A PRACTICAL GUIDE TO IDENTIFICATION AND CONTROL OF TOMATO DISEASES

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KEY ASPECTS COVERED

- Disease Diagnosis and Identification
- Cultural aspects of disease control
- Biological aspects of disease control
- Chemical aspects of disease control
A PRACTICAL GUIDE TO IDENTIFICATION AND CONTROL OF TOMATO DISEASES

PURPOSE OF THIS GUIDE
This guide outlines the key issues that should be considered in relation to the Diagnosis and Identification of Tomato diseases and also Integrated Disease Management (IDM) for tomato crop. The guide addresses the key control methods and their rating in an IDM system for the major disease from Fungi, Bacteria, virus, and nematode, and it also covers non-infectious diseases.

The guide is useful for research scientists, field assistants, marketing personnel and farmers.

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A PRACTICAL GUIDE TO IDENTIFICATION AND CONTROL OF TOMATO DISEASES

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Plant Disease Diagnosis

The diagnostician must have very good observation skills, and he or she also needs to be a good detective. It is important to keep an open mind until all of the facts related to the problem can be collected. The possibility of multiple causal factors must also be considered. Control measures depend on proper identification of diseases and of the causal agents. Therefore, diagnosis is one of the most important aspects of a plant pathologist’s training. Without proper identification of the disease and the disease-causing agent, disease control measures can be a waste of time and money and can lead to further plant losses. Proper disease diagnosis is therefore vital.

Often, plant pathologists have to rely on symptoms for the identification of a disease problem. Because similar symptoms can be produced in response to different causal agents, the use of symptoms alone is often an inadequate method for disease identification. The identification of the disease-causing agent may take a week or more. One needs to ask many questions related, in order to eliminate or identify possible causes of the problem. He also needs to consider various environmental and cultural factors. As a result of his questions and observations he may:

- Be able to identify a disease and disease-causing agent,
- Be able to narrow the problem down to several possibilities which will require further study in the laboratory before he can make a final diagnosis, or
- Be completely baffled by the problem.

This article presents the various steps/activities which are associated with accurate plant disease diagnosis. The process may vary with different diseases and conditions but the overall process is relatively consistent. The steps all require careful observations and questions. The steps include:

Know what Normal is

Proper plant identification. Identification of affected plants is one of the first steps in diagnosing a plant disease. Both scientific and common names of the plant should be noted.

Recognize healthy plant appearance. It is important to know the normal appearance of the plant species you are investigating. Each plant species has special growth habits, colours and growth rates. If you do not know what to expect of the plant you cannot recognize when something is wrong.

Check for Symptoms and Signs

Identify characteristic symptoms. Describing the characteristic symptoms exhibited by a specimen can be very difficult to do accurately. Because of this, it is often difficult, if not impossible, to determine what is wrong with a plant when a person is describing symptoms over the phone.

- Underdevelopment of tissues or organs. Examples include such symptoms as stunting of plants, shortened internodes, and inadequate development of roots, malformation of leaves, inadequate production of chlorophyll and other pigments, and failure of fruits and flowers to develop.
- Overdevelopment of tissues or organs. Examples include: galls on roots, stems, or leaves, witches' brooms, and profuse flowering.
- Necrosis or death of plant parts. These may be some of the most noticeable symptoms, especially when they affect the entire plant, such as wilts or diebacks. Other examples include shoot or leaf blights, leaf spots, and fruit rots.
- Alteration of normal appearance. Examples include mosaic patterns of light and dark green on leaves, and altered coloration in leaves and flowers.

Identify symptom variability. Variations in symptoms expressed by diseased plants may lead to an improper diagnosis. These variations can result from a couple of factors. It is possible that there is more than one problem present, and in some cases there may be more than one pathogen infecting a plant. Symptoms associated with these infected plants may be significantly different from the symptoms expressed in response to each of the different pathogens acting separately.

Look for signs of biotic causal agents. Signs of plant disease agents are the observable evidence of the actual disease-causing agent. Signs may include the mycelia of a fungal agent, fungal spores, and spore-producing bodies. Indications of insects causing problems may include the actual insect, insect frass, mite webbing, and insect eggs. Signs are much more specific to disease-causing agents than are symptoms and are extremely useful in the diagnosis of a disease and identification of the agent causing the disease. The use of a hand lens and a knife can be valuable for a diagnostician in the field.
Identify Plant Part Affected - Are symptoms associated with specific plant parts?

It is important to note if the symptoms observed are associated with specific plant parts. For example, is a wilt observed correlated with a disruption of the vascular system which may be indicated by browning of the vascular system or are the roots of the plants abnormal including rots, decreased feeder roots, etc.; are necrotic lesions observed strictly on younger leaves? The symptoms of some diseases are most commonly seen on specific plant parts and this observation can be important in diagnosis.

Check distribution of symptoms. One of the first things that a diagnostician should note is how the diseased plants are distributed over the affected area. Are they distributed uniformly across an area or are they localized? Is there a definite pattern to the distribution? For example, does it occur only along the edges of a greenhouse near open windows, next to roadways or driveways, in low spots of a field, along a planted row, or is it affecting plants at random in a field? This distribution can be especially important in looking at the possibility of non-infectious problems, such as improper herbicide use or various soil factors. A uniform pattern on an individual plant and uniform damage patterns over a large area are generally not associated with biotic agents, but are usually due to abiotic agents.

Check for host specificity. Is the problem occurring in only one plant species or are different plant species affected? If different plant species are affected, this suggests the possibility of a non-infectious problem which could be related to cultural or environmental problems. However, Phytophthora and Pythium root rots can cause problems on many different plant species; therefore, the fact that more than one plant species is affected does not completely eliminate infectious agents. If there is more than one species of plant involved, are these plants closely related and can they be infected by a common pathogen?

Laboratory Tests

Sometimes neither symptoms nor signs provide enough specific or characteristic information to decide the cause of an infectious plant disease. In such cases, it may be necessary to bring a sample back to the laboratory for further tests to isolate and identify the causal agent.

Incubation of plant material. One of the first steps when getting back to the laboratory may be to place a sample of the diseased tissue under conditions that will allow an infectious agent to grow and possibly induce sporulation. This can be accomplished by placing a leaf in a moist chamber. A moist chamber can be a sterile petri dish containing a wet filter paper in the bottom of the dish and a triangle of glass tubing on which the sample is placed so that the sample is not directly on the wet filter paper but is exposed to humid conditions. This type of moist chamber will work for small and relatively flat specimens such as leaves. Plastic bags or boxes may be necessary for larger specimens. Saprophytes that are present on the specimen can also be encouraged to grow on a moist chamber and a brief surface swab with 70% isopropanol or 0.1-1% sodium hypochlorite may be useful in reducing these saprophytes. Moist chambers are generally incubated at room temperature.

Isolation and identification of biotic plant disease causal agents. Isolation of fungi usually requires that pieces of infected plant tissue be placed on various nutrient media. The organism that grows out of this tissue is then isolated in pure culture. Bacteria are often isolated by chopping up infected tissue in a small amount of sterile water. This water: bacteria suspension is then streaked onto a bacteriological medium such as nutrient agar. Several problems can occur when trying to isolate the plant pathogenic agent. The infected plant tissue may contain one or more saprophytes which have moved into the infected tissue. These saprophytes may outgrow the plant pathogenic agent on the nutrient medium, obstructing accurate identification of the pathogen. In some cases where a specific plant pathogen is suspected, a medium selective for the suspected pathogen may be utilized. It is also beneficial to attempt to isolate the plant pathogen from the margins of the diseased tissue where the pathogen is more numerous or more active than saprophytes that quickly colonize the recently killed tissue.

Diagnostic tests for identification of biotic causal agents. A major problem in identification of biotic causal agents is the inability of some infectious pathogens to grow on artificial media. Viruses, as well as some fungi (e.g. powdery and downy mildew causing agents) and some prokaryotes (e.g. phytoplasmas), require a living host in order to grow. In cases where the plant pathogen is difficult or impossible to grow on artificial media, other methods may be used for their detection, such as the use of serological tests for viruses. Viral identification is often accomplished utilizing ELISA (enzyme-linked immunosorbent assay) which is based on the binding of an antibody produced to a specific virus with the virus in the infected plant material. More tests are currently being developed using the polymerase chain reaction (PCR) for detection of specific organisms. These types of reactions take specialized equipment and reagents, and the tests are not commonly done outside diagnostic and research laboratories. Other techniques used for the identification of viruses include negative staining and electron microscopy to view the viral particles in plant tissue or suspensions.
Plant Disease Management

The goal of plant disease management is to reduce the economic and aesthetic damage caused by plant diseases. Specific management programs for specific diseases are not intended since these will often vary depending on circumstances of the crop, its location, disease severity, regulations and other factors. Plant disease management practices rely on anticipating occurrence of disease and attacking vulnerable points in the disease cycle (i.e., weak links in the infection chain). Therefore, correct diagnosis of a disease is necessary to identify the pathogen, which is the real target of any disease management program.

The many strategies, tactics and techniques used in disease management can be grouped under one or more very broad principles of action. Included four general disease control principles, exclusion, eradication, protection and immunization (the latter principle is more appropriately called resistance since plants do not have an immune system).

EXCLUSION
This principle is defined as any measure that prevents the introduction of a disease-causing agent (pathogen) into a region, farm, or planting. The basic strategy assumes that most pathogens can travel only short distances without the aid of some other agent such as humans or other vector, and that natural barriers like oceans, deserts, and mountains create obstacles to their natural spread.

ERADICATION
This principle aims at eliminating a pathogen after it is introduced into an area but before it has become well established or widely spread. It can be applied to individual plants, seed lots, fields or regions but generally is not effective over large geographic areas.

PROTECTION
This principle depends on establishing a barrier between the pathogen and the host plant or the susceptible part of the host plant. It is usually thought of as a chemical barrier, e.g., a fungicide, bactericide or nematicide, but it can also be a physical, spatial, or temporal barrier. The specific strategies employed assume that pathogens are present and that infection will occur without the intervention of protective measures.

Many cultural practices can be modified to manage the occurrence, intensity or severity of plant diseases. These include selection of suitable growing sites for the crop, adequate tillage to bury pathogen-infested plant residues, rotation to non susceptible crops, selecting pathogen-free planting stocks, orientation of plantings to improve exposure to sun and air currents, pruning and thinning to eliminate sources of infection and improve aeration in and around susceptible plants, water management on both plants and in soil, adequate nutrition, proper cultivation to improve root growth and avoid plant injury, and sanitation procedures to eliminate sources of inoculum.

Biological control involves the use of one living organism to control another, and this management technology has received much attention in recent times. However, the number of biological agents registered for use is relatively small, success has been limited, and application has been largely restricted to intensively managed, high value crops such as greenhouse plants.

RESISTANCE
Use of disease-resistant plants is the ideal method to manage plant diseases, if plants of satisfactory quality and adapted to the growing region with adequate levels of durable resistance are available. The use of disease-resistant plants eliminates the need for additional efforts to reduce disease losses unless other diseases are additionally present.

