Agriculture
Canada

Publication 1479/E

Tomato diseases

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Recommendations for pesticide use in this publication are intended as guidelines only Any application of a pesticide must be in accordance with directions printed on the product label of that pesticide as prescribed under the Pest Control Products Act. **Always read the label.** A registered pesticide should also be recommended by provincial authorities. Because recommendations for use may vary from province to province, consult your provincial agricultural representative for specific advice.

Cover illustration
Photo by Janet Kochan

Agriculture Canada Publication 1479/E
available from
Communications Branch, Agriculture Canada
Ottawa, Ont. KlA 0C7

Cat.. No. A43-1479/19913 ISBN O-662-19194-3
Revised 1991 12M-232

Produced by Research Program Service

&alement disponible en fraqais sous le titre
Maladies de h *tomate*

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Acknowledgments

Advice and several photographs have been provided by B.N. Dhanvantari, J.C. Fisher, G. Ferguson, R. Garton, S.K. Khosla, and J. Kochan. S.D. Duransky and E Smith provided invaluable word-processing and editing skills, respectively.

Diagnostic key

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	Notso	5
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Lesions yellowish green on upper surface, with brown to purplish **fungal** growth below .... leaf mold

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Lesions dark brown or green brown 31

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	Discolored or corky patches	65

64. Fruit white or marbled all over, small, occasionally ridged; vascular system yellow-brown .... bacterial canker
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Discolored areas visible through skin 66

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66. Gray to grayish brown areas visible through translucent skin; flesh brown to black inside ... internal browning
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67. Roots with bulbous galls 1 mm to irregular masses 1 cm or more .... root knot
Roots with gray brown, or black lesions 68

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Black pinpoint lesions usually near corky root rot lesions .... black dot root rot

Introduction

Tomatoes are the second most important vegetable crop in Canada, with a production area of over 15 300 ha, yielding602 000 t. They are grown in the field as fresh-market and **processing** crops and in greenhouses for the salad market. In warm areas most home gardens have a few tomato plants. In southern Ontario, where tomatoes are grown for processing, yields of 50 t/ha or more are often harvested. Field tomatoes for the fresh market are also grown in British Columbia, Quebec, southwestern Alberta, and Nova Scotia. About 185 ha of greenhouses are used for tomato production, with the biggest concentration (70 ha) located around Leamington, in southwestern Ontario. Permanent greenhouses are covered with glass, temporary ones with plastic materials. Both types provide good growing conditions for crops grown traditionally in soil as well as hydroponically in sawdust (mostly in British Columbia) or rockwool, or by the nutrient film technique (NFT).

A satisfactory crop of top-grade tomatoes can be obtained only from well-nourished plants that are free from disease. Careful attention should therefore be given to disease control and to methods of culture. This publication can help growers to recognize and control diseases that attack tomatoes. In many instances, diseases can be diagnosed more easily with a good 10x or 15x hand lens.

Causes of disease

Diseases are caused by parasitic fungi, bacteria, mycoplasmas, viruses, nematodes, and environmental conditions.

Fungi

Fungi that cause plant diseases are mostly microscopic colorless plants that depend on green, living plants or dead organic matter for their existence. Fungi produce spores, which are carried by wind, water, or other means to their hosts, where under favorable conditions of temperature and moisture they germinate and infect healthy plants. Between growing seasons many fungi survive as dormant spores in plant debris in the soil. Sometimes the dormant structures take the form of **sclerotia,** which are hard bodies 1-5 mm across, usually brown or black, in or on the affected tissues. They may be of various shapes, and if they are inside the stems, as in stem rot, they tend to be shaped by the confining stem walls. **Sclerotia** may survive for many months or even years in dry conditions on plant debris or in the soil.

Bacteria

Bacteria are microscopic, single-celled, rod-shaped organisms that multiply very quickly in the host plant. Sometimes they occur in exudates on the surface of diseased plants. At other times the bacteria are released when the diseased tissue breaks open, and then they are spread to other plants by splashing water, insects, and humans.

Mycoplasmas

Mycoplasmas are the smallest organisms capable of independent growth and reproduction, lying somewhere between bacteria and viruses in size and properties. In plants they cause the yellows diseases, once thought to be caused by viruses. Mycoplasmas are usually spread among plants by leafhoppers.

Viruses

Viruses are the smallest forms of life that cause disease in plants. They are so minute that they cannot be seen through an ordinary light microscope, but their shape and size can be determined with the aid of an electron microscope. They are made up of complex protein substances that are multiplied rapidly in the plant. Viruses are transmitted by insects, such as thrips and aphids, or by infected sap carried on the fingers or on tools.

Nematodes

Nematodes are small, usually microscopic, soil-inhabiting, worm-like organisms. Endoparasitic nematodes feed on the roots of their host plants from the inside, whereas ectoparasitic nematodes feed on the roots from the outside. The latter type can transmit certain viruses. When either type is present in large numbers, affected plants become unthrifty and their yields are reduced. Root-knot nematodes produce swellings, or galls, on the roots of tomatoes, tobacco, cucumbers, and many other plants and are difficult to eliminate from the soil; in greenhouse soil they can survive at depths of 2 m or more.

Environment

Environmental conditions seriously affect normal growth. Such conditions may be adverse temperature or moisture above or below the ground, unbalanced nutrition, an inadequate or overabundant supply of minerals, an excessively acid or alkaline root environment, poor drainage, or industrial pollutants.

Disease prevention

In addition to control measures for specific problems, the following general practices can help to reduce losses from diseases:

- Buy treated seed only from a reputable dealer.
- Sterilize soil for seedling and transplant production, and for greenhouse production.
- Spray plants with appropriate pesticides.
- Use resistant cultivars or a soilless medium such as rockwool or NFT.
- Practice certain sanitary measures.

These recommendations are especially important in the early life of the crop, because a diseased plant can seldom be cured. When disease-free plants are set in a clean substrate, the likelihood of serious losses is greatly reduced. In the greenhouse careful regulation of the environment, especially preventing dew formation, avoids many diseases that depend on spores germinating in a water film for infection. If a disease is a problem in your area, consult-your local agricultural representative for the names of suitable resistant cultivars adapted to your locality.

Provincial ministries of agriculture publish details of suitable preventive treatments and provide lists of pesticides locally recommended.

Sanitation

Regardless of the care taken in treating the seed and the soil, diseases may develop if careful attention is not given to certain other sanitary measures.

Many weeds harbor microorganisms that infect tomatoes; therefore, do not leave weeds in or near the seedbed or plant beds. Since many of the disease organisms affecting tomatoes over-winter in old tomatoes and other plants, young plants must be isolated. After handling field vegetable crops, always wash your hands thoroughly with soap and water and change clothing before resuming work on greenhouse tomato crops.

Do not leave debris in the greenhouse or trash piles nearby outside. Remove all trash to a landfill site for burial.

In vegetable greenhouses avoid perennial plants such as oleanders, grapevines, and figs. It is impossible to sterilize the soil near them, and they harbor insects and viruses. For the same reason, avoid hanging baskets of ornamentals over vegetable crops. Soil splashed from them carries disease organisms.

Working with pesticides

Pesticides are coming to be regarded as disease controls of last resort. The use of disease-resistant cultivars, clean seed from a reputable source, and the observance of good sanitation practices in the seedling and transplant stages of crop production can reduce or eliminate the need for pesticides. Many greenhouse growers rely solely on biological control for insects and on hygiene and sound environment management for disease control.

In most provinces pesticides can be applied only to commercial crops by licensed operators trained in their safe use. In commercial crops and in home gardens pesticides should be mixed and applied strictly in accordance with the instructions on the label, and the containers should be disposed of in ways set out in provincial and local authority regulations. Never deviate from the rates given on the label; twice as much will usually do twice the amount of damage. Pesticides applied in anticipation of disease outbreaks as insurance sprays are seldom justified. Your provincial advisers are in the best position to give specific advice if epidemics threaten.

Diseases caused by microorganisms

Damping-off and late damping-off

Damping-off occurs primarily in the seedbed, when it is too cool and too wet. This disease is caused by various soil-inhabiting fungi, especially ***Pythium*** species and ***Rhizoctoniu solani***. The seedlings may be attacked either before they emerge, causing a reduction in emergence, or after they emerge, causing the plants to wilt, fall over, and die (Fig. 1). Occasionally, large groups of seedlings in beds are destroyed, especially if untreated seed was planted in unsterilized soil. In late damping-off disease (Fig. 2), although the affected seedling usually topples over, it dies slowly because the water-conducting vessels remain functional for several days. Late damping-off is usually caused by ***Rhizoctonia solani***, which attacks somewhat older plants in the seedbed as well as transplants in the groundbed.

Fig. 1 Tomato seedlings affected by damping-off caused by *Pythium*. The stems have been attacked at soil level, and no new roots have formed.

Fig. 2 Tomato seedlings showing late damping-off caused by *Rhizoctonia solani*. The dark brown discoloration at the base of the stem distinguishes this disease from *Pythium* damping-off.

Control

- Treat seed first with hot water and then with a fungicidal protectant.
- Sow the untreated seed in sterilized soil.
- Do not plant the seed too thickly because a crowded seedbed allows damping-off to spread rapidly
- Do not keep the surface of the soil continuously damp. Water the plants with a fine mist only when the soil is dry, and preferably before noon so that the surface of the soil is dry by late afternoon.
- Ventilate the greenhouse well. Keep seedling trays off the ground, preferably on well-ventilated benches well above the soil. This technique allows for bottom heat with good air circulation and keeps the seedlings out of the range of splashed soil.
- Protective fungicides provide some control, although they are not very effective against postemergence damping-off: Check with your provincial authorities before you use a fungicide.
- If using a hydroponic system, never use a soil starter block; always use rockwool or other soilless starter blocks. *Pythium* species are spread by fungus gnats and similar small flies, and therefore controlling them may be worthwhile, particularly in rockwool systems.

Collar rot

The fungi associated with collar rot are *Sclerotinia sclerotiorum*, S. *minor*, *Botrytis cinerea*, *Phytophthora parasitica*, *Alternaria solani*, and *Rhizoctonia solani*. Bacteria may also attack the stem at ground level. Irrespective of the causal organism, the disease appears as a canker, or rot, of the stem at or above the soil line (Fig. 3). When the stalk becomes girdled, the plant wilts and dies.

Control

- Remove infected plants.
- Sow seed treated with hot water.
- Handle plants carefully when pricking out and transplanting; bruises are quickly infected by microorganisms.
- Provide bottom heat and plenty of open-bench ventilation for seedlings and transplants.
- Practice thorough sanitation.
- Incorporate a fungicidal protectant in sterilized soil in greenhouses.
- Spray seedlings and transplants with a fungicide, as recommended in your provincial spray calendar

Fig. 3 Stems of tomato seedlings showing collar rot injury caused by *Sclerotinia minor.*

Septoria leaf spot

Septoria leaf spot disease, caused by ***Septoria lycopersici,*** produces numerous small circular spots on the leaves, stems, and leafstalks (Fig. 4). These spots are generally grayish, with a black border, although they are sometimes solid black. In the centre of the spots, small black pimples, the fruiting bodies of the fungus, may be seen with the aid of a hand lens. The disease starts on the lower leaves, progressing upward when water is splashed on them. Severely affected leaves turn yellow, dry up, and fall off. The damage to the crop results largely from a reduction of the leaf surface, which, in turn, reduces the size and quality of the fruit. Defoliation also exposes the fruit to sunscald.

In Ontario this disease is common, particularly where tomato crops have been planted frequently on the same soil; in localities where processing crops are grown, the disease does not usually become prevalent until late in the season. At that time less damage occurs to crops, compared with early in the growing season, when plants are young. Infection and spread of disease are enhanced by wind-blown rain and sandblast.

Control

- Plow under the refuse from the crop as soon as harvesting is finished, because the leaf spot fungus over-winters on tomato debris.
- Carefully gather all diseased leaves and stems found in the greenhouse and bury them.

- Rotate crops to include legumes and cereals in the sequence; rotation is a prime measure for disease prevention.
- Follow the spray schedule recommended by your provincial agricultural representative.

Early blight, or target spot

Early blight, or target spot disease is caused by *Alternaria solani* or, more frequently, by *A. alternata*. It and septoria leaf spot disease cause a serious loss of leaves in some seasons. These two diseases, either separately or together, are responsible for most of the defoliation that occurs on field tomatoes in Canada. Early blight also affects stems and fruit, Circular dark brown to black spots of various sizes appear on the leaves. The spots, about 1 cm in diameter, are readily recognized by the concentric rings, or zonations, from which the name target spot (Fig. 5) was derived. When these spots occur around the margin of a leaf, their symmetrical ring-like appearance is often lost in the uneven outline of the edge of the leaf. Early blight appears as black lesions, which subsequently enlarge and elongate on the stalks, branches, and fruit pedicels, sometimes girdling them. Unlike septoria leaf spot, the centre of the lesion remains dark. These enlarged lesions are referred to as collar rot when they occur on the stems.

