with Fusarium wilt and Verticillium wilt; the distinguishing characteristic is the presence of walnut trees. Since juglone affects the vascular system of the tomato plant, problems associated with water stress, such as blossom end rot, may appear.

Control—Do not plant tomatoes on or near land where walnut trees are grown. If walnut or butternut trees have been removed, wait 3 years before planting tomatoes.

Bacterial Canker

BACTERIAL CANKER (*Corynebacterium michiganense*), also called bacterial wilt, was first reported by Erwin F. Smith and was initially named "Grand Rapids disease" because it was discovered in a Grand Rapids greenhouse.

Bacterial canker was once a disease of serious consequence in processing tomato, but its important declined because of the use of hot water treatment of seed. Recent increased incidence of bacterial canker is related to the use of untreated seed.

The initial symptom of bacterial canker is a wilting of leaflets, which is more pronounced in younger plants. The leaflet margins wilt first, then turn brown and die progressively from the margins inwards toward the midrib. The petiole remains green and firm on older, hardened-off plants, whereas young, soft plants may wilt totally and die early. Leaflet die-back progresses from the bottom on the plant upwards, and often only one side of the plant may be affected. In the summer months, infected plants, may partially recover but generally are stunted and unthrifty.

Another important symptom is light-colored streaking beginning at leaflet junctures and extending up and down the outside of stems. These streaks darken and may break down to form cankers (necrotic sunken lesions). When the stem of a diseased plant is cut, a yellow or tan discoloration can be seen in the water-conducting tissue,

Bacterial canker on fruit

resulting in the formation of a yellow or tan line immediately adjacent to the exterior of the stem. Initially the bacteria are confined to the water- and food-conducting vessels; but, as decay progresses, the bacteria move to other areas of the stem. The stem tissue becomes yellow and mealy and often spongy to the touch.

The fruit can become infected in one of two ways. The bacteria in the vascular system can move into the fruit and cause a brown blister on the fruit surface. If infected when small, the fruit become stunted, malformed and discolored internally. Secondary spread of the bacteria from cankers to green fruit also takes place. Small water-soaked spots appear on the fruit and soon become surrounded by a white halo. The mature lesions are tan, slightly round and cracked and remain about 1/8 inch (3 mm) in diameter. The lesions are often confused with bacterial spot, the difference being that the halo caused by bacterial canker remains permanently.

The causal bacterium is known to persist in the soil for 1 to 3 years and survives in or on seed, in tomato debris and possibly in solanaceous weed hosts. Although the disease may develop over a wide range of temperatures, it is most severe in warmer years when temperatures consistently range in the 80s and there is frequent high humidity and rainfall. The bacterium is spread by wind-driven rain and enters the plant through wounds and natural openings.

Control—Control includes planting disease-free seed only and transplanting into disease-free soils. A 2 to 3 year crop rotation away from plants in the tomato family will eliminate the bacterium. Destroy weeds in and around the field, especially those in the tomato family e.g. nightshade). Copper sprays may reduce spread but will not cure systemically infected plants. Sprays should begin at leaf wilt appearance and be continued on a 7-day schedule.

Bacterial Speck

BACTERIAL SPECK caused by *Pseudomonas tomato* has been of minor importance until recent years. Within the last decade, this disease has been encountered with increasing frequency in northern areas. The use of new, possibly more susceptible varieties, establishment of a permanent population of bacteria in the soil, and changes in cultural or spray practice may all be partially responsible for the increased incidence. *Pseudomonas tomato* does not appear to affect other solanaceous crops such as potatoes, eggplant or pepper, but may survive on nonhost plants.

Bacterial speck may contribute to yield decrease; however, its most devastating affect is on fruit quality. The organism enters green fruit and produces small, slightly raised superficial black specks (1/16 inch diameter) which do not extend much deeper than the

Bacterial speck on fruit

Bacterial speck on leaf

skin. The ripe fruit loses susceptibility as it matures because of the low pH of red tomatoes. Small dark spots similar in size to these on fruit appear on leaves and occasionally stems and flowers. Often these spots are surrounded by a chlorotic halo. Yield reductions occur when the speck organism causes abortion of flowers. Occasionally the bacterium will cause necrosis of the leaf margins.