INTEGRATED DISEASE MANAGEMENT
Integrated Disease Management (IDM) is a concept derived from the successful Integrated Pest Management (IPM) systems developed by entomologists for insect and mite control. In most cases IDM consists of scouting with timely application of a combination of strategies and tactics. These may include site selection and preparation, utilizing resistant cultivars, altering planting practices, modifying the environment by drainage, irrigation, pruning, thinning, shading, etc., and applying pesticides, if necessary. But in addition to these traditional measures, monitoring environmental factors (temperature, moisture, soil pH, nutrients, etc., disease forecasting, and establishing economic thresholds are important to the management scheme.
Bacterial canker of tomato

Causal agent: *Clavibacter michiganensis* pv. *Michiganensis*

### Symptoms

<table>
<thead>
<tr>
<th>Conditions for disease development</th>
<th>Cultural and Biological control measures if any</th>
</tr>
</thead>
<tbody>
<tr>
<td>In systemic infections of mature plants, leaflets of the oldest leaves curl, yellow, wilt, and finally turn brown and collapse (known as firing). Sometimes, one side of a leaf is affected. Plants grow poorly and wilt. Pith of stems becomes yellow and later reddish brown, especially at the nodes, and has a mealy appearance. The pith may later become somewhat hollow. In advanced infections, cankers may or may not form at the nodes. Light and later dark streaks may develop on stems. Branches break off easily. Plants may die. In secondary infections, infection of the margins of leaves is common. Lesions are dark brown to almost black. Round to irregular spotting of leaves also occurs. Fruit may be spotted, especially near calyx. On fruit bacterial canker symptoms appear as yellow to brown spots, slightly raised, surrounded by a persistent white halo (“bird’s eye spot”).</td>
<td>Seed contamination with only a few bacterial cells, apparently below the level of detection, can result in relatively high numbers of infected transplants. Secondary spread occurs in splashing water, on contaminated equipment, during clipping, cultivation, or vine training operations, and other activities. Moderate (18-24) temp and greater than 80% RH favour disease development. Optimum moisture condition for plant growth, low light intensity and high nutrient concentration especially nitrogen also enhance disease development. Symptoms tend to be more severe in sandy soils. In fields of more mature plants, disinfesting equipment is not as critical because any spread to other plants would probably result in local, and not systemic, infections. It is cautious, however, to wash equipment that has been through a heavily infested field. Surface disinfectants include bleach solutions (0.5 to 1% sodium hypochlorite). Planting clean transplants is the most important control measure. Vigilantly monitor seed fields and implement strict quality control measures. Assay seed should for detectable levels of contamination and discard lots if the bacterium is found. It may be prudent to soak all seed for 30 minutes in a dilute solution of hydrochloric acid (the final concentration of hydrochloric acid should be 1.1% with a pH of 0.9). Alternatively, seed could be soaked in 130°F water for 25 minutes. In the greenhouse, potting mix and flats should be steamed or washed with a 1% solution of sodium hypochlorite. Empty greenhouses between crops of transplants to allow time to disinfest benches, irrigation hoses, etc. Overhead water pressure should be low to prevent wounding. Copper applications may be necessary to reduce the efficient, yet unnoticeable spread between plants. In the field, special measures may have to be taken once canker has been identified. Do not work fields when the foliage is wet. Frequent field operations at the wrong time can result in spread of the disease throughout the entire field. Unless the number of infected plants is small, it may do more harm than good to try to remove the symptomatic plants. Copper applications offer limited benefits because systemic infections cannot be affected and localized infections (the most probable scenario if other precautions are taken) pose a small economic threat. During wet weather, however, bactericides may be justified.</td>
</tr>
</tbody>
</table>
### Bacterial speck of tomato

**Causal agent:** *Pseudomonas syringae* pv. *tomato*

#### Symptoms

Bacterial speck appears as dark brown to black lesions of various sizes and shapes on leaves, fruit, and stems. Tissue adjacent to the lesions is initially yellow. Leaf lesions are frequently concentrated near margins, causing extensive marginal necrosis (tissue death). Lesions on immature fruit are slightly raised and small, varying in size from tiny flecks to 0.125 inch (3 mm) in diameter and cause raised black spots on mature fruit. Fruit lesions are superficial, seldom penetrating more than a few cells deep.

#### Conditions for disease development

The bacteria survive in soil, in debris from diseased plants, and on seeds. Infection is favoured by cool, moist weather. The pathogen is spread by splashing rain or sprinkler irrigation. Disease progress is stopped during hot weather. In severe cases, infected plants are stunted, which may result in a delay in fruit maturity and yield reduction. The disease development is favoured by cool (13-25 °C) rainy weather or sprinkler irrigation usually on day of leaf wetness is required for the disease to develop.

#### Cultural and Biological control measures if any

Delay planting in spring to avoid exposing tomatoes to cool, wet conditions that favour disease development. When the disease appears, change from overhead to furrow irrigation. Do not plant tomatoes in a field previously planted to tomatoes that developed the disease; instead rotate with a non-host crop such as small grains or corn.

#### Chemical control

<table>
<thead>
<tr>
<th>Chemical name</th>
<th>Dosage (g or ml/litre)</th>
<th>PHI</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streptomycin sulphate+ tetracycline hydrochloride (Agrimycin)</td>
<td>6g/10 litre</td>
<td>15</td>
<td>Should be used on younger stage of the crop growth, do not use during fruiting stage</td>
</tr>
<tr>
<td>Copper oxychloride (Blitox)</td>
<td>3g/litre</td>
<td>4</td>
<td>Used as soil drenching at the root zone of the plant</td>
</tr>
<tr>
<td>Copper hydroxide (kocide)</td>
<td>2g/litre</td>
<td>0</td>
<td>7-10 day interval application</td>
</tr>
<tr>
<td>Cuprous oxide (Nordox)</td>
<td>2g/litre</td>
<td>7</td>
<td>7-10 day interval</td>
</tr>
<tr>
<td>Copper sulphate (cuproxat)</td>
<td>2g/litre</td>
<td>1</td>
<td>5-10 day interval; a tank mix with mancozeb will give added control</td>
</tr>
</tbody>
</table>

Note: Copper sprays should not be continued in dry weather, especially hot, dry weather, because the sprays may cause plant injury.
**Bacterial spot of tomato**

Causal agent: Xanthomonas campestris pv. Vesicatoria

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Conditions for disease development</th>
<th>Cultural and Biological control measures if any</th>
<th>Chemical control</th>
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</thead>
<tbody>
<tr>
<td>Bacterial spot develops on seedlings and mature plants. On seedlings, infections may cause severe defoliation. On older plants, infections occur primarily on older leaves and appear as water-soaked areas. Leaf spots turn from yellow or light green to black or dark brown. Older spots are black, slightly raised, superficial and measure up to 0.3 inch (7.5 mm) in diameter. Larger leaf blotches may also occur, especially on the margins of leaves. Symptoms on immature fruit are at first slightly sunken and surrounded by a water-soaked halo, which soon disappears. Fruit spots enlarge, turn brown, and become scabby.</td>
<td>The bacterial spot bacterium persists from one season to the next in crop debris, on volunteer tomatoes, and on weed hosts such as nightshade and ground cherry. The bacterium is seed borne and can occur within the seed and on the seed surface. The pathogen is spread with the seed or on transplants. Secondary spread within a field occurs by splashing water from sprinkler irrigation or rain. Infection is favoured by high relative humidity and free moisture on the plant. Symptoms develop rapidly at temperatures of 68°F (20°C) and above. Night temperatures of 61°F (16°C) or below suppress disease development regardless of day temperatures. Some pathogen strains are virulent on either tomato or pepper and some may be virulent on both.</td>
<td>Bacterial spot occurs commonly in tomatoes throughout California. Using pathogen-free seed and disease-free transplants, when possible, is the best way to avoid bacterial spot on tomato. Avoiding sprinkler irrigation and cull piles near greenhouse or field operations, and rotating with a non-host crop also helps control the disease.</td>
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<td>6g/10 litre</td>
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### Symptoms

Mature, fruit-bearing plants are affected in mid-summer. The first symptom is wilting of a few leaves. This often goes unnoticed. Soon thereafter, the entire plant wilts suddenly and dies. Such dramatic symptoms occur when the weather is hot (86-95°F), and soil moisture is plentiful. Under less conducive conditions, wilt and decline will be slower, and numerous adventitious roots often form on the lower stems. In both cases, a brownish discoloration is present, first in the vascular system, and in advanced cases, spreading into the pith and cortex. The roots will exhibit varying degrees of decay.

### Conditions for disease development

There are a great many parasitic forms, including pathogens in most plants, animals, and also in humans root-knot nematode can cause injury to plant roots and favours penetration of the bacterium. Plant infection can also occur through stem injuries caused by cultural practices or insect damage. In some cases, plant-to-plant spread can occur when bacteria move from roots of infected plants to roots of nearby healthy plants, often via irrigation practices. Spread of bacteria by aerial means and subsequent plant contamination through foliage is not known to occur, thus making *R. solanacearum* a non-airborne pathogen. High temperatures (29-35°C) play a major role in pathogen growth and disease development. Several other factors that may affect pathogen survival in soil and water may also favours disease development, including soil type and structure, soil moisture content, organic matter in soil, water pH and salt content, and the presence of antagonist microorganisms.

### Cultural and Biological control measures if any

**Before plantation:**

Consider an effective weed control in and around tomato fields and aquatic weed control around irrigation ponds. Apply 3-4 years rotation and cover crops for infested fields to reduce *R. solanacearum*, weeds and nematodes. Do not irrigate rotation and cover crops with *R. solanacearum* contaminated pond or surface water, avoid infestation. Use well drained and levelled fields and do not use low-lying areas of the field. Raise soil pH to 7.5-7.6 and increase available calcium (liming). Consider using infested fields (after 3-4 years rotation) during cooler months for tomato production.

**During production:**

Exclude the pathogen by applying strict sanitation practices (pathogen free irrigation water, transplants, stakes, machinery, etc). Chlorinate your irrigation water continuously if you are using surface water or *R. solanacearum* infested pond water. Continue an effective weed control in and around tomato fields and irrigation ponds. Irrigate based on water need, avoid over irrigation. Apply plant resistance inducer, such as Actigard (Syngenta) if you are using moderately resistant cultivars. Actigard enhances resistance against this disease if it is used in combination with moderately resistant cultivars.
Pith necrosis of tomato
Causal agent: *Pseudomonas corrugata*

<table>
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<th>Cultural and chemical control</th>
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</thead>
<tbody>
<tr>
<td>Initial symptoms often appear just as the first fruit clusters reach the mature green stage and consist of yellowing and wilting of young leaves. Serious infections can result in chlorosis and wilting of upper portions of plants with brown to black lesions on infected stems and petioles. When stems are cut longitudinally, the centre of the stem (pith) may be extensively discoloured, hollow, and/or degraded. Stems may be swollen, numerous adventitious roots can form, and infected stems may shrink, crack, or collapse.</td>
<td>The epidemiology of this disease is not well understood; it is possible that the bacteria are seedborne and most certainly survive in the soil in association with infected tomato debris. Pith necrosis is caused by the bacterium <em>Pseudomonas corrugata</em>, which is considered a weak pathogen able to attack tomato plants that are growing too fast. It occurs primarily in greenhouses with affected plants randomly distributed. Symptoms typically develop when first fruit are close to mature green. Disease incidence and severity is favoured by high nitrogen fertilization, cool temperatures at night, high humidity, and plastic mulch. Nitrogen had been applied at a high rate in the high tunnel.</td>
<td><strong>Cultural Controls &amp; Prevention:</strong> Preventive measures to minimize the occurrence of this disease in high tunnels include: adequate ventilation to avoid high humidity levels (especially during cloudy weather), avoiding excessive nitrogen levels to prevent vigorous plant growth, incorporation of crop debris to speed decomposition of residue and associated bacteria, and crop rotation. <strong>Chemical Controls &amp; Pesticides:</strong> There is no effective treatment for this disease; however, affected plants may recover if environmental conditions improve (warm, sunny weather).</td>
</tr>
</tbody>
</table>
### Symptoms

As the tomato Alternaria canker spreads throughout each plant, the lower leaves will begin to turn yellow, and develop dark colored spots. These become progressively larger, until they cover the leaves entirely, causing them to die and drop to the ground. This fungus also causes rings to form around the stem of the plant and suffocates it, until the stem withers and collapses. The tomato fruit is affected as well, with brown cankers dotting them and making them inedible. Once the disease has spread to this point, little can be done to save the tomato plant.

### Conditions for disease development

Alternaria needs moisture to survive, and thrives in areas with humid climates, or where there has been significant rainfall. It lives in the seeds and seedlings, and is also spread by spores, as they become airborne and land on plants. Alternaria canker flourishes in dead plants that have been left in the garden during the winter. When dead debris is added to a compost pile, it can spread to other vegetables throughout the garden. It is made worse by the fact that the fungus grows so slowly that its presence will often only become apparent when seedlings become larger, and are transplanted into the garden.