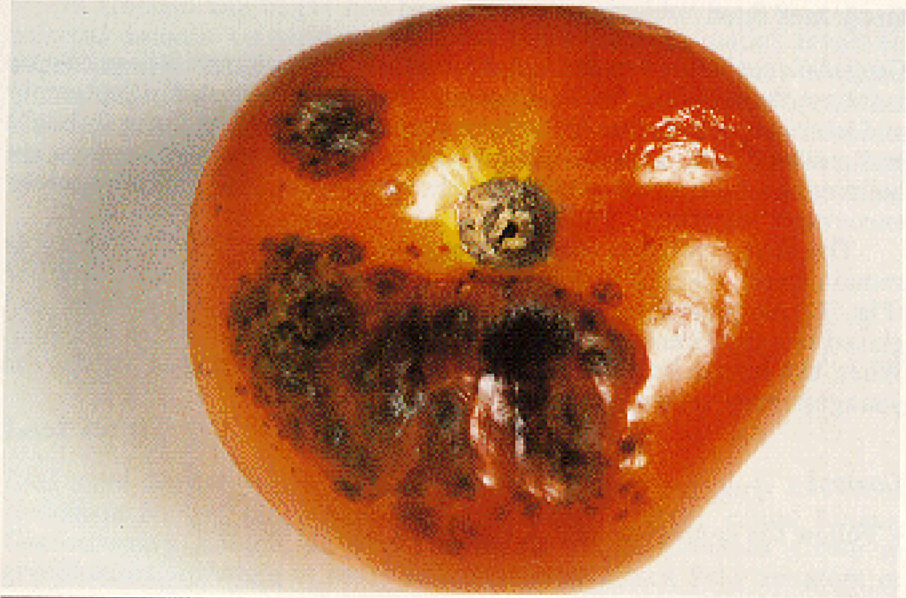
Large black leathery sunken areas are produced on the fruit (Fig. 6). These areas generally start around the fruit pedicel or in some small wound or crack, rapidly becoming enlarged. In overhead-irrigated crops, infections occur in the field during the summer Summer sprays must therefore be applied to provide protection. In most seasons, however, large amounts of fruit rot only in late August and September. In Ontario, fruit lesions often appear on tomatoes in late September and early October, when protective sprays are no longer applied.

Control

- Follow the control measures given for septoria leaf spot; in some areas, warnings of likely outbreaks, based on climatic conditions, are given by the provincial advisory service.
- Grow resistant cultivars.

Fig. 4 Tomato leaflets infected by septoria leaf spot; numerous small spots are typical of early stages of the disease.

Fig. 5 Early blight, or target spot, of tomato. Leaflets showing lesions.



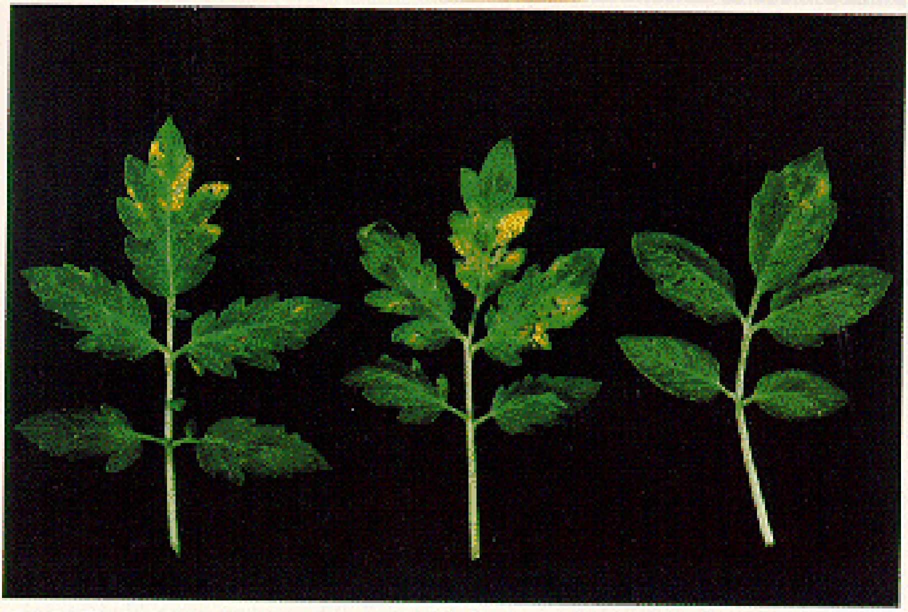


Fig. 6 Early blight of tomato fruit.

Fig. 7 Gray leaf spot.

Gray leaf spot

Gray leaf spot, caused by ***Stemphylium solani***, is a common foliage disease in the southern United States. Occasionally, it occurs about mid September and later in southwestern Ontario on processing crops. Unlike early blight and nailhead spot, this disease does not affect the fruit. The spores are believed to be carried on imported transplants. Hot, moist weather encourages infection.

The first infections usually occur on the oldest leaves. The spots remain small, about 3 mm in diameter, and are usually sharply angular (Fig. 7). As they become enlarged, the spots become tan-colored and glazed in appearance, and a tear usually appears in the centre of a spot. When the foliage has numerous spots, almost all the leaves, except the youngest, turn yellow, wilt, and eventually drop off.

Control

- Follow the control measures given for septoria leaf spot.

Late blight

Although late blight disease, caused by ***Phytophthora infestans,*** is more prevalent on potatoes, it infects tomatoes under favorable environmental conditions, particularly when the crops are near infected potatoes. The leaf symptoms are similar on both host plants. The disease causes severe defoliation of tomatoes and a destructive rot of the fruit. In some cooler areas of Canada, where heavy dews and showery weather prevail during August and September, late blight occurs regularly on tomatoes and potatoes. Apart from the epidemic years of 1946–1948, 1957, and 1976, the disease has not occurred in the chief tomato-growing areas of Ontario. In epidemic years it has been found occasionally in fall crops of greenhouse tomatoes in southern Ontario.

At first, irregular greenish black water-soaked areas appear on the oldest leaves (Fig. 8). The spots enlarge rapidly, and in humid weather a bluish gray growth of fungus sometimes develops on the lower leaf surfaces. Brownish cankers are often found on the stems and leafpetioles. In moist weather the infection develops so rapidly that large patches in affected fields have a frost-damaged appearance.

Fruit can become infected at any stage of growth. It is not common on the side of the fruit away from splashed soil. The water-soaked spot soon becomes greenish brown and has a firm, somewhat corrugated surface. The symptoms on fruit are sometimes mistaken for the broader zonate marking caused by buckeye rot. Under moist conditions a bluish gray downy growth of the fungus occasionally appears on the fruit. A field of infected fruit develops a characteristic fishy odor.

In Ontario late blight has been known to smolder for 2 months on infected tomato transplants obtained from Georgia; under favorable conditions, the disease then breaks out in epidemic proportions on fruiting plants. Late blight does not over-winter on dead plant debris in the soil, but it does persist in infected potato tubers in cull piles. It may appear in potato plants from diseased tubers used as seed or on volunteer plants from tubers in potato refuse piles, thereby gaining entry to potato and tomato fields.

Control

- Follow the spray schedule recommended in your province.
- Avoid potato cull piles.

Leaf mold

Leaf mold disease, caused by ***Fulvia fulva,*** is often popularly known as cladosporium leaf mold after the former name of the causal fungus, ***Cladosporium fiivum.*** It is mainly a disease of tomatoes grown in greenhouses, although in some seasons it may attack field tomatoes or seedlings in plant beds.

The symptoms of this disease are yellowish green indefinite areas on the upper surface of leaves, accompanied by brown to purplish velvety fungus growth on the underside (Fig. 91. When the atmosphere is humid, the fruit, stems, blossoms, and leaves may be affected. Because this fungus produces a great profusion of spores, the disease spreads rapidly, especially in the humid atmosphere of poorly ventilated plastic greenhouses.

Control

- Grow a resistant cultivar recommended by your local adviser. Reputable seed houses also indicate on the package whether or not their seeds are resistant. Susceptible cultivars can be grown if the humidity is kept as low as possible and yet is sufficient for good growth.
- Water the plants at ground level and try not to wet the leaves.
- When growing susceptible cultivars, reduce the spread of the disease by removing and destroying the first-affected leaves. Remove old basal leaves, even if they are not affected, to improve air circulation.
- Use fans and perforated plastic ducts to keep the air moving around the plants. The ducts are especially useful in plastic greenhouses.
- Avoid dewfall, at all costs, by expelling large volumes of humid air at nightfall and drying the night air with heat, while keeping ventilators slightly open.

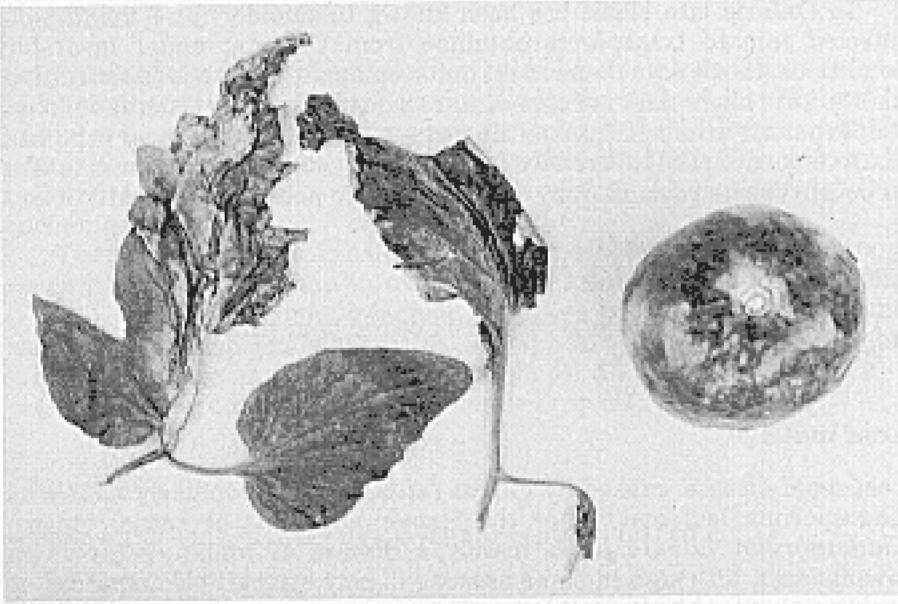


Fig. 8 Late blight causes dark areas on leaves and fruit.

Fig. 9 Leaf mold.

Anthracnose

Anthracnose, caused by ***Colletotrichum coccodes***, is a disease of ripe fruit that, if uncontrolled, causes serious losses in the early fresh market and processing crops in southern Ontario, Nova Scotia, and British Columbia. The early symptoms appear as small, slightly sunken circular spots (Fig. 10). The spots increase in size, sometimes to 1 cm in diameter, and often coalesce to cover a large area of the fruit. Spots are usually most numerous on the side of the fruit adjacent to the soil; they are usually depressed and have concentric ring markings. The centres become tan and have numerous dark specks, which are the bodies in which the fungus spores are produced.

The spores are produced in large numbers and are spread by rain to green fruit, where infection occurs. The fungus can penetrate the cuticle of uninjured fruit. Fruit infected when it is green and small shows no spotting until it begins to ripen. The fungus persists from season to season on infected plant refuse in the soil.

The anthracnose fungus, which is sometimes found as a weak parasite on the roots of greenhouse tomatoes affected by corky root rot, where it is the cause of black dot root rot. Occasionally, the disease may be severe in hydroponic production.

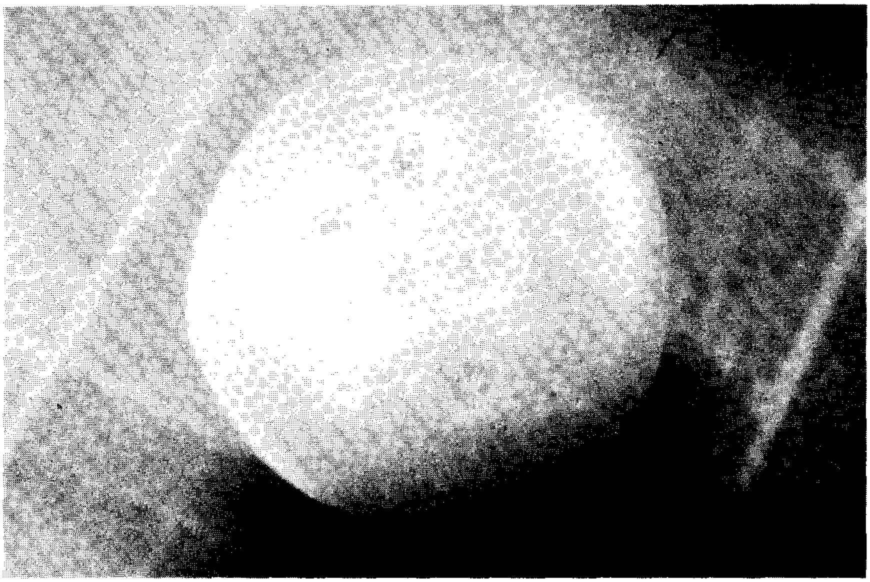


Fig. 10 Tomato fruit showing small, slightly sunken circular spots with concentric marking characteristic of anthracnose.