Bacterial population build-up and spread are greater under wet cool conditions, as free moisture on the surface of the leaves is necessary for infection. The organism is inhibited when the average daily temperature exceeds 70°F. The speck organism enters the plant through natural openings and wounds. The pathogen can colonize the surface of tomato leaves and maintain itself there until environmental conditions are favorable for infection.

Epidemics of bacterial speck occur most frequently after rainstorms when there has been extensive soil movement and abrasion of leaves. The optimum time for serious epidemics in Michigan occurs during June and the first part of July when temperatures are cool and fruit is still susceptible.

The bacterium can survive on seed, in plant debris in the soil and on many nonhost plants. Although previously it was not known to overwinter in northern regions, we now know that it can survive at least one season.

Control—Bacterial speck control programs are currently built around prevention. Rotation, the use of disease-free seed (hot water treatment advised) and transplants and the destruction of weeds around a tomato field are the most practical and effective measures of control, although some control has been achieved by the use of antibiotic and copper/mancozeb sprays. Antibiotics such as Agristrep can only be used on tomato transplants before they go to the field. Once in the field, it is advisable to spray plants every 4 to 5 days as long as weather conditions are cool and rainy.

Bacterial Spot

BACTERIAL SPOT (*Xanthomonas vesicatoria*) causes fruit blemish, leaf spotting and defoliation on tomato, pepper and other solanaceous hosts (e.g. nightshade). It is generally more of a problem on tomatoes in the southern and temperate zones, although it has caused much damage on peppers in Michigan in recent years.

Initial leaf and stem symptoms are small (1/16 to 1/8 inch) circular to irregular black spots with a greasy appearance. As the lesions enlarge, they may become surrounded by a yellow halo. Eventually centers of lesions on leaves dry out and frequently tear. If spots are numerous, leaves die and plants become defoliated.

Spots may also occur on flowers and petioles and may cause serious blossom drop, resulting in a split set of fruit.

On infected green fruits, small, slightly raised water-soaked spots appear. These lesions enlarge to 1/8 to 1/4 inch, turn light to dark brown and become rough and sca-

Bacterial spot on fruit

ly. Since the lesions are superficial, edibility is not the main concern of this disease but rather a reduction of fresh-market sales.

In the early stages of fruit infection a white halo surrounds the spot so that it may resemble a canker lesion (see **Bacterial Canker**). However, this halo disappears as the lesion matures. Spots do not appear on ripe fruit because the high-acid content does not allow the bacterium to develop.

The bacteria can be carried as a contaminant on the surface of seed and overwinter in the soil in association with roots of various non-hosts. The optimum temperature for bacterial growth is between 75°F and 86°F. Abundant rainfall and high humidity are needed for maximum spread and infection. Penetration of plant tissue occurs through wounds caused by broken plant hairs, insect punctures and windblown sand particles.

Control—Only hot water-treated seed or disease-free transplants should be used. Hot water treatment removes a high percentage of bacteria from the seed. A three-year crop rotation with nonsusceptible hosts is advisable, in addition to control of weeds from the tomato family. Sprays of copper plus mancozeb may reduce spread of the disease in the field. Spraying is of particular importance during warm, rainy weather. When weather conditions are conducive to spread of the organism, a 4- to 5-day spray program should be used.

Tomato Virus Diseases

SEVERAL VIRUSES—including tobacco mosaic, single streak, double streak, potato-X and cucumber mosaic—affect susceptible tomato cultivars. These viruses infect a wide range of cultivated plants and weeds of the family Solanaceae and plants in several families, as well.

Symptoms depend on the specific virus. Tobacco mosaic virus (TMV) causes narrow and pointed leaflets on young plants, a symptom known as "fern leaf". Affected leaves curl up at the tips, and the entire leaf has a yellowish-green mottling or mosaic appearance. Infected plants are stunted, and yield is reduced. Like TMV, single streak virus causes yellowish-green mottling of the leaves, but infected plants may also have brown streaks on stems and leaves. Fruit will occasionally be marked with broad, sunken brown rings about ½ inch in diameter.