### Cultural and Biological control measures if any

A good irrigation system will decrease the chance of Alternaria infecting tomato plants. Overhead irrigation systems should never be used on tomatoes though, as they cause the plants to remain wet, allowing the fungus to grow. Drip irrigation is the best system to use, as it keeps the roots wet, yet allows the rest of the plants to remain dry. Usually one irrigation tube is all that is needed for each row of tomato plants.

### Chemical control

<table>
<thead>
<tr>
<th>Chemical name</th>
<th>Dosage (g or ml/litre)</th>
<th>PHI (days)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azoxystrobin (Amistar)</td>
<td>0.5ml/litre</td>
<td>0</td>
<td>7- to 21-day interval; alternate after each use; no more than five applications, can also be used for drenching purpose for the plants which are infected early</td>
</tr>
<tr>
<td>Copper hydroxide (Kocide)</td>
<td>2g/litre</td>
<td>0</td>
<td>7- to 14-day interval; no more than four applications per crop, for drenching can be used.</td>
</tr>
<tr>
<td>Mancozeb (Dithane M-45)</td>
<td>2g/litre</td>
<td>7</td>
<td>Used as a protective application; 5-7 days interval, for drenching can be used</td>
</tr>
</tbody>
</table>

### Causal agent: Alternaria alternata f.sp. lycopersici

Note

For tank mixing of different chemicals see the label.
Symptoms: Symptoms appear on ripe fruit, often where the fruit is touching crop debris or soil. Small circular depressions appear and enlarge up to 12 mm in diameter. The centre of the lesion usually becomes tan in colour and is dotted with many dark-colored fruiting bodies of the fungus that form concentric rings in the lesion. Salmon-colored spores may appear on the surface of the lesion. At later stages, lesions may merge to affect large portions of the fruit or they may crack to allow secondary organisms to invade the fruit and cause soft rot. Green fruit may also be infected but symptoms will not appear until the fruit ripens. Such an infection is called latent.

Foliage symptoms are rare and characterized as small, circular brown lesions surrounded by yellow halos. Infection of roots is characterized by brown and decayed internal tissue with many small black dots (fungal fruiting structures) below the surface of the roots.

Conditions for disease development: The pathogens persist on alternate hosts, crop debris, and some weeds. The fungus spores are usually dispersed by splashing rain. Wetness is required for infection. The longer the period of fruit surface wetness, the greater the anthracnose severity. The optimum temperature for fruit infection is 20–24 °C with fruit wetness, although infection may occur from 10–30 °C. Fruit that are at or near the soil surface are most likely to become infected. Infection by the fungus may arise from wounds caused by windblown soil, especially where tomatoes are cultivated in light sandy soils. Overhead irrigation will foster development of anthracnose because of increased relative humidity and increased duration of leaf wetness. High anthracnose severity is frequently associated with severe early blight (Alternaria solani) development.

Cultural and Biological control measures: Rotate at least every other year with a non-solanaceous plant. Irrigate only as needed, never in excess. Remove and destroy infected fruit. In greenhouse production use pathogen-free soil, prevent root injury, and avoid closed-recirculation irrigation fertilization systems. Avoid damaging tomato roots when cultivating. Stake plants to improve air circulation and to reduce leaf and fruit wetness. Mulch to reduce soil splash onto fruit and lower leaves. Minimize or avoid overhead irrigation to reduce periods of wetness on tomato fruit. Harvest fruit promptly since anthracnose develops more readily as the fruit ages. Allow infested crop debris to decompose completely before planting again. Weed regularly.

Chemical control:

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</tr>
</thead>
<tbody>
<tr>
<td>Mancozeb+carbendazim (Dithane M-45+ Bavistin)</td>
<td>2+1g/litre</td>
<td>3</td>
<td>Used as a protectant as well as curative action</td>
</tr>
<tr>
<td>Pyraclostrobin (cabrio)</td>
<td>1g/litre</td>
<td>0</td>
<td>7-14 day interval; no more than two sequential application;</td>
</tr>
<tr>
<td>Chlorothalonil (kavach)</td>
<td>2g/litre</td>
<td>3</td>
<td>5-6 day interval as a protective application</td>
</tr>
<tr>
<td>Azoxystrobin (amistar)</td>
<td>0.5ml/litre</td>
<td>0</td>
<td>No more than two application per season, can be tank mixed with protectant fungicide</td>
</tr>
<tr>
<td>Trifloxystrobin+Tebuconazole(nativo)</td>
<td>1g/litre</td>
<td>3</td>
<td>Used as curative applicant</td>
</tr>
</tbody>
</table>

Note: For mixing chemical always see the label of the product.
Symptoms of black root rot are typical of many other root rots or root problems. Some of these symptoms may include yellowing of the plant, defoliation, stunting or wilting, as well as red brown lenticels and swelling of the crown. The fungus produces black spores in roots that when abundant cause the black lesions that are typical of black root rot. Thielaviopsis basicola can also attack seedlings, and the hypocotyl below the soil may become infected along with the roots. Infected tissue is first seen as elongated red lesions, which eventually turn black. In severe cases the entire root may appear black. Stunting of tap-root growth also occurs. Plants may develop new roots following infection, but they can only support the plant when sufficient moisture is available. If unchecked, root rot can lead to collar rot, causing wilting of leaves and tender stems.

### Symptoms

<table>
<thead>
<tr>
<th>Conditions for disease development</th>
<th>Cultural and Biological control measures if any</th>
<th>Chemical control</th>
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<td>Stress or adverse growing conditions can also increase the likelihood of disease development, and include factors such as saturated soils, salt build up, and adverse temperatures. Another environmental factor is soil pH. Maintaining a soil pH between 5 and 8.5 with a soil temperature between 55 and 70°F. Saturated soil can also increase disease, as well as increase the overall stress on the plant. The fungus can spread from infected roots to healthy roots if they come into contact. Spores can also be splashed from pot to pot when watering. Application of bio control agents like Trichoderma viridae or Trichoderma harzianum along with FYM at the time planting (1 kg mixed with 200 kg of FYM for one acre of land)</td>
<td>Chemical name</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-----------------------------------------------</td>
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</tr>
<tr>
<td>The Thielaviopsis state produces dark aleuriospores Chlamydomas are a type of resting spore and may survive in soil for many years. These spores are stimulated to germinate by compounds produced by the roots. Favourable conditions include a soil pH between 5 and 8.5 with a soil temperature between 55 and 70°F. Saturated soil can also increase disease, as well as increase the overall stress on the plant. The fungus can spread from infected roots to healthy roots if they come into contact. Spores can also be splashed from pot to pot when watering.</td>
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<td>Chemical name</td>
</tr>
<tr>
<td>A soil drench using approved fungicides may be applied as a preventative in nurseries, greenhouses, and commercial landscapes. There is no curative fungicide available.</td>
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</tr>
</tbody>
</table>

#### Black root rot of tomato

**Causal agent:** *Thielaviopsis basicola*
### Symptoms

Brown spots appear on green and ripe fruit, often at the blossom end. The spots have bands of dark and light brown rings. These spots remain firm and smooth, although internally the rotted tissue turns mushy and can cover half the fruit. Young green fruit, when infected, usually become mummified. A white cottony fungal growth appears under moist conditions. Fruit touching or near the soil are most likely to become infected. *Phytophthora* can cause a root and crown rot of tomato plants at all ages. Damping-off symptoms occur on seedlings while infections of the roots and crowns of young plants cause rapid wilt. On established plants, brown water-soaked lesions appear on roots, extending into the lower part of the stem. Severely affected roots become necrotic and decayed. The leaves become bronze and later dieback from the tip.

### Conditions for disease development

*Phytophthora* is a soil-borne pathogen that infects many solanaceous crops, including tobacco, tomato, pepper and eggplant. Once the fungus is introduced into the field it may remain indefinitely, although cold soil temperatures will kill the spores. The disease is favoured by warm, wet weather. Soil temperatures of 18–30 °C are needed for disease development, and 27 °C is ideal for fruit rot. Periods of extended rainfall or excessive irrigation will promote the disease. Root rot is more serious in compact or poorly drained soil. It is more serious in soil where excessive applications of nitrogen have occurred. The fungus may spread among harvested fruit if temperatures are 21 °C or above.

### Cultural and Biological control measures if any

Avoid poorly drained, heavy, compacted soils. Grow plants in well-drained soil on elevated beds. Use furrow irrigation instead of sprinkler irrigation. Remove diseased fruit or diseased plants from the field and destroy them. Use straw mulch to reduce soil splash. Stake tomatoes to get fruit off the soil surface. Harvest fruit as soon as possible from problem fields. Keep harvested fruit dry and cool.

### Chemical control

<table>
<thead>
<tr>
<th>Chemical name</th>
<th>Dosage (g or ml/litre)</th>
<th>PHI</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mancozeb (Dithane M-45)</td>
<td>2g/litre</td>
<td>7</td>
<td>Used as a protective application; 5-7 days interval, also can be used for drenching purpose to control root rot.</td>
</tr>
<tr>
<td>Chlorothalonil (kavach)</td>
<td>2g/litre</td>
<td>3</td>
<td>Can be used as a protective application; 5-7 days interval</td>
</tr>
<tr>
<td>Fosetyl-Al (Aliette)</td>
<td>1g/litre</td>
<td>14</td>
<td>Start sprays at 2- to 4-leaf stage or at transplanting on a 7- to 14-day schedule.</td>
</tr>
<tr>
<td>Dimethomorph (Acrobat)</td>
<td>1g/litre</td>
<td>4</td>
<td>5-7 days interval, not more than 3 application per season</td>
</tr>
<tr>
<td>Metalaxyl + mancozeb (Ridomil MZ gold)</td>
<td>2g/litre</td>
<td>14</td>
<td>Can be used as drenching purpose</td>
</tr>
<tr>
<td>Azoxystrobins (Amistar)</td>
<td>0.5ml/litre</td>
<td>0</td>
<td>Used as a curative application.</td>
</tr>
</tbody>
</table>

**Note**

For tank mixing of different chemicals see the label.

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**Buck eye fruit and root rot**

Causal agent: *Phytophthora capsici, Phytophthora nicotianae var. parasitica*
Symptoms

All stages of growth are attacked. The initial symptoms appear as small, pale yellow lesions with no definite margins on either the upper or lower leaf surface. The lesions on the lower leaf surface have a white fungal growth that turns to gray to black as the fungus sporulates. Later, black sooty fungal growth will occur on both the upper and lower leaf surfaces. This distinguishes it from leaf mold (Cladosporium fulvum) where the fungus sporulates on the lower leaf surface only and where the fungal growth is generally of a lighter brown to purple colour.

As the disease develops, the affected areas on each leaf will coalesce to form large patches. The affected leaves wilt, dry with age, and usually remain hanging on the plant with a dark soot-covered appearance.

Conditions for disease development

The presence of moisture on the foliage from dew, rainfall and fog provides good conditions for disease development. Increasing periods of leaf wetness are associated with increasing disease severity; consequently, the disease may become more serious during the rainy season when warm temperatures prevail. Its spores will not germinate if the relative humidity is less than 85%.

The fungus survives in plant debris (e.g., dried leaves for up to 18 months at 4 to 20 °C) and can produce spores in this debris at the beginning of the growing season. The fungus does not survive buried in soil for four months at high temperatures.

Cultural and Biological control measures if any

Avoid planting solanaceous crops such as pepper or eggplant for two years and control weeds (particularly black nightshade) that may serve as alternative hosts. Remove black leaf mold-affected tomato debris from the field to reduce carryover of inoculum, or incorporate the debris into the soil. The latter will promote rapid breakdown of diseased leaf tissue and exposure of the fungus to soil microorganisms that enhance its destruction.

Avoid planting new tomato plants while diseased plants remain nearby. Reduce incidence of leaf wetness by staking tomato plants, spacing plants to allow for good air movement, and avoiding overhead irrigation.