Control

- Practice crop rotation. Fields that have produced seriously diseased tomatoes should not be planted with that crop or with related crops oftener than every 4 years.
- Follow the spray programs recommended by provincial authorities for the control of early blight, septoria leaf spot, and late blight.

Verticillium wilt

Verticillium wilt disease is caused by ***Verticillium albo-atrum*** and ***V. dahliae***, the former being the more virulent of the two. In southern Ontario and in the interior of British Columbia, ***V. dahliae*** is prevalent, but in the Maritime Provinces and in other northern areas of Canada ***V. albo-atrum*** appears to be more widespread. Both species have been found in greenhouse tomato crops, although ***V. dahliae*** predominates. The symptoms of wilt caused by the two species differ in degree but not in type.

The causal fungi inhabit the soil and enter the plants through the roots. From the roots they advance through the woody tissue, where they usually cause a brownish discoloration in the vascular system, and then spread into the stem. The degree of browning of the water-conducting tissues of the stem varies, depending on the susceptibility of the plants and the softness of plant growth. In the greenhouse, the first visible aboveground symptom is the wilting of one leaflet or more on a single leaf The oldest leaves usually show symptoms first, and then wilt develops progressively in the younger leaves (Fig. 11). Greenhouse plants that become infected during January February and early March show sudden wilting of several leaves, which become characteristically patterned with bright autumnal colors-yellow and brown; these plants often die in a few days. During late spring and summer, infected plants usually survive in a considerably stunted, wilted condition. A heavy watering seems to induce rapid upward movement of the fungus in infected plants. In the field, symptoms appear as wilted, V-shaped, yellowed areas extending in from the margins of the leaves (Fig. 12). Frequently, the first symptoms appear on leaflets on only one side of the leaf The oldest leaves and yellowed areas die progressively Although the whole plant rarely dies, it remains unproductive.

Verticillium species attack potatoes, peppers, eggplants, watermelons, muskmelons, raspberries, strawberries, apricots, peaches, cherries, and a few other crops. The fungus also infects and multiplies in numerous common weeds, such as velvetleaf, cocklebur, and ragweed.

Control

- Practice a 3-4 year crop rotation in the field; do not include potatoes, eggplants, or peppers. A number of resistant cultivars are available for both field and greenhouse use; consult your local adviser.

Fig. 11 Verticillium wilt.

Fig. 12 Verticillium wilt; leaves assume autumnal colors in V-shaped lesions.

- Sterilize the soil with steam or chemical fumigants in the greenhouse. Use sterilized soil or a soilless substrate to grow susceptible transplants that are to be set out in the field.

Fusarium wilt

Fusarium wilt is a soil-borne disease caused by ***Fusarium oxysporum*** f. sp. ***lycopersici,*** which enters the plant through the roots. The fungus grows up through the woody tissue and produces toxic substances that cause the plant to yellow, wilt, and die. The woody tissues of the stems of affected plants show a brown discoloration. Fusarium wilt is encouraged by high soil temperatures (about 27°C), and accordingly is a minor disease in Canada. In southern Ontario, the fungus does not survive in the field for more than 2 years when tomatoes are absent.

Seedlings grown in infested soil may contract the disease, but often they do not show symptoms until after they have been transplanted. The disease is transferred to the field in this way

Control

- Practice a 2-3 year crop rotation and grow resistant cultivars in the field, as indicated in seed catalogs. Three races of the fungus are known, each of which attacks different cultivars. Most commercial cultivars in common production are resistant to two of the races. However, consult your seed supplier or local adviser for cultivars most suited to your conditions.

- Sterilize soils where the disease has occurred in the greenhouse, if you plan to grow a susceptible cultivar.

Fusarium crown and root rot

Fusarium crown and root rot, caused by ***Fusarium oxysporum f.*** sp. ***radicis-lycopersici***, is a destructive disease of greenhouse crops. It appeared for the first time in Canada in 1974, in the Leamington area of southwestern Ontario, where tomatoes are produced intensively under glass. The disease attacks field crops in fumigated soil in Florida and California and has recently become a problem in Canadian field crops that are raised in local greenhouses.

An early symptom of fusarium crown and root rot is the thinning of the stem at the top of the plant when it is *l-2* m high. When the first trusses of fruit are ripe, or nearly so, the plants begin to wilt, particularly in hot weather and in full sunshine. The wilt progresses from top to bottom, and, when the plant is almost dead, the leaves may turn golden brown from the margins. The disease is usually characterized by a remission of wilt symptoms on cooler and overcast days and after picking. The cause of wilt becomes clear when the base of the stem is examined at or just below soil level. A chocolate brown lesion extends through the external cortical tissues, girdling the stem in severe cases. When the stem is split open (Fig. **13**), the discoloration can be seen extending along the water-conducting vessels. In contrast to fusarium wilt, this discoloration rarely extends more than 20-25 cm up the stem. The fungus gains entry where adventitious roots break through the outer cortical tissues of the stem.

Fusarium rot also affects the roots. The rot at the base of the stem extends into the primary root and often destroys it completely The survival of the plant then depends on adventitious roots that are formed in the stem above the lesion. As in the stem, the fungus attacks the roots where the secondary roots break through the cortical tissue.

Control

Resistant pink- and red-fruited greenhouse cultivars are available, but processing cultivars currently grown are not resistant.

As a marked exception from the general rule, high standards of soil sterilization and greenhouse hygiene have often been followed by severe losses of susceptible cultivars. These losses are attributed to a lack of competition from antagonistic soil microflora, permitting the rapid spread of the pathogen unopposed in the soil when it returns to the soil surface as airborne spores. The reinvasion of newly sterilized soil can be stopped by sowing lettuce in the soil and by returning lettuce residues to the soil before the next tomato crop is planted. No further sterilization is necessary after

Fig. 13 Symptoms of fusarium crown and root rot, evident when the stem is split open at the base. The main root is often completely rotted away. Gray-brown lesions of fusarium crown and root rot are formed on the roots wherever the small secondary roots emerge.

the lettuce. Alternatively, companion crops of dandelion control the disease. Lettuce and dandelion contain antibiotic chemicals. No chemical treatment controls this disease satisfactorily.

Buckeye rot

Buckeye rot disease is caused by ***Phytophthora parasitica.*** Although the most common symptom of buckeye rot, and the one from which the name is derived, is seen on the fruit, this disease may also produce lesions on the stems and leaves, as well as damping-off of seedlings. Seedlings may be killed either before or shortly after emergence. Stem girdling, or collar rot, may occur on seedlings and mature plants. Leaf symptoms appear as irregular brown lesions on the lower leaves. Either green or ripe fruit, especially when in contact with the soil, may become infected through the uninjured skin. A small grayish brown spot first appears. As it enlarges, dark greenish tan to brown zones appear in the spot (Fig. 14).

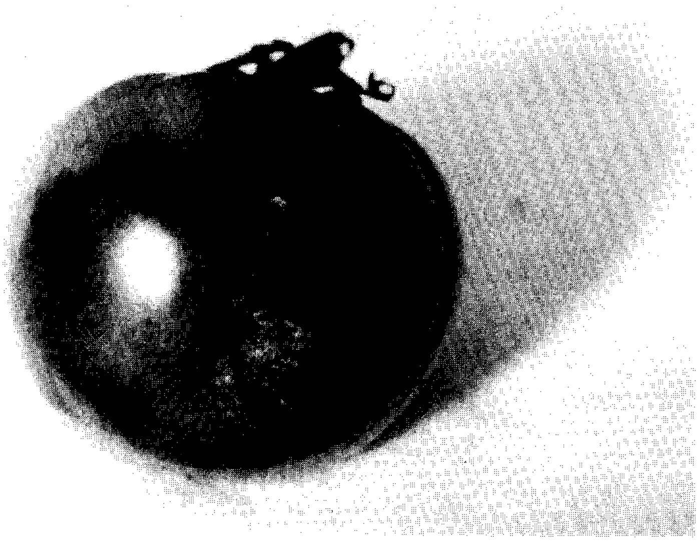


Fig. 14 Tomato showing diffuse tan-colored zones caused by buckeye rot.

The rot, which is leathery in texture, usually affects the fruit to a considerable depth. Under very moist conditions a cottony white fungus growth develops on the infected fruit.

Control

- Sterilize greenhouse soil.
- Plant on well-drained soil.
- Spray with a recommended fungicide.
- Avoid overhead irrigation if possible.

Soil rot

Soil rot disease, caused by ***Rhizoctonia solani,*** affects the fruit of tomato. The disease is widespread in Ontario, where early fresh-market crops are grown on light sandy loams. It is found on fruit in the field and in transit to markets, when early infection has escaped notice in grading. In southern Ontario the disease is usually more common on early July picks than on those made later. Soil rot also tends to occur after overhead irrigation. This same fungus also causes damping-off and girdling of stems of seedling plants.

Characteristically, a brownish spot, l-2 cm in diameter, appears on the part of the fruit in contact with the soil (Fig. 151. The spot has sharply outlined concentric zonate markings that are much narrower and closer together than those of buckeye rot. The spot can enlarge to 3 cm or more in diameter, and the centre of the spot usually cracks open. Soil particles are

firmly attached to the cracked area by a cottony **fungal** growth that extends from the soil into the fruit.

Control

- Because soil rot is commonest on soil-splashed wet fruit, do not irrigate overhead if you can avoid it.
- Follow the spray program recommended in your province.

Nailhead spot

Nailhead spot disease, caused by ***Alternaria tomato,*** is similar to early blight, with which it may be confused. Hard, scab-like spots on the infected fruit are characteristic symptoms of **nailhead** spot. The spots are dark brown and usually small, and the discoloration extends beneath each spot into the flesh of the fruit. Like early blight, it causes leaf defoliation. **Because** most modern cultivars are resistant, this disease is not important.

Control

- Practice crop rotation and sanitation.
- In severe cases spray with a fungicide recommended by your provincial agricultural representative.

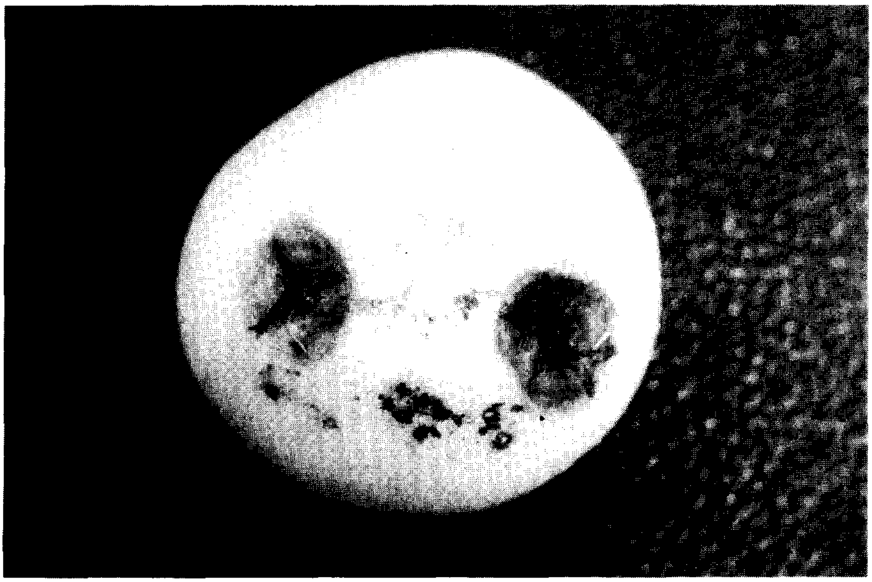


Fig. 15 Green tomato fruit showing **soil rot.**

Ghost spot and gray-mold rot

Ghost spot disease, caused by ***Botrytis cinerea***, is found on greenhouse and field tomato fruit when atmospheric humidity is high. The disease is aptly named, appearing on the fruit as a superficial pale halo or ring mark, with a brownish to black pinpoint spot in the centre (Fig. 16). On green fruit the halo may be pale green or silvery, and generally the tissue inside the halo is paler green still. On ripe fruit the halo is usually pale yellow Ghost spots rarely develop further, but they spoil market quality Cultivars vary in their susceptibility to fruit infection.

This fungus can also produce a gray mold rot on the leaves, leaf petioles, stems, and fruit, especially under humid greenhouse conditions. On the fruit, infection usually starts at either the blossom end or the stem end, and when the humidity is high a grayish growth of the fungus develops rapidly (Fig. 17) and a soft watery rot destroys the fruit. On the stems the fungus usually becomes established on dying tissue at the base of leaf petioles or at the petiole stump left after deleafing. Once it becomes established on dying tissue, the fungus invades the stem, often completely girdling it and killing the plant (Fig. 18). The fungus frequently causes lesions at several nodes on the stem of a plant. A common symptom is a concentric banding on the lesion.