Plants affected by double streak also exhibit leaf mottling and will develop a number of small greyish-brown spots on leaves. Numerous narrow, dark-brown streaks develop on the stems and leaf petioles. The very youngest leaves wilt and die, thereby halting additional plant growth. Overall, the plant becomes stunted, and the foliage curls under. Fruit set is much reduced, and fruit that form are rough and deformed with small, irregularly shaped, brown lesions.

Virus-infected tomato plant

Cucumber mosaic virus-infected leaves show a mild green mottling, are malformed and frequently have a shoestring appearance. Affected plants become very stunted and nonproductive. Symptoms vary in severity according to the strain of cucumber mosaic virus.

Most of these tomato viruses can be transmitted mechanically. Transmission will occur when infected plant material rubs up against a wounded area of health plants. Although cucumber mosaic virus is transmitted by aphids, tomato is not the preferred host of the aphid.

TMV can remain viable in soil for several months, either in plant debris or in roots of some crops. If plant material decomposes, the virus will rapidly disappear. Cucumber mosaic virus does not persist in soil or withstand periods of drying. TMV is probably the most prevalent of the viruses; however, resistance to TMV is readily available in many tomato cultivars. Rouging out virus-infected plants is recommended, as they seldom produce good yields and serve as a source of inoculum.

Tomato fruit infected with a virus

Physiological Disorders

Blossom end rot

Blossom end rot

Blossom End Rot

BLOSSOM END ROT (BER), an omnipresent, destructive disorder of tomatoes, occurs under conditions of high plant water stress and heavy fruit load. The first abnormal indication is a small, water-soaked area around the blossom end of the fruit. This may appear while the fruit is green or ripening. The lesion darkens and enlarges rapidly. Size of the spot may vary from very small to an area more than half the size of the fruit. Size depends on the time the fruit first showed symptoms.

As the lesion increases in size, the tissue shrinks so that the affected blossom end is flattened. This area then becomes depressed and dark until it eventually looks black. Secondary pathogens commonly invade the lesion. Some fruits on the plant may have blossom end rot, while later developing ones are normal.

This disorder can be induced in the greenhouse, using solution culture techniques by reducing the amount of calcium (Ca) in the nutrient solution. This conclusively shows that BER is a symptom of Ca deficiency. In the field, however, BER can occur when there is an abundance of Ca in the soil and even when tissue tests show there is a high level of Ca in the plant. Careful nutrient tests of tissue taken from the blossom end of affected fruit, however, show a localized Ca deficiency in this area. Thus, it is generally accepted that BER in the field is not due to a Ca deficiency, but to poor distribution of Ca within the plant.

The movement of Ca within the tomato plant is generally with water moving through the vascular system from the roots to the leaves. Water and the minerals dissolved in it move toward the leaves because that is where water is lost from the plant through transpiration. Under periods of moisture stress and/or excessive transpiration rates, Ca moves rapidly to the leaves, bypassing the fruits and thus causing a localized deficiency. Since Ca is an integral part of cell walls and must be present where rapid growth is occurring, lack of Ca in the blossom end of the fruit causes a collapse of the cells and the characteristic symptom of BER.

Even under ideal conditions, Ca does not move readily into tomato fruits because there are no openings in the epidermis of the fruit for moisture to be lost. Thus water—the carrier of Ca and other nutrients—is not transported in large amounts through the fruit. Under normal conditions, the fruit can accumulate the nutrients it needs by other processes which occur slowly compared with transpiration) through the leaves, which prevents Ca moving into the fruit. There are other causes. Overfertilization, especially of nitrogen (N), will cause an increased severity of BER because it stimulates vegetative growth, which provides more surface for moisture loss and the diversion of Ca away from the fruit. Also, varieties that have large amounts of foliage are more susceptible to BER than varieties with a lower foliage-to-fruit ratio.