Chemical control

<table>
<thead>
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<th>Chemical name</th>
<th>Dosage(g or ml/litre)</th>
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<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorothalonil (kavach)</td>
<td>2g/litre</td>
<td>3</td>
<td>Can be used as a protective application; 5-7 days interval</td>
</tr>
<tr>
<td>Mancozeb (Dithane M-45)</td>
<td>2g/litre</td>
<td>7</td>
<td>Used as a protective application; 5-7 days interval</td>
</tr>
<tr>
<td>Copper hydroxide (kocide)</td>
<td>2g/litre</td>
<td>0</td>
<td>Used as protective application</td>
</tr>
<tr>
<td>Trifloxystrobin+ Tebuconazole (nativo)</td>
<td>1g/litre</td>
<td>3</td>
<td>Used as curative applicant</td>
</tr>
</tbody>
</table>

Note:
For mixing chemical always see the label of the product.

Cercospora leaf mold
Causal agent: Pseudocercospora fuligena
Corcky root rot of tomato
Causal agent: *Pyrenochaeta lycopersici*

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Conditions for disease development</th>
<th>Cultural and Biological control measures if any</th>
<th>Chemical control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infected roots of plants with corky root rot are distinctly corky.</td>
<td>The fungus survives for long periods as microsclerotia. Potential alternate hosts include cucurbits, peppers, safflower, and solanaceous weeds such as on nightshades. Corky root is generally a problem in early plantings under cool conditions. Disease development is optimal at 60° to 68°F (15.5° to 20°C). Corky root usually does not kill plants, but may reduce yields.</td>
<td>Plant when soils are warm in spring. Avoid consecutive crops of tomatoes. Although not extensively tested, soil solarization has been used to control corky root rot in other areas of the world. Rotate with non-host crops.</td>
<td>Metham sodium (vapam) 1000 L of 33% a.i/hac  PHI (days) - After drenching, planting should be done after 3 months</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Chloropicrin + methyl bromide  117-168 Kg/hac  PHI (days) - Injected and covered with plastic trap for 48 hrs.</td>
</tr>
</tbody>
</table>
### Symptoms

Infection usually occurs on the stem at or above the soil-line, however, all foliar parts of the plant can be affected. Dark brown, sunken lesions form at the base of the plant and eventually expand to girdle the stem, resulting in yellowing and wilting of the older leaves. As the wilting progresses the plant may eventually die. Numerous black specks (pycnidia), which are the fruiting structures of the fungus, frequently form in the darkened stem lesions. Splashing water spreads the fungal spores from the pycnidia to the fruit, leaves and stems resulting in additional infections and disease spread. Fruit infection typically occurs at the calyx end and starts as a water-soaked lesion that progresses rapidly into a sunken black lesion with concentric rings. Leaf infection begins as small spots which develop into brown lesions with concentric rings. Pycnidia may develop in the centre of these lesions with the leaf eventually taking on a shot-hole appearance, or dying.

### Conditions for disease development

The fungus can survive in the soil, in infected plant debris and seed, as well as on nightshade and other related hosts. Didymella stem rot occurs over a wide range of conditions, however, 20°C (60°F) accompanied by splashing water from rain or overhead irrigation is optimum for disease development and spread. Plants become more susceptible as they mature, and deficiency of soil nitrogen and phosphorus can contribute to disease severity.

### Cultural and Biological control measures if any

A good sanitation program including the removal of all infected plant debris and alternative hosts, as well as a three year rotation between tomato crops can reduce losses from this disease. Avoid overhead irrigation and provide adequate ventilation when growing plants in the greenhouse.

### Chemical control

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</tr>
</thead>
<tbody>
<tr>
<td>Azoxystrobin + Chlorothalonil</td>
<td>0.5ml/litre + 2g/litre</td>
<td>1</td>
<td>Make two applications, the first at the 1 to 3 leaf stage and the second just prior to vine tip over or 10-14 days after the first, whichever comes first.</td>
</tr>
<tr>
<td>Chlorothalonil (kavach)</td>
<td>2g/litre</td>
<td>0</td>
<td>Can be used as a protective application; 5-7 days interval</td>
</tr>
<tr>
<td>Copper hydroxide (kocide)</td>
<td>2g/litre</td>
<td>0</td>
<td>7-10 day interval application</td>
</tr>
<tr>
<td>Pyraclostrobin (cabrio)</td>
<td>1g/litre</td>
<td>0</td>
<td>7-14 day interval; no more than two sequential application;</td>
</tr>
<tr>
<td>Tebuconozole (Folicur)</td>
<td>1ml/litre</td>
<td>7</td>
<td>For suppression only; 10-14 day interval</td>
</tr>
</tbody>
</table>

**Note:**
For mixing chemical always see the label of the product.
The leaves, stems and fruit on the vine may be affected. Symptoms on leaves are most likely to appear on the older foliage. Small dark spots enlarge into circular lesions consisting of concentric rings. The tissue surrounding the lesions becomes yellow and the spots later become irregular in shape. The leaf becomes yellow as greater parts of the tissue are affected. Stems and petioles affected by early blight have elliptical concentric lesions, which drastically weaken the plant. Lesions at the base of emerging seedlings can cause a collar rot. If this arises simultaneously on many seedlings, it may indicate contamination of tomato seeds or soil used for planting.

The disease is favoured by warm temperatures and extended periods of leaf wetness from frequent rain, overhead irrigation, or dews. The disease cycle is about five to seven days, so numerous repeating cycles can occur during the long growing season. Plants under periods of stress are more susceptible, for example, during fruiting, under attack from Nematodes, when inadequately fertilized, or on older plants. Early blight may be more prevalent on old transplants or transplants lacking vigour or stressed by wilting.

Minimize plant injury in transplants by controlling insects and by avoiding sandy soils. Avoid extended periods of leaf wetness on plants. Trellis tomato vines and avoid dense plant populations in fields to allow for good ventilation between plants. Use furrow or drip irrigation rather than overhead irrigation. Use a three or four-year rotation with non-solanaceous crops. If possible, remove diseased plants or destroy them immediately after harvest. Alternatively, bury diseased crop debris by deep ploughing to reduce spore levels available for infection of new plants.

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<tr>
<td>Copper hydroxide (Kocide)</td>
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<td>0</td>
<td>7- to 14-day interval; no more than four applications per crop</td>
</tr>
<tr>
<td>Mancozeb (Dithane M-45)</td>
<td>2g/litre</td>
<td>7</td>
<td>Used as a protective application; 5-7 days interval</td>
</tr>
<tr>
<td>Propineb (Antracol)</td>
<td>2g/litre</td>
<td>2</td>
<td>5-7 days interval</td>
</tr>
<tr>
<td>Difenoconazole (Score)</td>
<td>0.5ml/litre</td>
<td>10</td>
<td>Used as curative fungicide: No more than 4 application per season.</td>
</tr>
<tr>
<td>Pyraclostrobin (Cabrio)</td>
<td>1g/litre</td>
<td>0</td>
<td>7- to 14-day interval; no more than 2 sequential applications;</td>
</tr>
</tbody>
</table>

Note
For tank mixing of different chemicals see the label.

---

**Early blight of tomato**

Causal agent: *Alternaria solani*
Fusarium crown and root rot of tomato

Causal agent: *Fusarium oxysporum f.sp. radicis-lycopersici*

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Conditions for disease development</th>
<th>Cultural and Biological control measures if any</th>
<th>Chemical control not recommended, so go for sanitation measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>The fungus, after initially infecting secondary roots, moves into larger roots and eventually invades the plants vascular system. Crown rot-infected plants then start to show a unilateral vein-clearing. This is followed by slow wilting and the plants become stunted and yellow, beginning with the older leaves and then spreading to the whole plant. Eventually the entire plant turns brown and dies. The stems frequently have brown vascular streaks. Other symptoms include stunted growth and wilting on sunny days, especially if plants have heavy fruit loads. Infected plants may eventually die after repeated wilting. Although a parasite of the root and the collar, the fungus causes browning of the vessels up to 30 cm above the collar. Brown longitudinal necrotic lesions form on the stem from which drops of gum exude. The plant exhales a honeysuckle smell. The roots become brown and may rot away due to colonisation by secondary pathogens.</td>
<td>The fungus invades plants through wounds and natural openings created by newly emerging roots. Long-range dissemination of the fungus can occur through infected transplants, contaminated soil, and on contaminated shoes, plant stakes, machinery, transplant trays and other equipment. The fungus survives for long periods of time in the soil. The disease is favoured by cool temperatures 50-68°F, low soil pH, ammonical nitrogen and water-logged soil.</td>
<td>Use resistant cultivars where available. Use soil fumigants if available and if economically feasible. Manipulate soil fertility in such a way to decrease the growth, sporulation, and virulence of the pathogen: add lime amendments to obtain soil pH of at least 7.0; avoid excessive use of phosphorus and magnesium soil amendments. Avoid the use of diseased transplants or infested seed. Prevent dissemination of the pathogen by eliminating movement of infested soil into disease-free areas. Application of bio control agents like Trichoderma viridae or Trichoderma harzianum along with FYM at the time planting( 1 kg mixed with 200 kg of FYM for one acre of land) Seedling root dip treatment of bio control agents like Trichoderma viridae or Trichoderma harzianum during transplanting(10g/1litre of water)</td>
<td>a. Discard slabs, bags, cubes or other media that had infected plants growing in them previously. b. Do not replant into the same material unless it has been steam-sterilized. c. Remove and discard strings that may harbour spores from affected plants. d. If the crop was grown in soil, disinfect the beds. e. Discard soilless growing media far away from the greenhouse or bury it. f. Avoid handling diseased plants and fruit. g. Remove them from the greenhouse carefully, taking care not to allow contact of affected portions of plants with adjacent plants, and place them in a plastic bag. h. Discard the diseased material at a location away from the greenhouses to ensure that this fungus inoculum or subsequent overwintering spore inoculum is not carried back into the greenhouse by workers, wind, on tires, and by insects such as shore flies and fungus gnats. If the material is disposed of in a cull pile then ensure that the cull pile is located away from the greenhouse as far as possible. i. Cover the cull pile to prevent insects such as shore flies and fungus gnats from carrying the fungus spores back into the greenhouses. j. Alternatively, infected plant debris may be burnt or taken to a landfill. k. Do not leave it in an open field or incorporate it into the soil in fields where other susceptible crops may be grown.</td>
</tr>
</tbody>
</table>
### Symptoms

First symptoms are yellowing of the foliage, beginning with the lower leaves and working upward. Yellowing often begins on one side of the vine. Infected leaves later show downward curling, followed by browning and drying. The top of the vine wilts during the day and recovers at night, but wilting becomes progressively worse until the entire vine is permanently wilted. Vascular browning can be seen in infected stems and large leaf petioles. Affected plants and their root systems are stunted. The degree of stunting depends upon time of root infection. Plants infected when they are young will be more severely stunted than plants infected at a later stage.

### Conditions for disease development

The pathogen is soil borne and persists for many years in the soil without a host. Most infections originate from the fungus associated with infected tomato debris. Root-knot nematode infection makes Fusarium wilt-resistant varieties more susceptible to the fungus because of physiological changes in the root. Disease development is favoured by warm temperatures (for example, 27–28 °C), dry weather, and acidic soil (pH 5–5.6). Rapidly growing, highly succulent tomato plants exposed to fertilization with ammonium nitrate are especially susceptible to the disease.

### Cultural and Biological control measures if any

Raise soil pH to 6.5–7.0 and use sources of nitrate nitrogen (for example, calcium nitrate) rather than sources of ammonium nitrogen. Use clean equipment to avoid infesting new fields. Prevent the introduction of infested soil into production fields via contaminated tools, hands, clothing or shoes of farm workers. Cultivate crops only when necessary since entry by the fungus into plant tissue occurs through damaged tomato roots. Control of root-knot nematode may be necessary in soils. Application of bio control agents like Trichoderma viridae or Trichoderma harzianum along with FYM at the time planting (1 kg mixed with 200 kg of FYM for one acre of land).