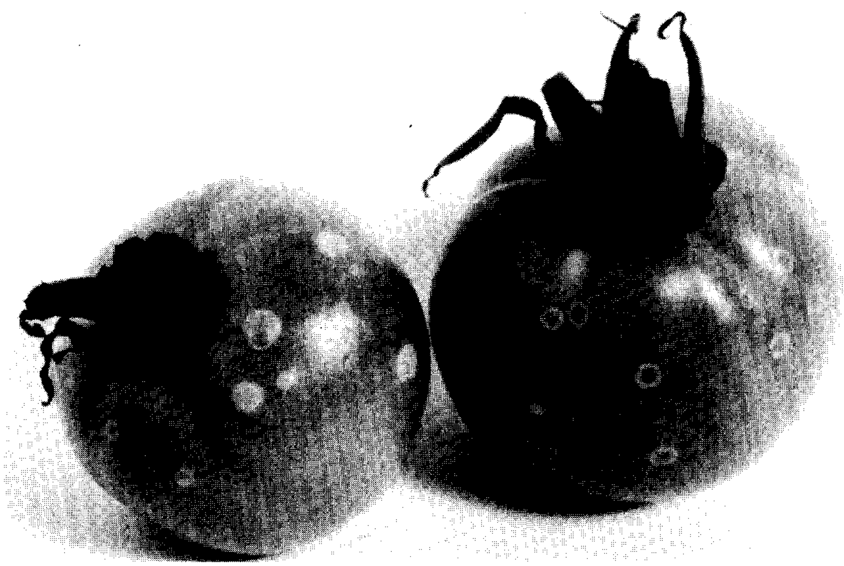


Fig. 16 Ghost spot on green tomato fruit caused by *Botrytis cinema*.

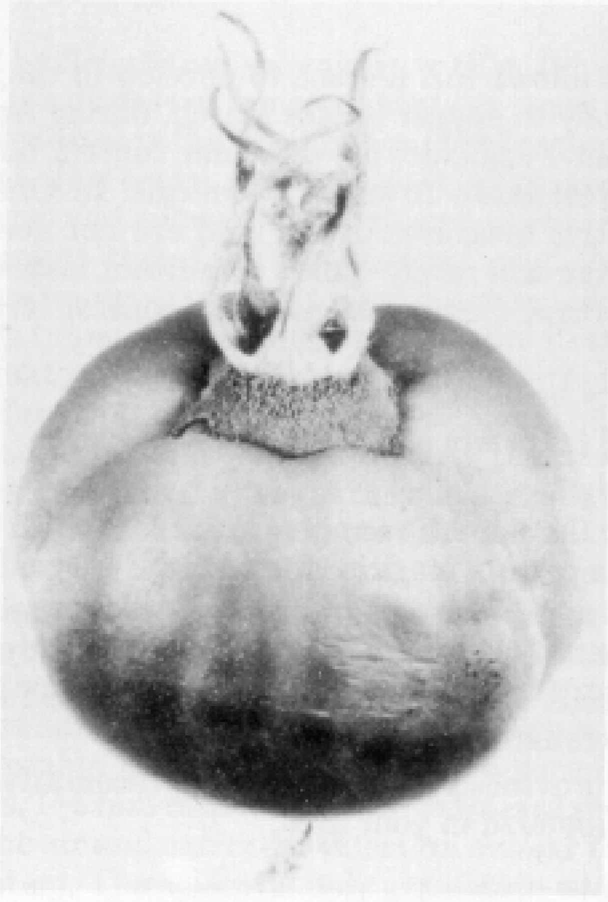


Fig. 17 A gray mold covers the calyx-end areas of tomato infected by *Botrytis cinerea*.

Fig. 18 A lesion on the stem caused by *Botrytis cinerea*.

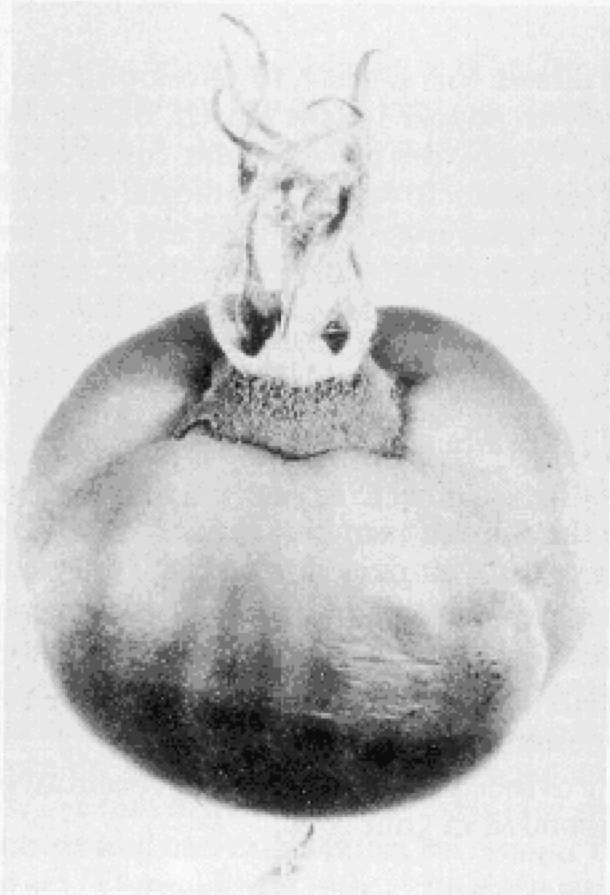


Fig. 17 **A gray mold covers the calyx-end areas of tomato infected by *Botrytis cinerea*.**

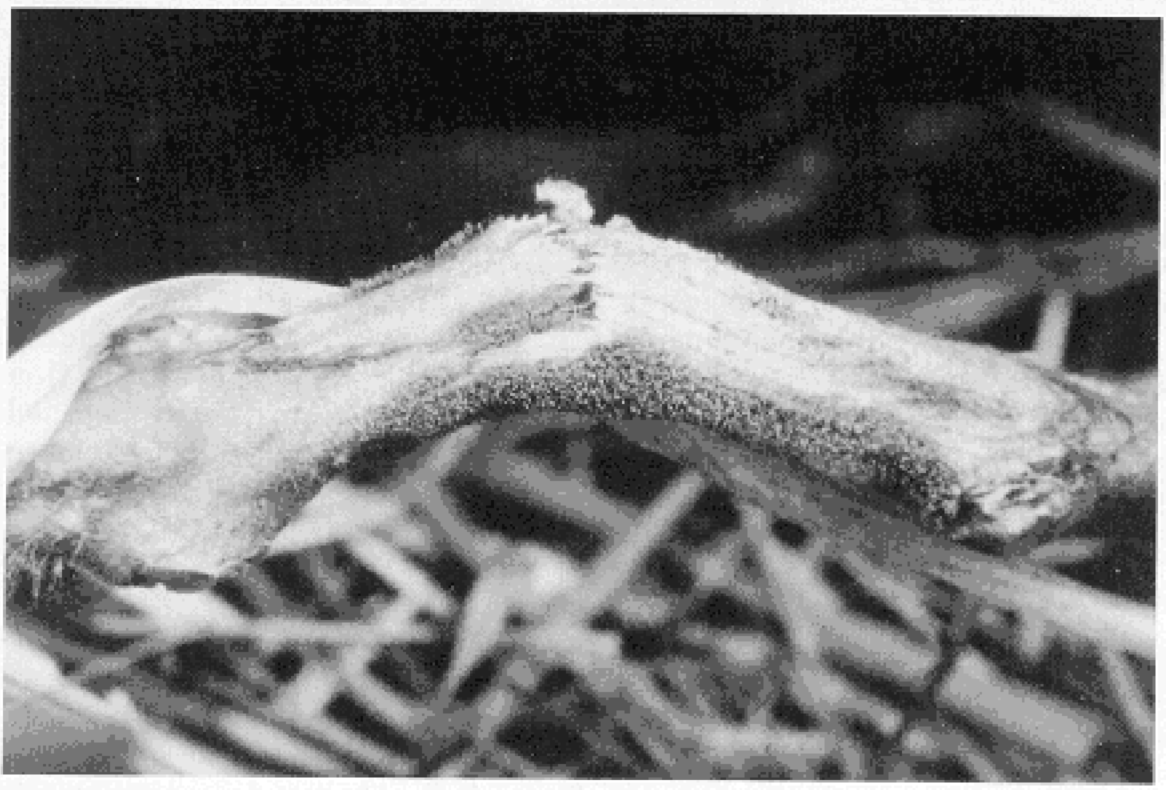


Fig. 18 **A lesion on the stem caused by *Botrytis cinerea*.**

Control

Poor management allows this disease to develop in the greenhouse. The disease is most likely to appear in late March, during April and May, and again in late autumn. Fungicides provide some control, but ***Botrytis cinerea*** quickly develops resistance to many chemicals. In Ontario and British Columbia, preventive measures in the field are not needed, because the disease is uncommon and rarely causes significant losses. In Nova Scotia, however, it is important. Fungicides give good control, if resistance to them has not developed.

- Provide **adequate** heat and ventilation.
- Avoid snags and tears when deleafmg.
- Remove all trash.
- Treat cankers on the stems by scraping the **soft** diseased tissue away with a knife; apply a thin paste of **fungicide** to and slightly beyond the **affected** area.
- Allow adequate space between and within rows; orient rows parallel to the prevailing wind so that wet plants dry out quickly.
- Do not allow weeds to grow, which both harbor the fungus and provide the right microclimate for its development.
- Consult your provincial agricultural representative for the spray program recommended in your area.

Stem canker

Stem canker, caused by ***Didymella lycopersici,*** is a common disease of field and greenhouse tomatoes in Europe. In Canada, however, it occurs only rarely in British Columbia and Nova Scotia. In Europe it can also affect the stem base and roots, as well as causing fruit rot. A girdling canker, dark brown and sunken, appears at or just above the soil level, with secondary cankers developing at intervals higher up on the stem. The lesion resembles gray mold but is somewhat darker, and instead of the gray brown cottony growth of ***Botrytis cinerea,*** stem canker lesions bear tiny black pimple-like protuberances, the fruiting bodies of the fungus. The stem cortex becomes very soft and the plant finally collapses. In humid conditions pinkish tendrils or wet masses of spores exude from these bodies.

Stem canker is a cool-temperature disease, thriving at an optimum temperature of about 15°C. The fungus is seedborne, but most infection comes from plant debris, canes, or string left from the previously diseased crop. The disease is extremely contagious and is carried by splashed water, the hands, and tools.

Control

- Use only treated seed from a reputable source.
- Remove all debris and bury it far away from the crop area.
- Sterilize canes, pots, and other associated hardware.
- Paint lesions with an oil-based fungicide paint.
- Rotate field crops every 3 or 4 years.

Stem rot

Stem rot, caused by ***Sclerotinia sclerotiorum*** (Fig. **19)** and occasionally by S. minor (Fig. 31, is a disease of tomatoes that can cause minor losses in the field and extensive losses in the greenhouse. The fungus often attacks snap beans, white beans, limabeans, soybeans, pole beans, cucumbers, potatoes, carrots, and lettuce, and a few other crops and weeds. Field tomatoes are rarely infected unless they follow a diseased crop. In the greenhouse, conditions that encourage gray mold also favor stem rot.

In field-grown tomatoes the fungus attacks the stem near the soil, and in greenhouse tomatoes it attacks the stem at a node that is often 1 m above the ground. The fungus causes a brownish decay of the soft tissues of the stem. Eventually, the plant wilts and dies. As the disease progresses, a grayish white **fungal** growth may cover the surface of infected tissues. At a late stage of the disease the infected portion of the stem, when broken open, shows cavities filled with white cottony fungus in which hard black sclerotia are embedded. **Sclerotia** of S. ***sclerotiorum*** are about the size of white bean seed, whereas those of S. ***minor are*** much smaller, about the size of cress seed, and are aggregated into masses on the outside stem.

The fungus can survive as sclerotia in plant refuse in the soil for several years. Under favorable conditions the sclerotia germinate and produce cup-shaped bodies, 1-5 mm in diameter, which release spores. These spores are ejected into the air and can cause infection similar to gray mold at the nodes along the stem. The sclerotia only germinate when they are within about 3 cm of the soil surface; deeper ones remain dormant until they are brought to the surface by cultivation.