Hot, low-humidity, breezy conditions, which are conducive to high transpiration rates, are also ideal conditions for inducing BER. Also, irregularities in soil moisture at a time of rapid growth will create a moisture stress on the plant which, of course, prevents distribution of Ca to the fruit.

Control—Since BER is closely associated with moisture relations in the plant, it is of paramount importance to prevent moisture stress. Avoid fluctuations in soil moisture during fruit set and fruit accumulation. Either overhead or trickle irrigation can prevent moisture stress on tomatoes. Give the plants 1 acre-inch of water per week, and perhaps a bit more during hot, dry weather. Remember that sandy soils have a higher water requirement because they have a lower water-holding capacity than clay soils.

Adjust nitrogen rates to the type of tomato being grown. A determinant variety that develops a limited amount of foliage needs more N than a indeterminant variety that produces excessive foliage. Also, avoid ammoniacal forms of nitrogen, for they compete with Ca during uptake from the soil.

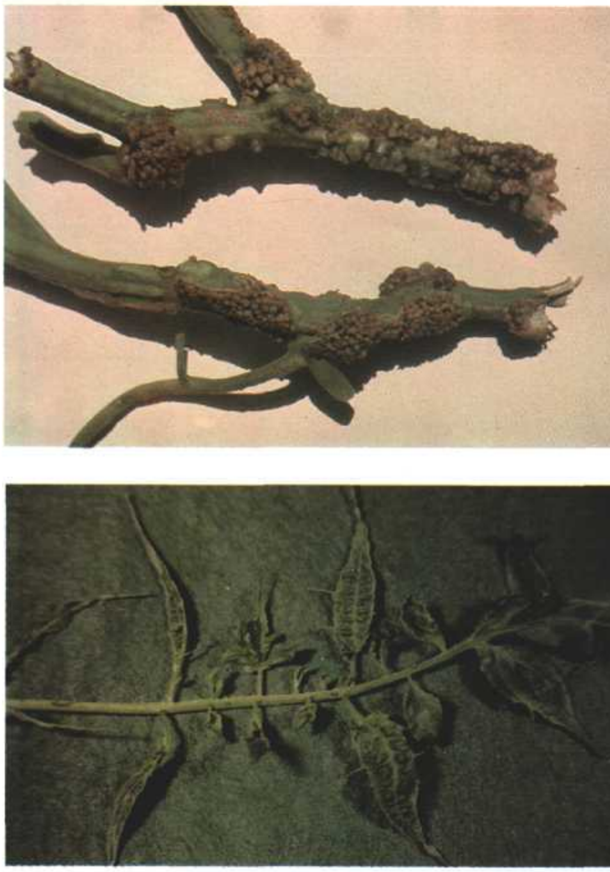
Check soil pH annually and apply lime when necessary. Apply phosphorus, potassium and magnesium as recommended by a soil test. The balance of these nutrients with Ca is very important in preventing BER. A soil test will indicate the degree of balance in your soil.

Foliar applications of Ca are ineffective in preventing BER, because the Ca does not get into the fruit where it is needed.

2, 4-D Injury

SPRAY DAMAGE due to the misuse of herbicides commonly occurs on tomatoes. Tomato plants are very susceptible to 2, 4-D injury at any stage of growth. The first damage symptom is a downward curvature of the leaves and the tips of the growing points. If damage is severe, stems and leaf stalks will twist and become distorted; leaves will become narrow and twisted or cupped, with light green, parallel veining apparent. The main stem may become thick, stiff and brittle; often it will split, and small shoots will develop at the opening. Mild leaf symptoms are often mistaken for those of common mosaic. Affected plants usually recover in due course and produce edible fruit. The fruits may become catfaced or plum-shaped as well as being hollow and seedless.