### Chemical control

<table>
<thead>
<tr>
<th>Chemical name</th>
<th>Dosage (g or ml/litre)</th>
<th>PHI (days)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper oxychloride</td>
<td>3g/litre</td>
<td>3</td>
<td>Used as drenching in the soil; for large scale application drenching is not feasible.</td>
</tr>
<tr>
<td>Carbendazim</td>
<td>1g/litre</td>
<td>3</td>
<td>Used as drenching in the soil; for large scale application drenching is not feasible.</td>
</tr>
</tbody>
</table>

1) For tank mixing of different chemicals see the label
2) Soil fumigation with effective materials is the only chemical control available for reducing soil borne populations of the pathogen.
3) Various chemical (e.g. chloropicrin, dazomet, formaldehyde, metam sodium) or non-chemical (e.g. steaming, solarization, bio fumigation) methods can be used on infested soil. None are 100% effective and they will only penetrate to a limited depth. Plants can still become infected if the wilt pathogen is re-introduced into the treated area by drainage / run-off water or capillary action, or by the roots growing down beyond the treated soil.
4) Fungicide treatment against wilt diseases gives variable and often poor results. For this reason there are few specific recommendations

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**Fusarium wilt of tomato**

Causal agent: *Fusarium oxysporum f.sp lycopersici*
Symptoms

Foliation of plants from seedlings to mature plant stage is affected. Brown to black specks appear on both the young and older leaves. The lesions expand slowly into 1-2 mm diameter round spots that remain brown or develop a gray centre surrounded by a yellow area. Sometimes the centre of the spot dries and falls out, forming a shot hole in the leaf.

Lesions may be numerous, causing entire leaves to turn yellow, then brown and drop. Lesions rarely coalesce. Defoliation can be severe, leading to sunburn damage of the fruit. Similar lesions may occur, infrequently, on the younger stems and petioles. Fruit are not affected.

Conditions for disease development

The pathogen can persist on dead or dying plant material or on alternate hosts (pepper, eggplant and other solanaceous crops or weeds). The disease often begins on young seedlings. The fungus spores are disseminated by wind or rain.

The disease is favoured by extended periods of leaf wetness from rains or dew and by moderate to warm temperatures (20-30 °C). Leaf wetness is required for the fungus spores to germinate and is more important than temperature in establishment of infection. Sporulation is favoured by alternating periods of leaf wetness and dryness. Overhead sprinkler irrigation is more favourable for disease development than furrow irrigation.

Cultural and Biological control measures if any

When growing transplants, avoid establishing seedbeds near tomato or pepper production fields. Use raised seedbeds, avoid shading, and ventilate seedlings to promote rapid drying of foliage. Plan overhead watering to allow for leaf drying before a new dew period begins in the evening. Check seedlings/transplants carefully before setting them in the production field.

In the production field, rotate with non-solanaceous crops. If possible, remove diseased plants or destroy them immediately after harvest. Remove volunteer tomatoes and solanaceous weeds or vegetable crops that may harbour the fungus. Alternatively, bury diseased tomato crop debris by deep-ploughing to reduce spore levels available for infection of new plants.

Chemical control

<table>
<thead>
<tr>
<th>Chemical name</th>
<th>Dosage (g or ml/litre)</th>
<th>PHI</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorothalonil (kavach)</td>
<td>2g/litre</td>
<td>0</td>
<td>Can be used as a protective application; 5-7 days interval</td>
</tr>
<tr>
<td>Mancozeb (Dithane M-45)</td>
<td>2g/litre</td>
<td>7</td>
<td>Used as a protective application; 5-7 days interval</td>
</tr>
<tr>
<td>Propineb (Antracol)</td>
<td>2g/litre</td>
<td>2</td>
<td>5-7 days interval</td>
</tr>
<tr>
<td>Difenoconazole (Score)</td>
<td>0.5ml/litre</td>
<td>10</td>
<td>Used as curative fungicide</td>
</tr>
<tr>
<td>Copper hydroxide (kocide)</td>
<td>2g/litre</td>
<td>3</td>
<td>Used as a protective application</td>
</tr>
<tr>
<td>Tebuconazole (Folicur)</td>
<td>1ml/litre</td>
<td>7</td>
<td>Used as a curative application</td>
</tr>
</tbody>
</table>

Note

For tank mixing of different chemicals see the label.

Causal agent: Stemphylium botryosum f.sp. lycopersici
"Ghost spots" appear on fruits after periods of prolonged high humidity. These superficial spots have a pale halo with a brown to black pinpoint spot in the centre. On unripe fruit, the halo is pale green or silvery, and generally the tissue inside the halo is paler green. On ripe fruit, the halo is pale yellow. If warm and sunny weather occurs, then ghost spot symptoms usually do not develop further. Botrytis may develop on dying flowers and subsequently infect the fruit calyx. The lesions on fruit appear as light brown to gray spots, up to 3 cm in diameter, and irregular in shape. Later, a dark gray, velvety growth develops on the fruit surface, followed by a watery, soft rot. Foliar symptoms are more common under humid greenhouse conditions. Affected leaves show light tan or gray spots, and the infected areas become covered by a brown fungal growth. The leaves wither and collapse.

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Conditions for disease development</th>
<th>Cultural and Biological control measures if any</th>
<th>Chemical control</th>
</tr>
</thead>
</table>
| “Ghost spots” appear on fruits after periods of prolonged high humidity. These superficial spots have a pale halo with a brown to black pinpoint spot in the centre. On unripe fruit, the halo is pale green or silvery, and generally the tissue inside the halo is paler green. On ripe fruit, the halo is pale yellow. If warm and sunny weather occurs, then ghost spot symptoms usually do not develop further. Botrytis may develop on dying flowers and subsequently infect the fruit calyx. The lesions on fruit appear as light brown to gray spots, up to 3 cm in diameter, and irregular in shape. Later, a dark gray, velvety growth develops on the fruit surface, followed by a watery, soft rot. Foliar symptoms are more common under humid greenhouse conditions. Affected leaves show light tan or gray spots, and the infected areas become covered by a brown fungal growth. The leaves wither and collapse. | Gray mold development, particularly fungus sporulation and infection, is favoured by cool, wet and humid weather. The fungus requires a water film of several hours for spore germination, and a longer period of surface wetness for symptom development. Optimum relative humidity for spore production is about 90%, and most spores are produced during the night when the temperature is lower and the relative humidity is higher than during the day. Temperatures of 17–23 °C are ideal for disease development. The length of the surface wetness period needs to be longer at the lower temperatures for disease development. | In the field, incorporate Botrytis-affected debris into the soil and allow it to decompose before establishing a new tomato crop, or burn diseased plant debris. In the greenhouse, maintain a relative humidity of less than 80%, especially during the night. Remove all clippings from the plant bed if seedlings are pruned. Do not leave any plant fragments attached to clipped seedlings. Remove decaying plant material from the plant bed. In all cases, trellising of vines and proper spacing of plants will allow a good flow of air throughout the crop, thus reducing duration of surface wetness. | Iprodione +carbendazim (quintal)  
Dosage(g or ml/litre): 1g/litre  
PHI: 5  
Remarks: 5-7 days interval; used as protective and curative application  
Chlorothalonil (kavach)  
Dosage(g or ml/litre): 2g/litre  
PHI: 3  
Remarks: Can be used as a protective application; 5-7 days interval  
Pyraclostrobin (Cabrio)  
Dosage(g or ml/litre): 1g/litre  
PHI: 0  
Remarks: For disease suppression only  
Difenoconazole (Score)  
Dosage(g or ml/litre): 0.5ml/litre  
PHI: 10  
Remarks: Used as curative fungicide  
Copper hydroxide (kocide)  
Dosage(g or ml/litre): 2g/litre  
PHI: 3  
Remarks: Used as a protective application  
Pyrimethanil (scala)  
Dosage(g or ml/litre): 0.5ml/litre  
PHI: 7  
Remarks: Repeat applications at 7-14 day intervals  |

Note
For tank mixing of different chemicals see the label.
Late blight of tomato

Causal agent: Phytophthora infestans

### Symptoms

All aboveground parts may show symptoms. On leaves, small (2–10 mm), irregular-shaped, pale, brown patches, sometimes with a purplish tinge, appear on the upper leaf surface. The margins of these spots are pale green or water soaked. The leaf spots may enlarge and coalesce very quickly until the entire leaflet is killed.

Under moist or humid conditions, a downy white mold growth appears near the leaf spot margins on the under surface of the foliage. Lesions on the stem and the petioles appear dark brown and water soaked and can have sporulation. Entire sections may be killed or the lesions may remain superficial and dry out. Invasion of fruit by the fungus can occur at any stage of fruit development, often beginning at the stem end.

The lesions have an olive-brown appearance with a rough leathery surface. The lesions may expand until the entire fruit is affected.

### Conditions for disease development

Late blight is a common disease of tomato crops grown in the tropical highlands and temperate regions. Extended periods of leaf wetness from frequent rain or dew formation, and cool to moderate temperatures (for example, 13–20 °C) are required. Hot, dry weather stops disease development.

The fungus persists on tomato and potato plants and residues, and in potato tubers. Many strains attack both tomato and potato. The spores are spread by wind and splashing rain.

### Cultural and Biological control measures if any

Remove and destroy blighted tomato or potato plants. Eliminate all tomato or potato cull piles in the vicinity of the tomato field. Reduce leaf wetness by staking tomatoes and using drip irrigation. If drip irrigation is not available, reduce the number of furrow irrigations to a minimum or use sprinkler irrigation in the morning or midday to prevent the foliage from being wet overnight.

Avoid over fertilization of nitrogen. Spores of *P. infestans* can be dispersed aerially over long distances; therefore, all tomato growers nearby in the production region need to collaborate to eliminate sources of inoculum. If this doesn’t happen, a few fields with infected plants can affect production over a much larger region. Use tomato varieties that are less susceptible to *P.infestans*. Check plants carefully for the first incidence of the disease particularly after extended periods of leaf wetness and moderate temperatures.

### Chemical control

<table>
<thead>
<tr>
<th>Chemical name</th>
<th>Dosage (g or ml/litre)</th>
<th>PHI</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mancozeb (Dithane M-45)</td>
<td>2g/litre</td>
<td>7</td>
<td>Used as a protective application; 5-7 days interval</td>
</tr>
<tr>
<td>Chlorothalonil (kavach)</td>
<td>2g/litre</td>
<td>3</td>
<td>Can be used as a protective application; 5-7 days interval</td>
</tr>
<tr>
<td>Propineb (Antracol)</td>
<td>2g/litre</td>
<td>2</td>
<td>5-7 days interval</td>
</tr>
<tr>
<td>Dimethomorph (Acrobat)</td>
<td>1g/litre</td>
<td>4</td>
<td>5-7 days interval, not more than 3 application per season</td>
</tr>
<tr>
<td>Metalasyl +mancozeb (Ridomil MZ gold)</td>
<td>2g/litre</td>
<td>14</td>
<td>Protective and curative application; 5-7 days interval</td>
</tr>
<tr>
<td>Azoxystrobin (Amistar)</td>
<td>0,5ml/litre</td>
<td>0</td>
<td>Used as a curative application.</td>
</tr>
</tbody>
</table>

Note: For tank mixing of different chemicals see the label.
Symptoms | Conditions for disease development | Cultural and Biological control measures if any | Chemical control
--- | --- | --- | ---
Yellow spots without a definite margin appear on the upper leaf surface, and olive-green to brown or purplish masses of spores and velvety growth appear on the lower leaf surface. Disease symptoms appear first on the older leaves. As the disease progresses, the leaves become chlorotic, then necrotic, followed by drying and defoliation. Although this is primarily a foliar disease, unripe fruit may occasionally develop dark leathery lesions | Tomato is the only crop that is affected. High relative humidity (greater than 90%) and warm temperatures (22–24 °C) are required. In the tropics, the disease is more severe during cooler periods and especially when either relative humidity exceeds 90% or leaf wetness occurs. In greenhouses of temperate regions, the disease may be more common during the summer and autumn growing periods when conditions are more favourable for periods of high relative humidity. Once the disease appears, there is potential for it to spread very rapidly through the crop. Large numbers of spores may be readily disseminated throughout the growing season, primarily by air currents, but also by water, workers moving through the affected plants, or by insects. | Reduce plant densities to improve air circulation within plants, thereby reducing periods of leaf wetness. Reduce high rates of nitrogen fertilization, which make tomato plants more susceptible to infection by the fungus. Remove and destroy infected crop residues from the field. Avoid planting new tomato plants while diseased plants remain nearby. The transfer of spores from the older, diseased plants to the younger plants in the same location and subsequent infection will cause higher levels of disease at an earlier stage of development in the young crop.