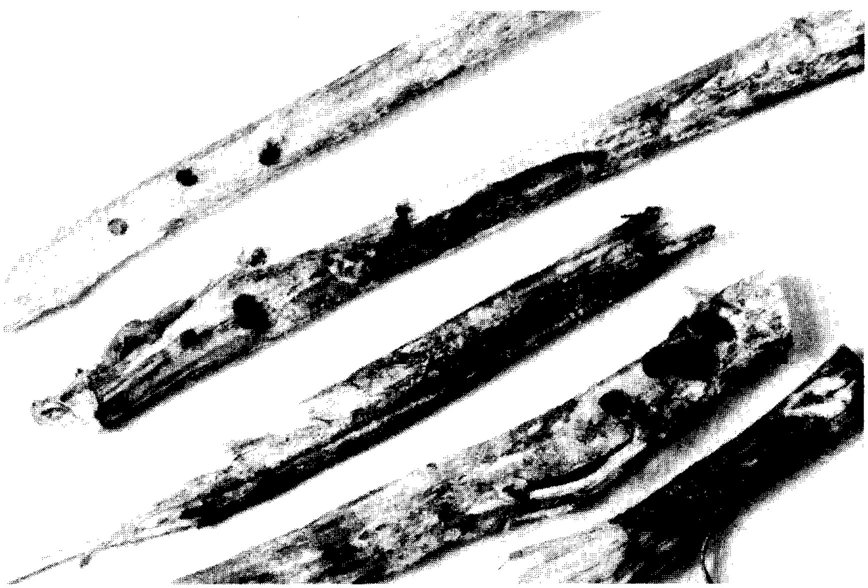


Fig. 19 Stem rot caused by *Sclerotinia sclerotiorum*.

Control

- Do not plant tomatoes in the field after any crop that suffered seriously from the disease the previous year Only cereals are safe rotation crops.
- Sterilize the soil with steam or a chemical fumigant in the greenhouse; make sure that trash piles are far removed, because spores of the fungus can be carried through the air for long distances.

Black dot root rot

Black dot root rot disease is caused by ***Colletotrichum coccodes*** and is characterized by black pinpoint dots on weak and rottingroot systems. The dots are the fruiting bodies of the causal fungus. This disease usually appears late in the season and is often symptomatic of other problems, such as overwatering, overfeeding, and other imbalances. It usually appears on plants weakened by other diseases, particularly those affected by corky root rot.

Control

- Maintain plants in a well-balanced growing condition; recurrence is largely prevented by soil sterilization and attention to general hygiene.

Corky root rot

Corky root rot, caused by ***Pyrenochaeta lycopersici*,** is a disease of greenhouse crops. It has frequently been confused with black dot root rot because the fruiting bodies of ***Colletotrichum coccodes are*** usually found at the same time. However, the fruiting bodies of ***P. lycopersici are very rare.***

The first signs of corky root rot are elliptical light-brown areas up to 5 mm long, on the thin roots. This stage is often referred to as brown root rot. On the larger roots, the discoloration is darker brown, and the roots become somewhat swollen, dry and corky, with splits all over the outer sheath (Fig. 20). The sheath, or cortex, is readily pulled off the central core, or stele. Massive root failure causes general unthriftiness, severe wilting in hot weather, and eventually, death. The disease is most severe when transplants are put into soil that is too cold.

Control

The fungus is soilborne and capable of **remaining viable** in the soil for many years. Because it grows slowly, attacked plants can sometimes be saved by mounding clean peaty soil around the base of the stem to encourage the production of new adventitious roots. This soil warms up faster than the main soil groundbed and enables the plant roots to outgrow the fungus. Mulchingwith straw should be delayed until the groundbed soil warms up.

Fig. 20 Corky root rot.

The fungus can be eradicated by sterilization or steam or by fumigation with methyl bromide applied by a licensed operator. Other fumigants and fungicide drenches are less effective. Resistant rootstocks are known, and therefore grafting can be used to avoid the disease in greenhouses where soil sterilization is not possible. Before sterilizing the soil, remove and destroy as much of the old root system as possible. Warm the soil before transplanting and have it adequately drained.

The disease is becoming common in soilless media usually because of lapses in hygiene procedures that permit contamination from soil.

Feeder root rot

Occasionally, mature cropping (and therefore stressed) plants collapse quite suddenly The cause is the destruction of tiny feeder roots by fungi in the genus *Pythium*. No other root symptoms are obvious.

Control

- Maintain plants in a well-balanced growing condition without undue fruit loads.

Bacterial canker

Bacterial canker disease, caused by ***Clavibacter michiganense*** ssp. ***michiganense*** is contagious and can be destructive to field and greenhouse crops. Symptoms can vary quite widely between cultivars.

Seedlings are infected occasionally, but they often show no prominent symptoms until several days after they have been transplanted to the greenhouse or the field. Wilting of the leaflets is the first symptom on plants of all sizes; on older plants the margins of the leaflets wilt first. The affected leaflets turn brown and die progressively from the margins in toward the midrib. Usually only the leaflets on one side of the leaf are affected. Plants do not die but survive in an unthrifty, wilted condition and bear some fruit. During the hot summer months, infected plants show the greatest capacity to survive. Also, during July and early August in Ontario, leaf symptoms may appear only as brown areas between the veins.

Light-colored streaks extending up and down the outside of the stem and on the leafstalk may accompany **leaflet** wilt (Fig. 211. When these streaks occur, they sometimes break open to form a canker.

In the early stages of infection the bacteria move through the **water-** and food-conducting strands of the plant stem. Eventually, they break out into the cortex of the stem. As decay progresses, the pith becomes yellow and mealy, and cavities form in the soft tissues of the stem. When an infected stem is squeezed gently at the nodes, a sponginess is detected. When the stem is cut lengthwise, a creamy white, yellow, or tan streak appears just outside the softened woody tissue.

Canker bacteria sometimes survive for several weeks in minute yellowish tan to rust-colored inconspicuous lesions on the surface of stems and leaves, without causing systemic infection. These lesions constitute serious sources of infection. In greenhouse crops, fruit symptoms are common. The bacteria pass from the vascular tissues into the stem end of the fruit and then radiate out through the pulp. If fruit is infected when it is small, it becomes stunted, malformed, and occasionally ridged; on some cultivars the skin turns white. Slightly older fruit shows a mottling or marbling of the surface.

When infected fruit is cut open, the vascular tissue that extends from the stem scar to well within the pulp is yellowish brown (Fig. **22).** When the fruit is picked, the vascular traces on the **calyx** scar are **prominently** yellow brown. Severely infected fruit also shows extensive internal breakdown, with yellow or brownish cavities, especially near the stem end.

If greenhouse or field crops are watered by overhead irrigation, small **bird's-eye** cankers (Fig. **23)** may form on the surface of fruit on infected plants. These infections appear first as snow-white spots that extend scarcely beyond the skin. The margins of the spots remain white and flat; the centres become slightly raised and tan-colored, and then crack open. These spots do not exceed 3 mm in diameter. The halo around the spot helps to distinguish bacterial canker from bacterial spot disease. **Bird's-eye** spot is a common symptom of the disease in field crops.

Contaminated seed may be the source of primary infection. Once established in a greenhouse, bacterial canker may hold over from one season to the next on crops infected by plant debris in the soil or by pots, flats, and other containers. In the greenhouse and in staked field crops, the disease is spread readily from plant to plant by pruning, tying, pollinating, and handling. In processing and fresh-market crops, canker is spread mainly by rain and overhead irrigation. Under field conditions, the bacteria may survive from year to year in the soil.

Control

- Buy seed only from a reliable source.
- Make sure seed has been hot-water treated or chemically decontaminated.
- Sow seeds in sterilized soil. Use only new or sterilized flats, pots, and other containers.
- Locate seedbeds away from contaminated areas, because bacterial canker may persist for several months in soils that contain tomato refuse.
- Immediately remove infected plants and a few adjacent plants from the greenhouse. Place a plastic bag over the affected plants so that no other plants are touched by them as they are removed. Burn all infected plants or bury them deeply
- If canker develops in the seedbed, destroy the plants and steam the soil.
- Pesticide sprays are ineffective and may well spread the disease.
- Disinfect all pruning tools and pollinators with diluted household bleach (10%) at frequent intervals when working in the crop.
- Avoid all unnecessary handling of plants, and wash your hands often with soap and water. When workingwith diseased crops, try to handle affected areas of plants last of all.

Fig. 21 A tomato plant showing wilt and scarring of leaflets, characteristic of bacterial canker.

Fig. 22 Bacterial canker: brown discoloration in the vascular system of the fruit.

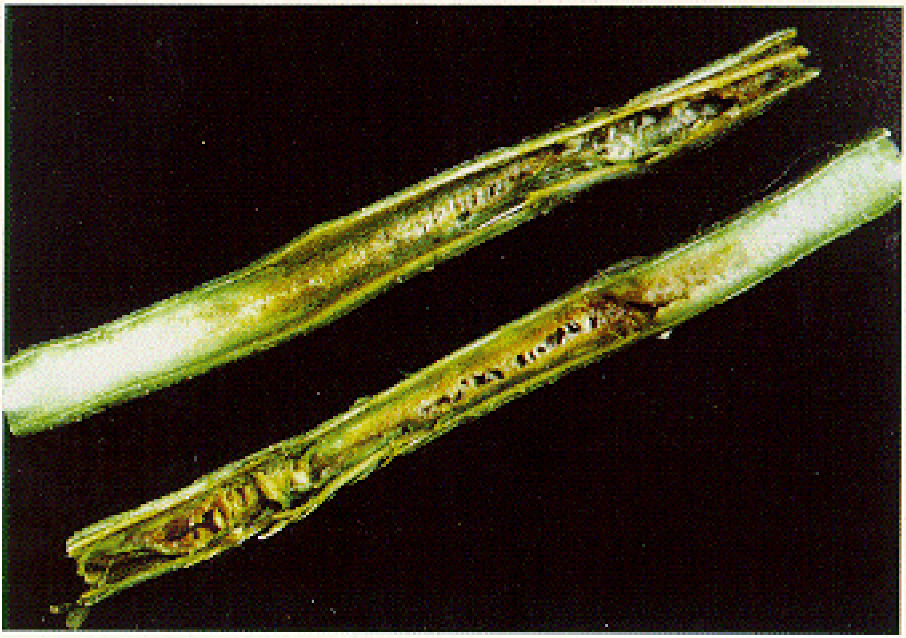


Fig. 23 Bird's-eye symptom of bacterial canker.

Fig. 24 Bacterial stem rot.

Bacterial stem rot

Bacterial stem rot is caused by a soft-rotting bacterium, ***Erwinia carotovora*** ssp. ***carotovora*****,** and typically appears in greenhouse tomatoes when the fruit is first picked. The lower leaf scars are surrounded by dark brown lesions, and the stem becomes hollow and water-soaked. The cortex sloughs off easily. As infection advances, the whole plant wilts and collapses (Fig. 24). The disease is particularly prevalent along rows beneath the roof gutters, where high humidity and free water on the plants are more likely to occur The bacterium may be present in the soil and can be splashed onto deleafing wounds by drips from the roof; it can also be carried in irrigation water from wells and outside reservoirs. The bacterium spreads by contact with contaminated hands and tools.

Control

- No effective pesticides are known.
- Avoid over-fertilization with nitrogen; a direct relationship exists between the potassium-to-nitrogen ratio and freedom from the disease, 1:1 providing susceptibility and 1:4 or more providing greater resistance.
- Avoid humid conditions.
- Keep gutters in good repair to prevent drips.
- Take hygienic precautions, as for bacterial canker.

Southern bacterial wilt

Southern bacterial wilt disease, caused by ***Pseudomonas solanacearum*****,** is not uncommon in Canada, usually appearing in crops raised from seedlings imported from the southern United States. It is doubtful that ***P. solanacearum*** survives in Canada from year to year

Affected plants wilt suddenly and may die. Those that survive remain greatly stunted, and the wilted leaves become yellow (Fig. 25). When the stem of a wilted plant is cut across near the ground, the pith is dark brown to black and water-soaked; in the later stages, decay of pith causes extensive hollowing of the stem (Fig. 26). Sometimes black streaks appear on the stems and leafstalks, and adventitious roots are produced on the stems. These symptoms somewhat resemble those of pith necrosis, which occurs in greenhouse crops.

Control

- Remove infected plants from the field immediately, because the causal bacteria spread from diseased to healthy plants by splashed rain or during flooding after rain.
- Burn or deeply bury all infected plants. Do not replace them with healthy plants.

Fig. 35 A plant showing symptoms of southern bacterial wilt.

Fig. 26 Longitudinal section of lower stem of tomato plant infected with southern bacterial wilt showing stem hollowing caused by pith decay

Pith necrosis

Pith necrosis disease, caused by ***Pseudomonas corrugata***, occasionally occurs in greenhouse plants allowed to grow too soft or luxuriant. The disease is characterized by elongated blackish lesions that appear on the stems. This condition is most troublesome at the beginning of picking. The stems may collapse wherever the lesions occur The pith is black, soft, and rotted, sometimes with cavities near the base of the stem. The leaves wilt and may be yellowish near the top of the stem. The disease does not appear to spread within the crop, but much of its biology is not well understood (Fig. 27).