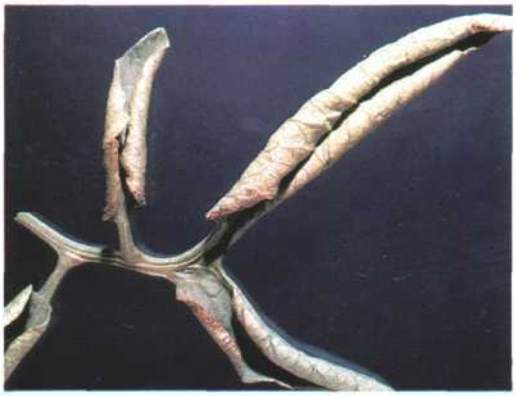
Use the following precautions when applying 2, 4-D: Do not spray when the wind may carry spray drift toward tomatoes or other sensitive crops. Use the amine form of 2, 4-D. Apply the spray at a low pressure with a coarse spray to minimize spray drift. Since it is extremely difficult to remove 2, 4-D residues from a sprayer by washing and rinsing, use a separate sprayer to apply 2, 4-D.



Two examples of 2, 4-D injury

Catface

Sunscald



Leaf roll

Catface

CATFACE FRUIT is misshapen, with irregular bulges at the blossom end interspersed with bands of leathery, dark green tissue. These fruits are unmarketable.

Catfacing is most often found among first-formed fruit. This syndrome is caused by abnormal growing conditions, such as cold weather, during blossoming. Disturbance of growth during blossom formation causes a distortion of the growth of pistil cells, resulting in the death of cells at the blossom end of the ovary and the formation of a leathery callus. Secondary diseases rarely invade this scar tissue.

Some cultivars appear to be more susceptible to catface than others. The only control measure is to grow cultivars that rarely develop this peculiarity.

Sunscald

SUNSCALD may appear on tomato foliage or fruit. The foliage may become covered with yellowish blotches when cloudy weather is followed by a bright, dry period in midseason. The yellow areas dry out rapidly, leaving brown, brittle tissue.

Sunscald affects the fruit when green or ripening tomatoes are overexposed to the sun. Such damage is likely to occur after plants have suffered premature defoliation due to disease or the application of defoliants. The side of the fruit which is exposed to the sun becomes yellow; then it ripens, and the injured area becomes white and blister-like. The tissue loses water rapidly, shrinks, and flattens into a grayish, sunken, papery-like lesion. Secondary fungi commonly invade sunscald damaged areas.

To avoid sunscald, protect plants from foliar diseases so as to maintain an adequate canopy over the ripening fruit.

Leaf Roll

LEAF ROLL is a common physiological disturbance of tomato. The edges of the leaves roll upwards and inwards. In severe cases this will continue until the margins of opposite sides touch or overlap. Leaf blades become firm and leathery. Most of the plant may exhibit these symptoms. Growth of the plant is not inhibited, and after a few days the plant returns to normal.

This malady is the reuslt of irregular water supply. Symptoms are intensified by pruning. The disorder is temporary.

Lightning Injury

LIGHTNING INJURY to tomatoes is not uncommon. Damage occurs in a circular or elliptical area, 10 to 60 feet across. The most severe injury is at the center of the area, where plants are usually killed. Within a few hours of lightning striking, leaves on the ends of branches will begin to droop. Wilting will follow; in severe cases, the plant dies. Stems, branches and petioles shrivel and die due to collapse of the pith. If one of these stems is cut lengthwise, the pith will often be seen to have a ladder-like arrangement. Cortical tissue may show bronzing or bleaching.

Lightning injury

Radical growth cracks

Concentric growth cracks

Blotchy ripening

Growth Cracks

GROWTH CRACKS are a universal malady. Cracks appear at the stem end, spreading out in a radial, concentric pattern on the shoulder of the fruit. The depth may vary from minute to deep splits. These blemishes provide entry points for fruit-rotting organisms. Early defoliation by leaf blight organisms aggravates cracking; however, the cause of growth cracks appears to be rapid growth brought on by heavy rains following a dry period.

The best way to avoid growth cracks is to grow resistant cultivars.

Blotchy Ripening

BLOTCHY RIPENING of tomato is a physiological disorder indicated by the absence of normal red pigment (lycopene) on localized areas of the fruit wall. These areas will appear yellow or gray in an otherwise normal, nearly mature red fruit. Underlying the blotchy tissue, there may also be necrosis of the vascular bundles.