<table>
<thead>
<tr>
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<td>Chlorothalonil (kavach)</td>
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<tr>
<td>Mancozeb (Dithane M-45)</td>
<td>2g/litre</td>
<td>7</td>
<td>Used as a protective application; 5-7 days interval</td>
</tr>
<tr>
<td>Propineb (Antracol)</td>
<td>2g/litre</td>
<td>2</td>
<td>5-7 days interval</td>
</tr>
<tr>
<td>Copper hydroxide (kocide)</td>
<td>2g/litre</td>
<td>3</td>
<td>Used as a protective application</td>
</tr>
</tbody>
</table>

Note
For tank mixing of different chemicals see the label.
### Symptoms
Small black lesions develop on either leaf surface enlarging to about 1/2 in. in diameter, appearing irregular to round in shape, slightly sunken and zonate; stem lesions are elongate but similar; fruit lesions are sunken black spots of increasing size at sites of wounds, insect punctures or stem scar cracks; all foliar and fruit spots develop black pycnidia obvious with hand lens.

### Conditions for disease development
Contact with soil, via skin injuries, and high storage temperatures. Phomopsis prefers temperatures between 29 °C and 32 °C and relative humidity above 55%.

### Cultural and Biological control measures if any
Where fungi cause diseases on other plant parts, such as leaves and stems, controlling the disease on these plant parts will reduce the levels of fruit infection. Fruit infections will be reduced when; seed is treated with hot water before planting. Seed-borne infections fruit does not come in contact with soil fruit is kept cool and dry after picking to reduce fungal growth.

### Chemical control

<table>
<thead>
<tr>
<th>Chemical name</th>
<th>Dosage (g or ml/litre)</th>
<th>PHI</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azoxystrobin+ Chlorothalonil</td>
<td>0.5ml/litre + 2g/litre</td>
<td>1</td>
<td>Make two applications, the first at the 1 to 3 leaf stage and the second just prior to vine tip over or 10-14 days after the first, whichever comes first.</td>
</tr>
<tr>
<td>Chlorothalonil (kavach)</td>
<td>2g/litre</td>
<td>0</td>
<td>Can be used as a protective application; 5-7 days interval</td>
</tr>
<tr>
<td>Copper hydroxide (kocide)</td>
<td>2g/litre</td>
<td>0</td>
<td>7-10 day interval application</td>
</tr>
<tr>
<td>Pyraclostrobin (Cabrio)</td>
<td>1g/litre</td>
<td>0</td>
<td>7-14 day interval; no more than two sequential application;</td>
</tr>
<tr>
<td>Tebuconazole (Folicur)</td>
<td>1ml/litre</td>
<td>7</td>
<td>For suppression only; 10-14 day interval</td>
</tr>
</tbody>
</table>

**Note:**
For mixing chemical always see the label of the product.

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Phoma rot of tomato:
Causal agent: *Phoma destructiva*
Symptoms of *Oidiopsis taurica* consist of yellow blotches or spots on the upper leaf surface. A white powdery growth occurs on the underside of the leaves. This fungus penetrates within the leaf tissue. For *Oidium neolycopersici*, symptoms first appear as small, powdery white colonies on the upper surface of the leaves. The fungal growth does not penetrate deeply into the leaf. The lower surface of the foliage may also be affected during later stages when the disease is severe. With both pathogens, the older colonies of the fungus may turn a dirty white colour with age. The severely affected leaves turn yellow, then brown, and later become shrivelled. Generally, the lower leaves are affected first and the disease gradually moves up the plant.

Both fungi are prolific producers of spores that are readily dispersed by wind and rain. Many cycles of disease development occur during the plant’s growing period. The fungus is also spread by insect pests (thrips, aphids, and whiteflies) and field workers, but to a lesser extent. The fungus is not seed borne. Spore germination and infection are favoured by wide fluctuations of temperature and humidity during the day and night, which create periods of leaf wetness. *O. taurica* is favoured by high relative humidity (greater than 85%) at night followed by warm (25°C), less humid conditions during the day. For *O. neolycopersici*, optimum disease development occurs at 22°C particularly after 16 or 24 hours of leaf wetness; symptoms can appear within 7 days from the time that the spore lands on the leaf surface.

Avoid high rates of nitrogen, which make plants more susceptible to infection. Avoid crowding and shading, which lead to the development of leaf wetness and conditions that promote infection. Avoid overhead irrigation for the same reason. Avoid planting young tomato plants while diseased plants remain nearby. Control weeds around the planting site since both fungi have a wide host range and could persist on these plants during the growing season or during the off-season.

### Chemical control

<table>
<thead>
<tr>
<th>Chemical name</th>
<th>Dosage (g or ml/litre)</th>
<th>PHI</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wettable sulphur</td>
<td>3g/litre</td>
<td>0</td>
<td>Should not be used at flowering stage</td>
</tr>
<tr>
<td>Dinocap (karathane)</td>
<td>1ml/litre</td>
<td>7</td>
<td>Used as contact fungicide, 5-7 days application interval</td>
</tr>
<tr>
<td>Myclobutanil (Systhane)</td>
<td>1g/litre</td>
<td>14</td>
<td>Used as curative application, should not be used at flowering stage</td>
</tr>
<tr>
<td>Carbendazim (Bavistin)</td>
<td>1g/litre</td>
<td>3</td>
<td>Used as preventive and curative application, apply at 5 days interval</td>
</tr>
</tbody>
</table>

Note

For tank mixing of different chemicals see the label.
Damping off

Causal agent: *Pythium* spp., *Phytophthora* spp., *Fusarium* spp., *Rhizoctonia solani*, and other fungi

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Conditions for disease development</th>
<th>Cultural and Biological control measures if any</th>
</tr>
</thead>
</table>
| Affected plants usually occur in patches in nursery beds or in low parts of sloped fields. In level fields, affected plants are generally found in scattered areas. Damping off may occur before and/or after emergence. In pre-emergence damping off, the seeds fail to emerge after sowing. They become soft, mushy, turn brown, and decompose as a consequence of seed infection. In post-emergence damping-off, the seedling emerges from the soil but dies shortly afterwards. The affected portions (roots, hypocotyls and perhaps the crown of the plant) are pale brown, soft, water soaked, and thinner than non-affected tissue. Infected stems collapse. Stunting of plants due to root rot or collar rot may also occur. | Seedlings during the first three weeks after sowing are susceptible, especially when any of the following occur:  
• planting in heavily infested soil or growth medium;  
• overwatering or poor drainage;  
• overcrowding or poor ventilation of seedlings;  
• excess application of nitrogen;  
• stressful environmental conditions such as cloudy, wet weather that results in etiolated plants, prolonged soil moisture, or low light that prevents drying; or  
• Pathogenic nematodes are present. | If possible, use plug transplants and a soilless pathogen-free growth medium to avoid damping off. Water seedlings only when the soil or growth medium is dry, preferably in the morning to allow drying to occur by the late afternoon. Avoid contact with ground soil or other sources of contamination.  
Pots or transplant containers should be new or treated recently with a disinfectant (10% household bleach) or fungicide drenching of Ridomil gold MZ+ Bavistin @ 2+1 g/litre of water.  
For seedbeds, choose well-drained locations. Keep the seedbed well ventilated and dry. Sow on raised beds. Avoid overcrowding of plants and the movement of infested soil or contaminated plant material into the nursery bed. Workers should clean their hands and tools before handling healthy plants. Water plants in the late morning. Surface irrigation ponds may be a source of fungal contamination. |
Symptoms usually first appear on the older, lower leaves and stems when plants are setting fruit. Symptoms commonly develop on leaves, but can occur on petioles, stems, and the calyx. The initial symptoms are small, water-soaked circular spots 1/16 to 1/8” in diameter on older leaves. The centres of these spots gradually turn gray to tan and have dark brown margins. The spots are distinctively circular and are often quite numerous. As the spots age, they sometimes enlarge and often coalesce.

Septoria leaf spot is sometimes confused with bacterial spot of tomato. These diseases can be differentiated using a diagnostic feature of Septoria leaf spot—the presence of many dark brown, pimple-like structures called pycnidia (fruiting bodies of the fungus) that are readily visible in the tan centres of the spots.

### Septoria leaf spot

**Causal agent:** *Septoria lycopersici*

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Conditions for disease development</th>
<th>Cultural and Biological control measures if any</th>
<th>Chemical control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Symptoms</strong></td>
<td>Septoria leaf spot is favoured by warm, wet, humid conditions. Although the fungus can survive in or on seed and in weed hosts, the main source of inoculum is from leaf fragments and other plant debris from diseased plants that “overwinter” in the soil. This inoculum results from crumbled leaf fragments that fall to the soil. Under wet conditions, spores of the fungus are produced in the pycnidia. Spore production is abundant when temperatures are between 60°-80°F. Spores are usually spread to healthy tomato leaves by windblown water, splashing rain, and overhead irrigation. However, spread can also occur on hands and clothing of pickers, cultivation equipment, and through the activities of several types of insects.</td>
<td>In large fields where plant removal is not practical, plant debris can be covered and buried by deep ploughing. These simple sanitary practices can significantly reduce disease development the following year since they remove key sources of the fungus that overwinter in the soil. It is also helpful to practice a 3- to 4-year rotation with non-Solanaceous crops, if possible, and to control weeds in and around the garden. It is helpful to avoid overhead watering or to water early in the day so that the leaves dry. It is also helpful to avoid working with plants when they are wet, since the fungus can be spread during these types of activities. Staking and mulching can also help reduce infections. Staking increases air circulation and helps to dry the leaves—this reduces favourable conditions for infection.</td>
<td><strong>Chemical control</strong>&lt;br&gt;<strong>Chemical name</strong>&lt;br&gt;Azoxystrobin (Amistar)&lt;br&gt;Chlorothalonil (kavach)&lt;br&gt;Mancozeb (Dithane M-45)&lt;br&gt;Propineb (Antracol)&lt;br&gt;Difenoconazole (Score)&lt;br&gt;Pyraclostrobin (Cabrio)&lt;br&gt;<strong>Dosage (g or ml/litre)</strong>&lt;br&gt;0.5ml/litre&lt;br&gt;2g/litre&lt;br&gt;2g/litre&lt;br&gt;2g/litre&lt;br&gt;0.5ml/litre&lt;br&gt;1g/litre&lt;br&gt;<strong>PHI</strong>&lt;br&gt;0&lt;br&gt;0&lt;br&gt;7&lt;br&gt;2&lt;br&gt;10&lt;br&gt;0&lt;br&gt;<strong>Remarks</strong>&lt;br&gt;7- to 21-day interval; alternate after each use; no more than five applications&lt;br&gt;Can be used as a protective application; 5-7 days interval&lt;br&gt;Used as a protective application; 5-7 days interval&lt;br&gt;5-7 days interval&lt;br&gt;Used as curative fungicide: No more than 4 application per season.&lt;br&gt;7- to 14-day interval; no more than 2 sequential applications.</td>
</tr>
</tbody>
</table>

### Chemical control

- **Azoxystrobin (Amistar)**: 0.5ml/litre, PHI 0; 7- to 21-day interval; alternate after each use; no more than five applications.
- **Chlorothalonil (kavach)**: 2g/litre, PHI 0; can be used as a protective application; 5-7 days interval.
- **Mancozeb (Dithane M-45)**: 2g/litre, PHI 7; used as a protective application; 5-7 days interval.
- **Propineb (Antracol)**: 2g/litre, PHI 2; 5-7 days interval.
- **Difenoconazole (Score)**: 0.5ml/litre, PHI 10; used as curative fungicide: No more than 4 application per season.
- **Pyraclostrobin (Cabrio)**: 1g/litre, PHI 0; 7- to 14-day interval; no more than 2 sequential applications.