Control

- No effective pesticides are known.
- Avoid cultural practices that promote over-lush growth.
- Increase the level of potash in the fertilizer schedule.

Bacterial spot

Bacterial spot disease, caused by ***Xanthomonas campestris* pv. *vesicatoria***, is characterized by spotting on the leaves, stems, and fruit. The most conspicuous spots are on the fruit. Occasionally, 2-mm black spots that have a greasy appearance develop on the leaves and stems. On the fruit the spots form slightly raised rough, black, scabby lesions, in the centre of which numerous cracks sometimes occur (Fig. 281. Although the spots may enlarge to 6 mm in diameter, they do not extend deep into the fruit. The symptoms sometimes closely resemble those of bacterial speck; a laboratory examination is required to distinguish between the causal bacteria. The disease spreads during heavy rains. ***Xanthomonas vesicatoria*** also attacks peppers, producing lesions, similar to those on tomatoes, on the fruit and leaves.

In recent years bacterial spot has been uncommon in Ontario, although it has been destructive occasionally Its presence on the fruit makes the skin difficult to remove during whole-pack processing.

Control

No effective pesticides are known. The chief measures of control are seed treatment and rotation of crops in seedbed and field. The disease is impossible to control once it appears in the field.

- Use disease-free transplants.
- Use only hot-water-treated seed from a reputable source.
- Sow the treated seed in sterilized soil.
- Do not include peppers in the crop rotation.

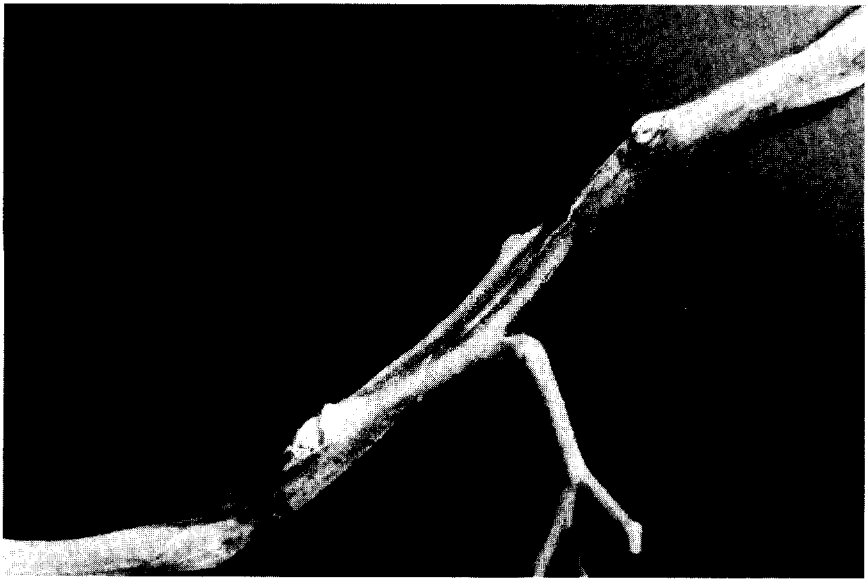


Fig. 27 Pith necrosis is characterized by long black lesions on the stem and by blackened pith.

Fig. 28 Tomato fruit showing slightly raised rough, black, scabby lesions characteristic of bacterial spot.

Bacterial speck

Bacterial speck disease is caused by ***Pseudomonas syringae*** pv. tomato. In recent years, this disease has been much more prevalent than bacterial spot, often in crops raised from imported transplants. The bacterium is indigenous to Florida and Georgia, and therefore the bulk of the **inoculum** for Canadian crops is renewed annually on imported transplants; the bacterium is also believed to survive in Canadian greenhouses used for raising transplants.

The disease is most noticeable on the fruit, where it causes numerous dark brown spots, l-2 mm in diameter (Fig. 29). These spots do not extend much deeper than the thickness of the skin. Sometimes the lesions are larger and more irregular closely resembling those of bacterial spot. Both diseases have been reported on the same fruit. On the leaves bacterial speck causes dark brown to black spots that are usually slightly larger than those on the fruit.

Infection occurs most abundantly after heavy rains that splash the bacteria to all parts of the plant. This disease does not affect peppers.

Control

Use the same control measures as for bacterial spot. Breeding programs have identified resistant germplasm for incorporation into new **cultivars.**

Fig. 29 Tomato fruit showing numerous small dark brown spots caused by bacterial speck.

Tomato yellows

Tomato yellows disease is caused by the beet curly-top mycoplasma. In some years serious outbreaks of tomato yellows have occurred in southern British Columbia. Disease severity varies from year to **year;** occasionally 30% of the crop, or more, may be lost. The disease is widespread throughout the Pacific Coast region, extending from British Columbia to Mexico.

Diseased plants are readily distinguishable in the field, because they are rigid and have stiff brittle leaves that tend to roll inward along the midrib. They curve downward slightly and have a drooping but not wilting appearance. The veins are generally, but not invariably, purplish, and the normally green leaves change to sulfur yellow. The infected plant ceases to grow, and the fruit already formed does not enlarge. The pith dries out and the stem becomes hollow. Eventually, the plant turns brown and dies. The disease runs its course in l-2 weeks. Affected plants may recover somewhat but never regain a normal appearance. The small roots become brown and decayed. In the greenhouse, an early symptom is transparent veins; purpling is rare.

The mycoplasma is spread by the beet leafhopper. This migratory insect breeds in weedy waste areas of the semiarid region in and west of the Rocky Mountains.

Control

- Always separate crops of tomatoes from beets because this disease is caused by the same mycoplasma that causes curly-top of beets.
- Consult your local authority about safe distances between crops.
- Maintain good weed control.

Purple-top

Purple-top disease, caused by the aster yellows mycoplasma, has been reported on field tomatoes in many Canadian provinces. The incidence of the disease varies from year to year; although seldom high, it is highest when the mycoplasma is prevalent in weeds and other susceptible crops in the same area.

The most characteristic symptom is the purplish tinge in the foliage, which is particularly apparent in the youngest leaves. Affected plants show an upright appearance because of slight hardening of the stem and leafstalks. The leaves also show a tendency to roll slightly Considerable stunting of growth occurs.

Control

Purple-top disease is rarely serious enough to warrant specific control measures. Good weed control is always sound husbandry because it removes sources of inoculum.

Tobacco etch

Tobacco etch disease, caused by the tobacco etch virus, is serious in field tomatoes only when the virus is epidemic in nearby burley tobacco and sweet pepper crops.

Tobacco etch causes a clearing of the veins and a mild **mottling without** much leaf distortion. Growth is only slightly retarded. The virus is transmitted by the green peach and potato aphids in Ontario, but it may be transmitted by other aphids elsewhere. When tobacco etch occurs in greenhouse crops, it is usually in association with tomato mosaic and cucumber mosaic viruses.

Control

- Control aphids and weeds in and around greenhouses.
- Keep a reasonable separation between tomato crops and tobacco and pepper crops.

Tomato mosaic

Mosaic diseases are highly contagious and can be spread easily by anyone who handles or brushes against diseased plants and then contacts healthy ones in such operations as tying, suckering, cultivating, and harvesting. Diseases are also spread on machinery.

Tomato mosaic virus used to be common and widespread, but most modem cultivars are resistant. The virus exists in several strains that cause a variety of symptoms. Its common symptom is light to dark green mottling on the leaves (Fig. 301, often accompanied by wilting of young leaves on sunny days when plants first become infected. The leaflets of affected leaves are usually distorted, puckered, and smaller than normal. The plant is reduced in size and becomes pale green and spindly Occasionally, brown markings and blotches occur on green and ripe fruit of greenhouse cultivars that have incomplete resistance to tomato mosaic virus. These blemishes (Fig. 311 are often circular, up to 3 cm in diameter, and confined to the skin. Usually, fruit in only one or two trusses is affected, but if it occurs in young plants, yield is severely reduced and the whole plant is stunted and deformed. In winter, with low light intensity, short days, and temperatures below 20°C, plants are often severely stunted, and the leaflets are distorted to a femleaf, or tendril, shape.

Disease symptoms are greatly influenced by temperature, day length, light intensity, age of plant, virus strain, and cultivar of tomato. Various strains of tomato mosaic virus cause winter necrosis, summer necrosis, or crusty-fruit diseases, all of which are rare in Canada.

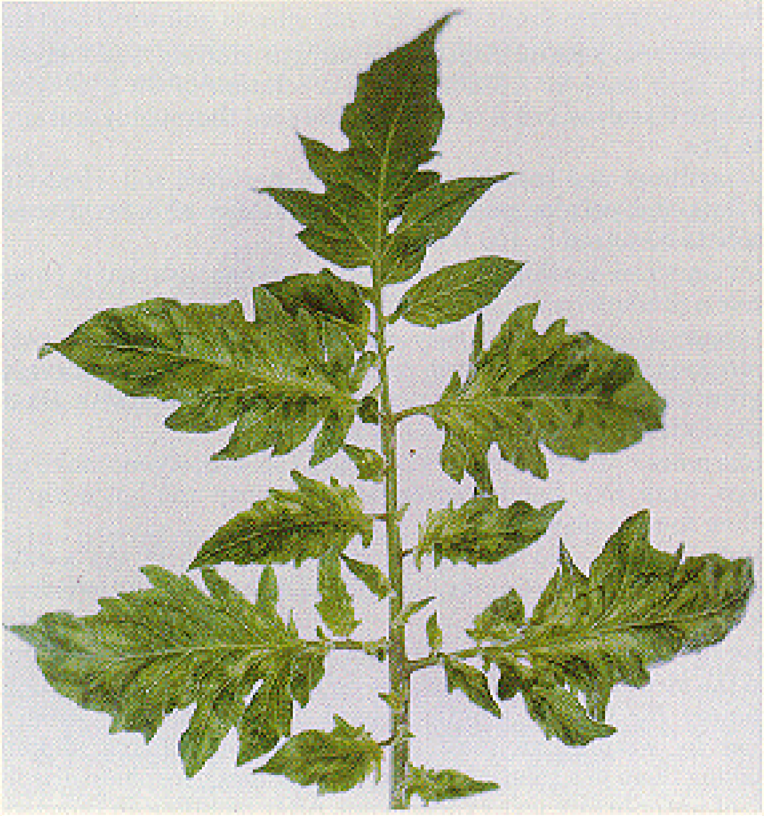


Fig. 30 Tomato leaf showing the green mottle caused by tomato mosaic virus.

Fig. 31 Blemishes caused by a single-streak strain of tomato mosaic virus.

Control

- Select seed from healthy plants; as an extra precaution, 1 or 2 days before sowing, soak seed for 15 minutes in a solution of 90 g of trisodium phosphate dissolved in 1 L of water. Rinse seed thoroughly and spread it out to dry.
- Grow seedlings and transplants in steam-sterilized soil. Heat-sterilize used flats and pots or wash them in a solution of 3 kg of trisodium phosphate dissolved in 100 L of water.
- Do not start new seedlings in a section of a greenhouse that is being used to grow a production crop of tomatoes.
- The tomato mosaic virus may spread to tomatoes from petunias, snapdragons, peppers, tobacco, and certain other plants; therefore do not grow tomato seedlings and transplants near such plants. Do not fill up space with hanging baskets of ornamentals.
- Tomato mosaic virus sometimes occurs in tobacco; if you smoke or chew tobacco, wash your hands thoroughly with soap and hot water before handling tomato plants.
- Carefully remove and destroy all infected plants in the seedbed or transplant beds. Do not transplant plants infected with tomato mosaic virus.
- Rotate field tomatoes with crops other than tobacco and potatoes.
- Since the virus can remain infective on clothing, equipment, tools, and machinery for several months, guard against infection from these sources by washing all tools and then heat-sterilizing, dipping, or rewashing them in a solution of 3 kg of trisodium phosphate dissolved in 100 L of water before using them again. After handling an infected crop, change to freshly laundered clothing before working in a mosaic-free crop. Do not use sacking to brush granular herbicides from field plants.
- In some pink-fruited greenhouse cultivars, resistance to tomato mosaic virus can be overcome; therefore do not expose the young plants to infection or allow the temperature to rise above 30°C.
- Apply a fertilizer that is high in nitrogen and phosphorus as soon as plants show symptoms of mosaic infection.

Internal browning

Internal browning (tomato mosaic virus) is a disease of tomato fruit that causes serious losses annually in field crops in Ontario and in greenhouse crops across Canada. The disease is caused by a late infection by the tomato mosaic virus, which usually severely affects the fruit on one or two clusters without affecting other fruit at all.

The characteristic symptoms of internal browning are noticeable when the fruit is cut across near the stem end. In slightly diseased fruit only a few small brown areas may occur External symptoms are gray or grayish brown areas that often show through the translucent skin of the green or partly ripe fruit. These appear occasionally as blotchy, ill-defined areas (Fig. 32). In severely diseased green or ripe fruit much of the flesh tissue of the wall is brown (Fig. 331.