The physiological cause of blotchy ripening is related to adverse climatic, cultural and nutritional balances. Blotchy ripening is more prevalent in potash-deficient plants; tomatoes which are resistant to blotchy ripening have higher potassium uptake rates than do susceptible ones. Low light intensity or an inadequate number of hours of sunlight also promotes the development of blotchy ripening. Other theories advanced to explain blotchy ripening are rank vine growth, high humidity, low temperature, high soil moisture levels, soil compaction, excess fertilization and nutritional imbalance. These external factors result in a low accumulation of food reserves in the fruit. Since the biosynthesis of lycopene, the normal red pigment in tomatoes, requires a high level of available energy, it, in turn, is dependent upon adequate food reserves.

TMV infection of the fruit can cause similar symptoms. TMV can also have a secondary influence in aggravating the physiological imbalance.

Control—Since blotchy ripening is related to inadequate plant food reserves, adherence to well-managed cultural practices should minimize its occurrence.

Zippers

IT IS COMMON to see thin brownish lines extending from the blossom end to the stem of the tomato fruit. These superficial lines are known as zippers and may be very prominent under certain growing conditions. Although fruit quality is not affected, this external blemish detracts from appearance and may keep the fruit out of U.S. Grade No. 1.

Zippers are caused by anthers which adhere to the ovary wall in the very early stages of fruit development.

Zippers

The abrasion of the ovary wall causes formation of a callus, the brownish streak seen on the exterior of the tomato fruit.

Cold temperature at the time of flowering and fruit set is probably most responsible for this disorder. The use of hotcaps, plastic tunnels and windbreaks for early transplanted tomatoes will provide some protection.

Yellow Shoulder

CERTAIN CLIMATIC CONDITIONS prevent the accumulation of lycopene (the red pigment in tomatoes) in the pericarp (wall tissue) surrounding the stem of the fruit. This disorder occurs during the ripening process and results in fruit which are entirely red except for the shoulders, which are deep yellow, The fruit are unmarketable.

Cultivars which have dark green shoulders when immature appear to be more susceptible to this disorder than fruit when uniformly light green. Also, high temperatures during the ripening season tend to accentuate this disorder. Fruit which are exposed to direct sunlight appear to be most susceptible.

If this disorder is a major problem, only cultivars which are uniform in ripening (non-green shoulder) should be grown. Also, foliage should be protected from insects and disease, which could cause premature defoliation.

Yellow shoulder

Blossom Drop

If fertilization of the ovary within the tomato flower does not occur within about 48 hours after pollination, the flower will abscise (fall off). Fertilization of the ovary initiates production of the plant's own growth-regulating substances which cause the flower not to fall off and induce the ovary to enlarge.

Lack of flower fertilization is caused by nonvigorous pollen or unfavorable conditions at the time of pollination. Since the pollen is formed 2 to 3 weeks prior to pollination, environmental conditions at this time can affect the viability of the pollen. High temperatures, greater then 90°F, or low temperatures, less then 50°F, will reduce pollen viability. Thus, even if there are ideal conditions at the time of pollination, if the pollen is of such poor vigor that fertilization cannot occur within the critical 48 hour period, the flower will fall off.

Also, at the time of pollination, high temperatures—particulary high night temperature (greater than 70°F)—will induce the style of the flower to elongate rapidly. Under these conditions, the stigma is often extended beyond the anther cone) and pollination cannot occur. Tomatoes are virtually 100% self-pollinated. Thus, if the stigma is outside the anther cone, there will be no pollen available to it and the flower will fall off.

Likewise, if the temperature is too cold—less than 50°F—the pollen tube will not grow through the style to the ovary, even if pollination has occurred. Once again, if the fertilization does not occur within 48 hours due to slow pollen tube growth, the flower will fall off.

There is no sure way to prevent blossom drop, but protection from extreme temperatures during the early development of the plant is extremely important. Also, select cultivars which have been evaluated in your production area for their fruit-setting ability.

◄ Stigma elongated beyond the anther cone