Note<br>For tank mixing of different chemicals see the label.
Symptoms

Young infected plants wilt suddenly and permanently. On older plants, symptoms first appear as a dark brown lesion on the stem near the soil surface. The lesion girdles the stem, causing leaf yellowing and wilting. White mats of fungal growth are produced on the stem and nearby in the soil on any organic debris. Wilting in infected plants may be more evident when soils begin to dry out. After a few days, mustard seed-sized (0.5 mm diameter), round, tan to dark brown overwintering structures known as sclerotia appear on the white fungal growth. The abundant sclerotia that form on the outside of the stem tissue are a good diagnostic feature. They are round, soft, and smaller in diameter, and lighter in colour than those caused by another fungus, Sclerotinia sclerotiorum.

Conditions for disease development

The fungus affects many crops, including tomato, other solanaceous crops (potato, pepper, and eggplant), legumes, and cucurbits. The pathogen persists on crop residues and as dormant sclerotia. The fungus infects plants either directly or through wounds caused by nematodes or insects. Fruits, leaves or branches that touch the soil also may be infected by the germinating sclerotia.

The fungus is spread into a field by infested soil or cultivating tools, infected transplants, running water, and as sclerotia mixed with seeds. High temperatures (above 30 °C) and high soil moisture favour disease development while low soil moisture favours survival of the sclerotia. The germination of sclerotia is most abundant at the soil surface and drops off with depth in the soil.

Cultural and Biological control measures if any

Crop rotation has a strong influence on survival of the fungus. Grow tomato after non-host crops such as maize, sorghum, small grains, or cotton. Allow ample time for breakdown of green manure before planting the tomato crop. Bury crop debris to a depth of 24 cm. Eradicate weeds, avoid dense planting, and choose fields that are well drained, rich in humus, and not too acidic. Plastic mulch may shield the branches and fruit from sclerotia. Disease levels have been reduced by application of ammonium nitrate either before planting or as three side dressings at monthly intervals while the crop is growing. Efforts are being made to develop solarization and biological control practices.

Chemical control

<table>
<thead>
<tr>
<th>Chemical name</th>
<th>Dosage(g or ml/litre)</th>
<th>PHI</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbendazim (Bavistin)</td>
<td>2g/litre</td>
<td>3</td>
<td>Used as drenching</td>
</tr>
<tr>
<td>Copper hydroxide (kocide)</td>
<td>2g/litre</td>
<td>0</td>
<td>Used as drenching</td>
</tr>
<tr>
<td>Fluzilazole (nustar)</td>
<td>2ml/10litre</td>
<td>15</td>
<td>For preventive application apply once in 15 days</td>
</tr>
<tr>
<td>Tebuconazole (Folicur)</td>
<td>1ml/litre</td>
<td>5</td>
<td>For preventive application and curative</td>
</tr>
</tbody>
</table>

Note

For tank mixing of different chemicals see the label.

Southern blight tomato

Causal agent: Sclerotium rolfsii
Target spot of tomato
Causal agent: Corynespora cassiicola

Symptoms appear on all aboveground parts of the plant. Foliar lesions begin as small, pinpoint, water-soaked spots on the upper surface. Gradually these increase in size (up to 2 cm diameter), becoming circular, frequently ringed, and pale brown with conspicuous yellow halos. The lesions will coalesce leading to blighting of foliage. The subsequent premature defoliation affects fruit quality and yield. The lesions on stems and petioles are brown and oblong. These increase in size and may girdle petioles and stems leading to collapse of the leaflets. On young fruit, the lesions are small, light-brown freckles with darker margins, and centres that are slightly sunken and somewhat dry. Fruit lesions enlarge and coalesce resulting in large areas of sunken, necrotic tissue. On ripe fruit, large circular lesions develop with brown centres that crack. Severe fruit infection and subsequent damage can cause significant yield loss.

The fungus attacks many hosts such as tomato, pepper, tobacco, soybean, cowpea, snap beans, and cucurbits; certain strains only affect certain hosts. Disease development is favoured by warm temperatures and extended periods of leaf wetness. The optimal Temperature range for disease development is 20–28 °C with 16 hr or more of leaf wetness. The fungus sporulates abundantly on rain-moistened crop debris or from target spot lesions on dead tomato leaves. The fungus can colonize weeds or other crop plants. It remains viable for up to two years. The spores are readily dispersed by wind or windblown rain. Splashing soil or windblown soil particles create wounds in the fruit for the spores to enter.

Remove affected debris to prevent carryover into the next crop. Use an adequate period of crop rotation. Genetic resistance to this fungus has been documented in tomato and soybean but commercial varieties are not yet available.

<table>
<thead>
<tr>
<th>Chemical name</th>
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</tr>
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<tbody>
<tr>
<td>Azoxystrobin (Amistar)</td>
<td>0.5 ml/litre</td>
<td>0</td>
<td>7- to 21-day interval; alternate after each use; no more than five applications</td>
</tr>
<tr>
<td>Chlorothalonil (Kavach)</td>
<td>2 g/litre</td>
<td>0</td>
<td>Can be used as a protective application; 5-7 days interval</td>
</tr>
<tr>
<td>Copper hydroxide (Kocide)</td>
<td>2 g/litre</td>
<td>0</td>
<td>7- to 14-day interval; no more than four applications per crop</td>
</tr>
<tr>
<td>Mancozeb (Dithane M-45)</td>
<td>2 g/litre</td>
<td>7</td>
<td>Used as a protective application; 5-7 days interval</td>
</tr>
<tr>
<td>Propineb (Antracol)</td>
<td>2 g/litre</td>
<td>2</td>
<td>5-7 days interval</td>
</tr>
<tr>
<td>Difenoconazole (Score)</td>
<td>0.5 ml/litre</td>
<td>10</td>
<td>Used as curative fungicide; No more than 4 application per season.</td>
</tr>
<tr>
<td>Pyraclostrobin (Cabrio)</td>
<td>1 g/litre</td>
<td>0</td>
<td>7- to 14-day interval; no more than 2 sequential applications</td>
</tr>
</tbody>
</table>

Note
For tank mixing of different chemicals see the label.
Verticillium wilt of tomato
Causal agent: Verticillium albo-atrum, Verticillium dahliae

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Conditions for disease development</th>
<th>Cultural and Biological control measures if any</th>
<th>Chemical control</th>
</tr>
</thead>
<tbody>
<tr>
<td>The bottom leaves become pale, then tips and edges die and leaves finally die and drop off. V-shaped lesions at leaf tips are typical of Verticillium wilt of tomato. Infected plants usually survive the season but are somewhat stunted and both yields and fruits may be small depending on severity of attack. A light tan discoloration in the stem similar to that caused by Fusarium wilt may be found but is usually confined to lower plant parts. The discoloration is typically lighter in color than with Fusarium wilt. Symptoms on one side of the plant only are sometimes seen (Figure 5)</td>
<td>Verticillium wilt is caused by the fungi Verticillium albo-atrum and V. dahliae. These fungi attack a wide range of plant species, including cultivated crops and weeds. They are soil borne in field and greenhouse soils where they can persist for many years. V. albo-atrum is a cool weather organism that grows best when soil temperatures are between 65 and 75 degrees F. V. dahliae is more active between 75 and 83 degrees F. Although disease is retarded by the higher temperatures that favor Fusarium wilt, visible symptoms may appear to be more severe when high temperatures exist, due to restricted water movement in the plant brought about by damage done to the water conducting vessels earlier in the growing season. Verticillium fungi are widespread and persist several years in soil, a long crop rotation (4 to 6 years) is necessary to reduce populations of these fungi. Avoid using any solanaceous crop (potato, tomato, pepper, eggplant) in the rotation, and if Verticillium wilt is a problem, also avoid the use of strawberries and raspberries, which are highly susceptible. Rotate with cereals and grasses wherever possible. Keep rotational crops weed-free (there are many weeds hosts of Verticillium). Whenever practical, remove and destroy infested plant material after harvest. Maintain a high level of plant vigour with appropriate fertilization and irrigation, but do not over-irrigate, especially early in the season.</td>
<td></td>
<td>Chemical name</td>
</tr>
<tr>
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</tr>
<tr>
<td>Carbendazim (Bavistin)</td>
<td>2g/litre</td>
<td>3</td>
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<tr>
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<td>0</td>
<td>Used as drenching</td>
</tr>
</tbody>
</table>

Note
1) For tank mixing of different chemicals see the label
2) Soil fumigation with effective materials is the only chemical control available for reducing soilborne populations of the pathogen.
3) Various chemical (e.g. chloropicrin, dazomet, formaldehyde, metam sodium) or non-chemical (e.g. steam, solarization, biofumigation) methods can be used on infested soil. None are 100% effective and they will only penetrate to a limited depth. Plants can still become infected if the wilt pathogen is re-introduced into the treated area by drainage / run-off water or capillary action, or by the roots growing down beyond the treated soil.
4) Fungicide treatment against wilt diseases gives variable and often poor results. For this reason there are few specific recommendations.
### Symptoms

**First, a rapidly expanding soft rot centers on a piece of organic material such as decaying leaves and flower petals.** Affected stems turn light tan to a straw color and, under moist conditions, are covered with white cottony mycelium. Hard, black, irregularly shaped sclerotia less than 0.25 inch to almost 1 inch long develop in the mycelium and within the tomato’s stem tissue. Fruit may be infected; if so, it looks gray and develops a watery surface. Stems may be girdled, killing the plant portions above the lesion. High humidity and free moisture favor infection.

### Conditions for disease development

A fungus, *Sclerotinia sclerotiorum* that attacks numerous other hosts and overwinters as hard, black sclerotia in soil and plant debris. The fungus colonizes any organic debris such as old leaves, stems or blossoms. Usually it grows from these materials into the healthy parts of the tomato. "The fungus will often "colonize" any organic debris such as old leaves, stems or blossoms. Usually it grows from these materials into the healthy parts of the tomato. High humidity and free moisture favor infection.

### Cultural and Biological control measures if any

Space plants so the lower canopy dries out between irrigations. Limit overhead irrigation to only that necessary for crop production. A few deep irrigations are better than frequent shallow ones. In smaller plantings, remove infected material to reduce the sclerotia population in the soil. Use long rotations (3 to 4 years) with cereal crops.

### Chemical control

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Note: For tank mixing of different chemicals see the label.
**Root Knot of Tomato**

Causal agent: *Meloidogyne* spp.