Internal browning usually develops as a shock symptom when plants become infected at a certain stage in their development; the symptoms are often confused with those of blotchy ripening.

Control

Use the control measures recommended for tomato mosaic virus.

Aucuba mosaic, or yellow mosaic

Aucuba mosaic (tomato mosaic virus, yellow strain) is similar in many respects to common tomato mosaic but differs from it in that the mottling is brilliant yellow to yellow green.

Control

Follow the control measures given for tomato mosaic virus.

Streak

Streak is caused by a strain of tomato mosaic virus whose symptoms are longitudinal brown streaks on the stem and leafstalks, and blemishes on the fruit. This is single-virus streak. A more severe disease, double-virus streak, is the result of combined infection by tomato mosaic virus and potato virus X. It occurs in greenhouse and field crops and is usually found where tomatoes are grown close to potatoes. In the greenhouse this double virus disease may occur when workers handle potatoes before handling the tomato crop. It is also encountered when unsterilized soil containing potato debris is brought into the greenhouse to renew the soil or when a new greenhouse is constructed on a site where potatoes were grown earlier in the year

On the fruit of certain greenhouse cultivars, symptoms caused by tomato mosaic virus (Fig. 31) are sometimes confused with those caused by streak. Symptoms caused by tomato mosaic virus, however, seldom include black streaks of dead tissue on the stem.

Streak is characterized by a sudden wilting and dying of the tips of the youngest shoots and a cessation of plant growth. Dark brown to black elongated streaks of dead tissue appear along the stems and leafstalks (Fig. 34), which give the disease its name. On the leaf blades and fruit, the areas of dead tissue (Fig. 35) are often irregularly shaped.

Greenhouse crops infected with streak set few fruits and often fail to show much recovery. Field crops infected with streak in midsummer pass through an acute stage of infection in which they suffer markedly, but eventually they recover and may produce a low yield.

The severity of symptoms depends on the strains of viruses, the vigor of plant growth at time of infection, and the cultivar affected. Air temperatures above 27°C reduce the severity of the disease and hasten recovery

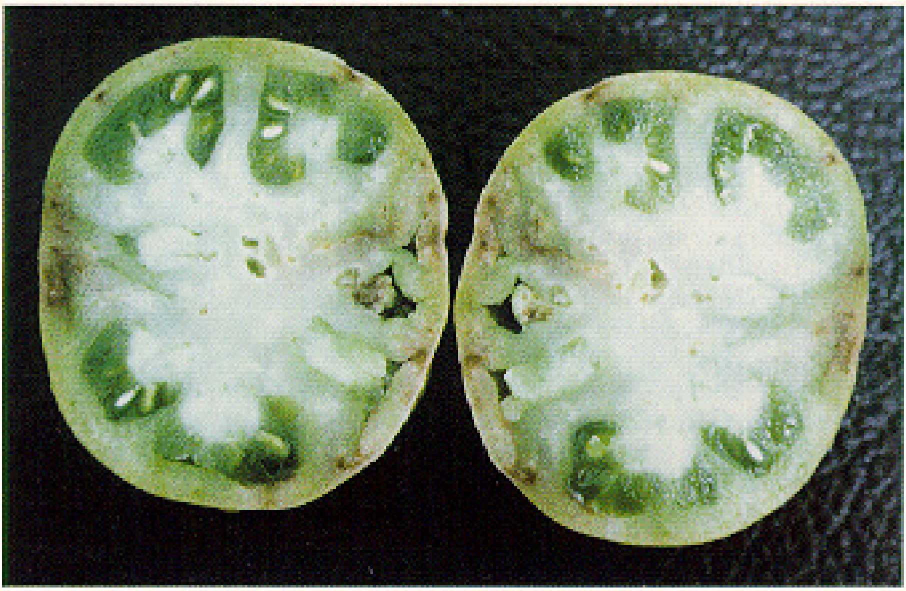


Fig. 32 Tomato mosaic virus can cause pale, depressed areas on the fruit wall.

Fig. 33 The single-streak strain of tomato mosaic virus can cause brown discoloration in the fruit wall.

Fig. 34 Dark brown to black elongated streaks on the stem and leafstalks are symptoms of double streak caused by a combination of tomato mosaic virus and potato virus X.

Fig. 35 Dark brown to black areas of dying tissue on tomato fruit are symptomatic of double streak.

Control

Follow the control measures given for tomato mosaic virus and guard against additional infection by potato virus X. If only a few greenhouse plants show symptoms of streak, remove them at once to prevent further spread, and take the recommended sanitary measures. However, if the disease is well distributed throughout the greenhouse, roguing will be of little value.

Potato virus X

Tomatoes may become infected with potato virus X, particularly if they are grown in soil that has produced a potato crop in the previous 4-6 months or if they are grown near potatoes. The symptoms of this virus in tomatoes are variable and depend partly on the strain of the virus. Some cultivars show a fine, indistinct green mottle in paler areas between the veins. Others show a prominent yellowing of the foliage. Small brown dead spots often accompany the mottling. Infected plants usually show little distortion of leaf tissue or stunting of the plant.

Control

After handling potatoes, always wash your hands thoroughly with soap and hot water before touching tomato plants. Tractors and cultivating equipment are less likely to carry the virus from potato to tomato crops if an interval of a few hours elapses or some other crop is cultivated before the machinery is taken into the tomato field.

Shoestring, or fernleaf

Shoestring, caused by the cucumber mosaic virus, is characterized by narrow, spindly leaves and mottling symptoms similar to those produced in winter by some strains of tomato mosaic virus. The first symptoms are often a corkscrew twisting of the young leaves around the terminal bud and yellowing of the other leaves, especially along the vines. Some strains of the virus cause such a pronounced elongation of the leafblade that a shoestring leaf is produced (Fig. 36). The cucumber mosaic shoestring symptom is often mistaken for a fernleaf symptom of tomato mosaic virus. However, the blade of a fernleafleaflet is not as narrow as that of a shoestring leaflet. Tomatoes affected by shoestring become stunted and unproductive.

Control

- Control weeds growing near seedbeds, fields, and greenhouses that harbor this virus. Such weed hosts are catnip, ground-cherry, jimsonweed, mallow, milkweed, nightshade, pokeweed, wild lettuce, motherwort, and a few others. The virus is transmitted from these hosts to tomatoes either by direct contact or by aphids.

- Control aphids.
- Remove infected plants and burn or bury them as soon as they appear in greenhouse crops.

Although cucumber mosaic is less readily spread by handling than tomato mosaic, infected greenhouse crops are often a means of disease transmittal.

Tomato spotted wilt

Spotted wilt, caused by the tomato spotted wilt virus, is becoming **common** in Canada. It is a highly contagious disease that can be spread easily during crop handling. The outstanding symptom is bronzing of young leaves, followed by one-sided distortion, severe stunting, and near-cessation of growth. Bronzing sometimes forms isolated spots or may cover most or all of the leaf surface. The intensity of the bronzing varies from an inconspicuous green-brown glaze, to a distinct dark brown, to an almost black glazed area. Bronzed areas usually roll inward, and tissue in affected areas dies. Depending on age and **cultivar,** other symptoms may include ring spots, black necrotic veins, black or brown stem cankers, wilting, and distorted flowers. Depending on the cultivar, slight to conspicuous brown to black spots 1 cm in diameter or larger form on the fruit, sometimes with concentric bands (Fig. 37). The fruit is often tinkled and pitted.

Tomato spotted wilt virus is transmitted by the onion thrips or the western flower thrips, a newcomer to Canada in the mid 1980s. Although the virus is also spread by mechanical means, it is not serious unless thrips are present.

Western flower thrips are the predominant vector. They feed in flower and **leaf buds** and may infect the buds before they open. Only l-2 mm long, thrips are best sought in flowers or on yellow sticky insect traps.

Control

- Monitor for thrips constantly, and control them.
- Never allow ornamental perennials and hanging baskets in seedling- or tomato-producing greenhouses. Tomato spotted wilt virus has over 200 hosts among ornamentals, including petunias, many other bedding plants, cyclamens, and chrysanthemums, as well as grapevines and many weeds.
- Control weeds rigorously outside the greenhouse.
- Discard any suspect batches of seedlings.

Fig. 36 Tomato leaves showing shoestring symptoms caused by cucumber mosaic virus.

Fig. 37 Tomato fruit showing concentric circular markings caused by spotted wilt virus.

Root knot

Root knot is caused by ***Meloidogyne incognita*** and ***M. hapla*,** nematodes that live in the soil and feed on the roots of such plants as tomatoes and cucumbers. Because root-knot nematodes are killed when soil freezes, this disease is generally of minor importance in the field in most parts of Canada. However, heavy losses may occur in greenhouses, where the nematodes can survive at depths of 2 m.

The disease is readily identified by the distinctive swellings, or galls, formed on the roots (Fig. 38). Aboveground symptoms are pale to yellowish foliage, unthrifty growth, and progressive dying of the oldest leaves.

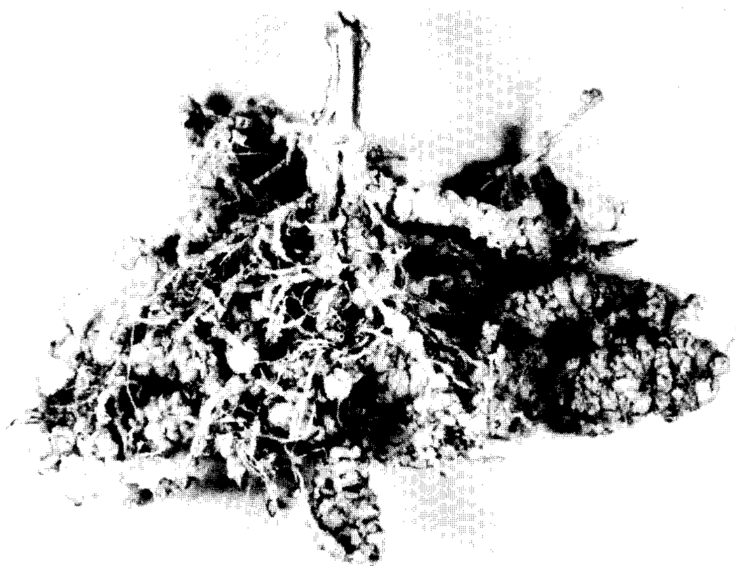


Fig. 38 Swellings or galls on tomato root caused by the root-knot nematode.

Environmental diseases and disorders

Blossom-end rot

Blossom-end rot is associated with environmental conditions and is not caused by a pathogen. It is confined to the blossom end of the fruit and appears as a brownish sunken dead area (Fig. 391. The rot is usually dry and firm. Occasionally, secondary organisms invade this tissue and produce a soft rot. Internal blackening, or blackheart, can also occur and may be present without the characteristic external symptoms (Fig. 40).

In the field the disease usually follows drought or widely fluctuating conditions of moisture. Excessive moisture preceding the drought encourages the disease. First-formed fruit is more often affected than later fruit.

A deficiency of calcium in the affected tissue is a fundamental cause of blossom-end rot. Rapid growth, often associated with this disease, requires an immediate and abundant supply of calcium, but calcium is slow to move through the plant if the water supply is erratic. Nutrient balance in the soil is also important; the plant is predisposed to blossom-end rot by a relatively high potassium-to-calcium ratio, as well as by high levels of magnesium and nitrogen.

Control

- Make sure that soils contain an adequate supply of calcium. In greenhouse soils a minimum calcium level of 150 parts per million is recommended. Blossom-end rot can sometimes be reduced in a growing crop by applying calcium nitrate to the soils; however, this form of fertilizer can be used only if plants also require nitrogen.
- Apply fertilizers containing ammonium salts and high potassium content sparingly.
- Water regularly, not in alternating periods of drought and flood.
- On field soils known to be deficient in calcium, use lime and avoid excessive applications of commercial fertilizers that contain more soluble salts.
- In the field, spray with calcium chloride dissolved in water at 5 kg/100 L per hectare when the first fruits are about the size of golf balls. The number of applications depends on the level of calcium in the soil and its balance with other elements; therefore, a general spray schedule cannot be recommended. More than three or four applications may cause marginal leaf burn.
- Avoid blossom-end rot in irrigated fields by applying water regularly but not to excess. In both field and greenhouse soils, a soil test done before cropping will indicate the need for additional lime.

Blotchy ripening

Tomato mosaic virus is one proven cause of uneven ripening, although the problem of blotchy ripening (Fig. 41) is not well understood. In some cultivars an association between blotchy ripening and low potassium levels has been established. Low boron levels in plants may predispose fruits to blotch. Temperature and light also appear to be contributing factors. In Ontario during June, July, and August, when greenhouse temperatures are high, the incidence of the disorder increases. The more hours of sunshine there are, the less is the reported incidence of blotchy ripening.

In greenhouse crops, blotchy ripening is more prevalent on red-skinned cultivars, but appreciable differences may occur in susceptibility among red-skinned cultivars, both in the greenhouse and in the field.

Control

Because this disorder is not completely understood, no definite control measures can be assigned. However, it is wise to avoid sudden temperature changes in greenhouses and to maintain adequate levels of potassium and boron in soils. Be advised by soil and tissue tests. Some cultivars are more susceptible to blotchy ripening than others. Consult your provincial agricultural adviser.

Walnut wilt

If tomatoes are planted within **10–15** m **of walnut** trees or in soil from which walnut trees have been removed in recent years, the tomatoes may wilt and die. Walnut wilt is caused by **juglone,** a toxin that is secreted from the roots of the trees into the soil. This toxin remains in root debris in the soil for several years after trees have been removed.

Control

Do not set tomato plants near walnut trees or on land from which such trees have been removed within the previous 3 years.

Sunscald

Sunscald may occur in field crops whenever green or ripening tomatoes are exposed excessively to the hot sun. This injury is common on plants that have suffered from a premature loss of their foliage caused by diseases such as septoria leaf spot, early blight, late blight, or verticillium wilt.

At first a yellowish white patch appears on the side of the fruit facing the sun (Fig. **42).** As the fruit ripens, a blister-like area develops. Later this area forms a large, slightly depressed grayish white blemish with a dry papery surface.

Control

Protect the plants from foliage diseases and grow verticillium-resistant cultivars. Do not apply defoliants prematurely to hasten ripening.

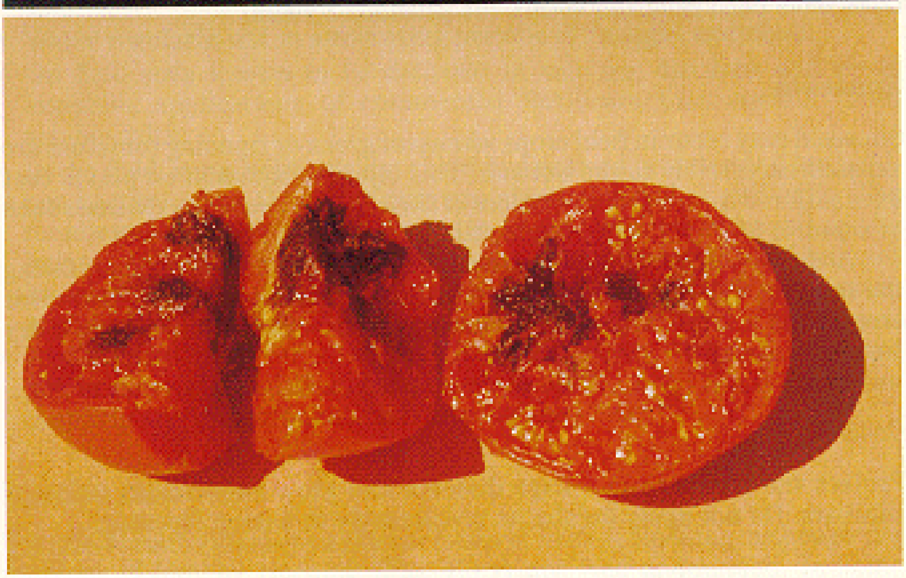


Fig. 39 Tomato fruit affected by blossom-end rot, a symptom of local calcium deficiency.

Fig. 40 Internal blackening, or blackheart, another symptom of local calcium deficiency.

Fig. 41 **Blotchy ripening.**

Fig. 42 **Sunscald injury.**

Catface

The condition known as **catface** (Fig. **43)** occurs most often on the first-formed fruit. It is sometimes found in greenhouses but occurs more often in fields. The condition is caused by abnormal development of the pistil of the flower. Serious disturbances to growth during blossoming, such as prolonged cool weather, are believed to cause the **catface** symptoms.

Fruit affected by this abnormality becomes misshapen and has irregular protuberances at the blossom end. Streaks and bands of scaly, dark greenish to tan scar tissue often occur between the swellings. Affected fruit is unmarketable.

Control

In greenhouse crops maintain temperatures above 16°C.

Leaf roll

Leaf roll is a common but temporary physiological disorder of many field crops. The edges of the leaves roll upward and inward, and in severe cases they even overlap (Fig. 441. The rolled leaves remain firm. Sometimes most of the foliage on the plant shows the condition but growth is not checked, and after a few days the plant resumes its normal leaf appearance.

Leaf roll is believed to be caused by irregular water supply Severe pruning may also cause leaf roll.

2.4-D injury

The herbicide 2,4-D **(2,4-dichlorophenoxyacetic** acid) is effective for **controlling** many broad-leaved weeds in corn, cereals, pastures, lawns, and waste areas. Tomato plants are susceptible to 2,4-D injury at any stage of their growth (Fig. **45)**. The first symptom is a downward curvature of the leaves and tips of the growing points. Even minute amounts of 2,4-D drift may cause noticeable distortion of growth. In more severe cases, stems become thick, stiff, and brittle, showing a whitening of the external surface accompanied by a severe curvature and twisting of the leaves. New leaves do not expand fully and are elongated, with abnormally pointed tips. The veins become prominent and light green, and appear parallel. Portions of the tissue between the veins often appear as darker green islands. Mid-leaf symptoms are often mistaken for those caused by tomato mosaic virus. Fruit that develops on the affected plants becomes slightly pointed at the blossom end and often shows a malformation similar to **catface.** Few seeds form in fruit thus affected. Occasionally, the inner parts of the fruit remain green when externally the fruit appears to be ripe. Ripe fruit is harder than usual to remove from the affected plants.

In the greenhouse 2,4-D injury and injury from other herbicides usually occur in the vicinity of ventilators, where spray has drifted in.

Fig. 43 Catface.

Fig. 44 Tomato leaves showing pronounced leaf roll.

Control

- Use the amine form of 2,4-D and apply at a low pressure with a coarse spray to minimize drifting.
- Do not spray if the wind can drift the spray toward tomatoes or other sensitive crops.
- Do not spray when the wind speed exceeds 10 km/h.
- Do not use a sprayer for any other pesticide if it has been used for herbicides: 2,4-D is impossible to wash out.
- Do not store herbicides in or near the greenhouse.

Lightning injury

In many parts of central Canada lightning injures field tomatoes and other crops almost every year The damage generally occurs in a fairly circular area, from 3 to 20 m in diameter. The plants in the centre are usually killed, whereas those toward the margin of the area suffer less damage. The stems and leafstalks shrivel and die. In many plants in the affected area the stem becomes flat, and the pith is laddered in appearance when the stem is split open (Fig. 461.

Puffiness

Puffiness, or pockets, is a nonparasitic disease of tomato fruit of greenhouse crops most often encountered during the late fall. Affected fruit is usually somewhat triangular and pointed toward the blossom end. When the fruit is squeezed gently, the walls are noticeably flexible. When affected fruit is cut in cross section, a cavity is found between the wall and the pulp. Affected fruit is unmarketable. The condition is thought to be caused by an improper nitrogen balance in the plant.

Control

Results of soil and tissue tests may indicate changes in the use of fertilizer that can remedy the condition.

Growth cracks

Fruit shows growth cracks wherever tomatoes are grown, making the fruit unmarketable and susceptible to secondary soft rot organisms. Cracking occurs after sudden changes in soil moisture and is commonest after heavy rains that follow a dry spell.

Control

- Consult your provincial agricultural adviser for the names of cultivars that are resistant to cracking.

Fig. 45 Tomato plants showing leaf distortion caused by 2,4-D injury.

Fig. 46 Lightning injury in the pith of the stem.

- Ventilate greenhouse crops with fans to prevent excessively high temperatures; maintain uniform watering practices.

Hail injury

Light hail injury on tomato fruit is sometimes difficult to identify, particularly when the injury occurs on small green fruit. Hailstones may cause depressed areas of variable sizes and outlines. When the skin is unbroken, the affected spot is a lighter green than the surrounding tissue. If the skin is broken, the surface of the spot becomes grayish white and paper-like (Fig. 47). A few days after the injury has occurred, the affected area is often sharply delimited from the surrounding healthy tissue by a greenish to tan halo.

Sand abrasion

Where field tomatoes are grown on light sandy soils, high winds often blow sand in exposed areas when the plants are small. Stems and fruit on the windward side may be injured by the force of the drifting sand. After 2 or 3 days the injury shows as superficial, light tan-colored roughened areas. If injury is severe, dead areas develop along the stems and on the fruit (Fig. 481, and distorted growth results. Affected fruit becomes misshapen and is unmarketable. Even small wounds open the tissue to other disease organisms.

Control

Establish hedgerows or a few rows of wheat or corn in exposed areas to break the sweep of the wind.

Boron deficiency

Most soils in British Columbia and some soils in other parts of Canada are deficient in boron. An insufficient supply of this element causes tomato fruit to become misshapen and to form **scabby** or **corky** patches on the surface of the skin.

Control

Apply a boron compound, preferably in the autumn, at the rates indicated on the label. One application is usually enough for 3 years. Do not apply boron to soil where cucumbers or beans are likely to be grown within 2 years of the application. Ask your provincial agricultural adviser to test the soil.

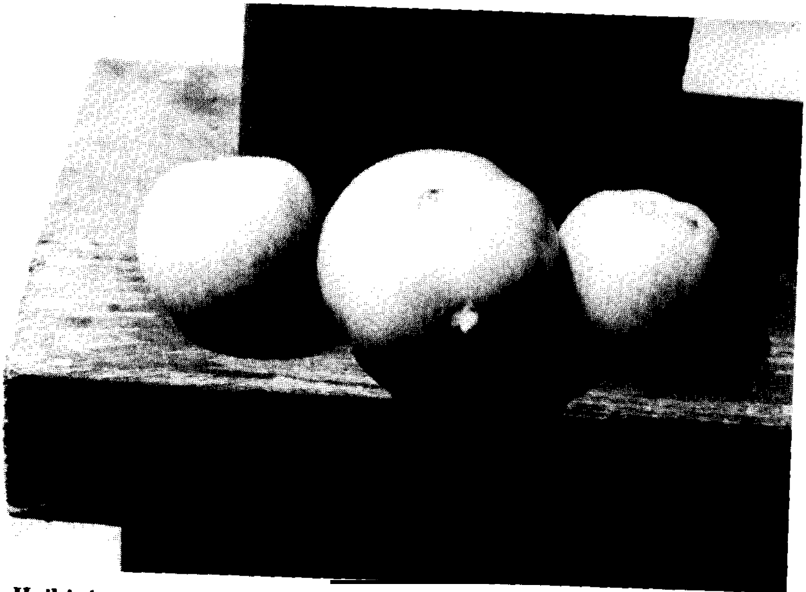


Fig. 47 Hail injury.

Fig. 48 Sand abrasion on fruit.

Fig. 49 Symptoms of magnesium deficiency.

Fig. 50 Symptoms of iron deficiency with marked manganese toxicity.

Magnesium deficiency

Magnesium deficiency is fairly common in greenhouse tomatoes and in some outdoor areas. The leaves tend to become rather brittle. The veins remain dark green and somewhat bluish, with a thin dark green leaf margin, but the interveinal areas turn yellow and finally brown (Fig. 49). The greater the distance from the vein, the greater the discoloration. The symptoms are more severe in older leaves. Stems and fruit have no obvious symptoms, but because of reduction in green leaf area, yield may be reduced and secondary organisms such as ***Botrytis cinerea*** may become established on the dead leaf tissue.

Control

- Use magnesium limestone where lime is called for in the fertilizer program.
- Spray the plants three times at 3-week intervals with a solution of 5 kg of Epsom salts (magnesium sulfate) in 1000 L of water to which a proprietary wetter has been added.
- Add 1 kg of Epsom salts per 100 m^2 to the fertilizer schedule at 2- to 3-week intervals or as recommended by your provincial agricultural adviser.
- Avoid an over-supply of potash, which impedes the supply of magnesium to the plant.

Iron deficiency

Iron deficiency is recognized by the pale yellow (almost sulfur-yellow) color of the topmost leaves, with interveinal mottling close to the midrib of the leaflets near the base of the compound leaf (Fig. 50). Symptoms of iron deficiency can also appear in seedlings with poor root aeration, as when their roots are waterlogged. In hydroponic systems, iron deficiency is often compounded by excessive amounts of heavy metals such as calcium, manganese, and zinc, which restrict iron translocation from the roots to the shoot tip. Symptoms of iron deficiency are sometimes accompanied by symptoms of manganese toxicity

Control

A balance of elements is essential to healthy growth. If in doubt, conduct a soil and tissue test. Apply iron chelates to the soil to correct iron deficiency at about 5-10 g/m^2 or spray only the tops of the plants with iron chelate at a rate of about 0.2 g/L of water. After the tests keep track of the correct rate, and be especially cautious with hydroponic systems.

Index of diseases and disorders