<table>
<thead>
<tr>
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<th>Cultural and Biological control measures if any</th>
<th>Chemical control</th>
</tr>
</thead>
<tbody>
<tr>
<td>All stages of plant growth are attacked. Aboveground symptoms often develop slowly over time and may go unnoticed until plants are well developed. Symptoms consist of stunting, yellowing and a general unthrifty appearance of plants. Infested plants may wilt or die in hot, dry weather. Belowground, the roots will have obvious galls or knot-like swellings. These swellings prevent movement of water and nutrients to the rest of the plant resulting in stunted plant growth. Plants affected by root-knot nematodes are more easily infected by soil-borne diseases caused by <em>Ralstonia solanacearum</em> (bacterial wilt), <em>Sclerotium rolfsii</em> (southern blight) <em>Fusarium</em>, <em>Pythium</em>, or <em>Rhizoctonia</em>. This secondary infection may lead to extensive discoloration of internal stem and root tissue, and rapid plant death.</td>
<td>Nematodes can survive as dormant eggs a few months until environmental conditions are suitable for hatching to occur. They are generally intolerant of flooded soil conditions. The eggs and juveniles survive in intact plant roots and are released into the soil as the plant disintegrates. Nematodes are active throughout the year in warm, moist soils. Nematodes are spread by using or moving infested soil or by transplanting infested seedlings. Infested soil may also be spread by irrigation water, by running water from one sloped, affected portion of a field to another portion of a field, on farm machinery or implements, and on workers’ shoes.</td>
<td>Use resistant varieties. Rotate the tomato crop (susceptible) with other crops such as grasses or brassicas (tolerant), followed by onion (resistant) and then dry fallow during hot, dry weather if possible. Repeated ploughing of the soil at the end of the growing season during hot, dry weather of the fallow period exposes nematodes to desiccation and death. Adding organic matter (compost and manures) to the soil will reduce nematode populations, amendments but they must be applied at 4–10 t/ha to be effective. Solarization for 4 to 8 weeks in small gardens is also possible. It will be most effective when conducted during the hottest season of the year. Application of 2 kg of MULTIPLEX Nyantran (Poaecilomyces) in 100 kg FYM and broadcast to 1 acre uniformly. Application of 250-400 kg of neem cake/hac</td>
<td><strong>Chemical name</strong></td>
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<td></td>
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<td></td>
<td>Methy bromide</td>
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<td></td>
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<td></td>
<td>Oxamyl (vydate)</td>
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<td></td>
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<td></td>
<td>Carbofuron (Furadan)</td>
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<td></td>
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<td></td>
<td>Fenamiphos (nemacure)</td>
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</tbody>
</table>

**Note**

For tank mixing of different chemicals see the label.
**Symptoms**

Young plants that are infected with this disease are usually killed. Plants that are infected at a later stage of development may survive, but they will be yellow with stunted growth. The leaves will become thicker and crisp and will roll upwards as the petioles of the leaf roll become downwards, which gives the disease its name. They will also turn a dull yellow colour with purple coloured veins. The fruit will ripen prematurely and will be dull and wrinkled, which is a characteristic symptom of curly top. Calyx tissues will often be abnormally large and thickened as well. Both normal and affected fruit will be visible on the same stem if the plants are infected after fruit set. Infected plants are usually scattered in a field.

**Conditions for disease development**

Beet leaf hopper that have acquired BCTV can transmit the virus for the reminder of their life. However the number of plants infected decreases when the insects are not continually or frequently feeding on infected plants. A tomato plant can begin to show symptoms about 7-14 days after infection. The spread of BCTV in tomato fields depends on the seasonal cycle of the BLH. Sugar beet is a common host and may serve as a virus reservoir, tomato is not a desired host for BLH, but the insects will remain in tomato fields long enough to transmit the virus while feeding. The edges of fields or isolated plants with a lot of soil around them are more susceptible to BLH feeding, which can result in high infection rates in these areas.

**control measures**

One of the most promising management practices to reduce the effects of BCTV in tomatoes would be to use of resistant cultivars of tomatoes, some observations shown that plant grown in shade do not contract virus, this may be insect preference to feed in areas where sunlight is abundant shade cloth placed over tomato plants may help prevent infection.

Double planting is the practice of planting twice as many plants in the space that normally one plant would occupy the probability that BLH will feed on every plant is decreased. Infected plants would die out leaving virus free tomatoes to fill out the remaining area.

The inconsistent nature of this disease and the migratory behavior of the BLH (which serves as vector) make it very difficult to acquire consistent control.

Foliar application of Confidor (Imidacloprid) 1ml/litre of water 21 to 45 days apart are recommended on coarse soils or where the longest periods of protection is required. Make the first application between bud break and pea-berry stage.

**Curly top of tomato**

**Causal agent:** Beet curly top virus (BCTV)

**Transmission:** Beet leaf hopper (*Circulifer tenellus*)
Infected leaves show mild leaf mottling symptoms and some distortion. A droopy appearance with curved petioles and leaves rolled downward may occur in plants infected for some time. In some cases, symptoms may be more severe and may consist of dark brown, dead areas on more mature leaves, yellowing along veins, stems with purple streaking, terminal leaflets with severe necrosis, and mature plants that are stunted. There are no symptoms on the fruit.

Potato virus Y infects tomato, potato, pepper, tobacco, and many other plants, including solanaceous weeds. Weeds may act as a reservoir for the virus. Several aphid species, such as the green peach aphid (*Myzus persicae*), transmit the virus. The aphids acquire the virus by feeding on an infected plant for less than a minute and can transmit it as quickly also. The aphids will retain the virus for periods of 1 day or longer if the aphids do not feed after acquiring the virus.

Effective control of this disease focuses on preventing infection:

- Avoid planting tomato crops close to established potato, tobacco, and pepper crops. Plant tomato crops in areas less likely to support aphid populations.
- Plant earlier to avoid high aphid populations that occur later in the season.
- Late plantings should be set as far as possible from fields used to produce early tomatoes and peppers. The latter can act as sources of viruses and aphids for subsequent crops.
- Use netting of 32-mesh or greater to exclude aphids from transplants.
- Destroy all annual weeds in the field, including those in ditch banks, hedges, fencerows, and other locations. Reflective mulches may be used to repel aphids, thereby reducing the rate of spread of aphid-borne viruses. Minimize plant handling to reduce the amount of virus spread mechanically. Do not touch other seedlings while discarding diseased plants.
- Disinfect tools, stakes, and equipment before moving from diseased areas to healthy areas. This can be done by 1) heating or steaming at 150 °C for 30 minutes; 2) soaking 10 minutes in 1% formaldehyde or a 1:10 dilution of a 5.25% sodium hypochlorite.
- Scout fields for the first occurrence of virus symptoms. If affected plants are found, spray them with an insecticide like Confidor (Imidacloprid) @ 1ml/litre of water, first to prevent aphids from migrating to nearby healthy plants. Remove the affected plants and place in a plastic bag. Do not touch other plants nearby with hands, tools or clothing to prevent mechanical transmission of the virus.
Infection by PVX usually causes leaf mottling and slight stunting, but in some cases the foliage may have distinct yellowing depending upon the virus strain. The mottled areas may have small, brown spots. Tomato plants infected with both PVX and tomato mosaic virus (ToMV) have what is known as double virus streak (see photo). Symptoms include long brown streaks on petioles or stems. Petiole lesions may cause the death of leaves. Infected fruit will have irregular, brown, raised, greasy, randomly occurring spots that may coalesce, become dry, sunken, and finally crack. Symptoms of double virus streak are masked or very faint above 26°C.

The virus infects many crops, especially solanaceous crops such as eggplant, potato, tobacco and pepper, as well as various weeds and ornamentals. Potato virus X often originates from nearby potato crops and from stored potato tubers. Tomatoes, if grown in soil that has produced a potato crop in the previous 4–6 months, may become infected with the virus. Double virus streak disease may be a problem where crops of potatoes and tomatoes are grown nearby. Potato virus X is transmitted by workers on contaminated hands, clothing, and tools during routine horticultural operations such as transplanting, tying, pruning, grafting, pollinating, cultivating, spraying, watering, and harvesting, as well as on the mouthparts of chewing insects such as grasshoppers. The virus may sometimes be found in streams, drainage canals, ponds or rivers.

Potato virus X on tomato

Causal agent: Potato virus X (PVX)
Transmission: Mechanical, chewing insects and grasshoppers

Tomato varieties with resistance to PVX (and ToMV) are available. Avoid growing tomatoes near potato fields. Workers who handle potato plants or tubers should change clothes and wash thoroughly with soap and water before working with tomatoes. Similarly, tools and equipment used with potatoes should be thoroughly cleaned before being used in tomatoes.
### Symptoms

Initial symptoms may vary from irregular white banding patterns on the leaves to necrotic lesions or rings. Leaves soon turn from green to a pale yellow which may have interspersed green areas. Eventually the affected leaves may fall from the plant. New leaves frequently are twisted and have necrotic tips. An abundance of side shoots occurs, giving the plant a bushy, stunted appearance. Lower leaves become chlorotic and purple as the disease progresses. Excessive fertilizer on young plants can result in soft stems that when infected may develop lesions at the soil line. The seedling may be girdled at that point, resulting in death of the plant. Fruit symptoms can vary from chlorotic blotches to rings or line patterns.

### Conditions for disease development

TBSV is a very stable virus with a very diverse natural host range. It is soil-borne and readily transmissible in water. A natural vector of the virus is currently unknown but it is believed that the virus infects plants through wounds in the roots. This virus has been found in river water so it is possible that it is spread in irrigation water.

### Control measures

Avoid planting in soils known to contain the virus. Once present in the soil this virus is difficult to control.

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**Tomato bushy stunt**

Causal agent: Tomato bushy stunt virus

Transmission: Mechanical
## Symptoms

Leaves may show mild mottling, crinkling, distortion, reduction in size, and pronounced downward curling. Plants infected early have shortened internodes and can be severely stunted; fruits from such plants are mottled and do not reach full size. All stages of plant growth may be affected.

Tomato, pepper, tobacco, and various solanaceous weeds are the main plants affected. Symptoms may be confused with other viruses such as potato virus Y (PVY) or tomato mosaic virus (ToMV). Because several varieties carry partial resistance to ToMV and none have been bred for resistance to either TEV or PVY, plants with general mottling suggest TEV or PVY infection.

TEV symptoms are usually more severe than those of PVY, which usually consist of only faint mottling and slight distortion of leaves.

## Conditions for disease development

The green peach aphid (*Myzus persicae*) and several other aphid species transmit the virus. The aphids acquire the virus by feeding on an infected plant for less than a minute and can transmit it as quickly also. The aphids will retain the virus for periods of 1 day or longer if the aphids do not feed after acquiring the virus. The virus is also readily transmitted mechanically and by grafting, but not by seeds.

## Control measures

Use a screen house with 32-mesh or greater to keep out aphids while growing transplants. Cultural practices include the use of reflective mulches to reduce aphid visits to plants and thus delay virus spread. This results in reduced virus incidence and increased yields. Plant early to avoid high aphid populations that occur later in the season. Late plantings should be set as far as possible from fields used to produce early tomatoes and peppers, which can act as sources of viruses and aphids for subsequent crops.

Disinfect tools, stakes, and equipment before moving from diseased areas to healthy areas. This can be done by (1) heating or steaming at 150 °C for 30 minutes; (2) soaking 10 minutes in 1% formaldehyde or a 1:10 dilution of a 5.25% sodium hypochlorite.

Scout fields for the first occurrence of virus symptoms. If affected plants are found, spray them with an insecticide like Confidor (imidacloprid) @ 1ml/litre of water, first to prevent aphids from migrating to nearby healthy plants. Remove the affected plants and place in a plastic bag. Do not touch other plants nearby with hands, tools or clothing to prevent mechanical transmission of the virus.

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### Tobacco etch on tomato

- **Causal agent:** Tobacco etch virus
- **Transmission:** Aphids

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<tr>
<td>The green peach aphid (<em>Myzus persicae</em>) and several other aphid species transmit the virus.</td>
<td>Use a screen house with 32-mesh or greater to keep out aphids while growing transplants. Cultural practices include the use of reflective mulches to reduce aphid visits to plants and thus delay virus spread. This results in reduced virus incidence and increased yields. Plant early to avoid high aphid populations that occur later in the season. Late plantings should be set as far as possible from fields used to produce early tomatoes and peppers, which can act as sources of viruses and aphids for subsequent crops. Disinfect tools, stakes, and equipment before moving from diseased areas to healthy areas. This can be done by (1) heating or steaming at 150 °C for 30 minutes; (2) soaking 10 minutes in 1% formaldehyde or a 1:10 dilution of a 5.25% sodium hypochlorite. Scout fields for the first occurrence of virus symptoms. If affected plants are found, spray them with an insecticide like Confidor (imidacloprid) @ 1ml/litre of water, first to prevent aphids from migrating to nearby healthy plants. Remove the affected plants and place in a plastic bag. Do not touch other plants nearby with hands, tools or clothing to prevent mechanical transmission of the virus.</td>
</tr>
<tr>
<td>The aphids acquire the virus by feeding on an infected plant for less than a minute and can transmit it as quickly also.</td>
<td></td>
</tr>
<tr>
<td>The aphids will retain the virus for periods of 1 day or longer if the aphids do not feed after acquiring the virus.</td>
<td></td>
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<tr>
<td>The virus is also readily transmitted mechanically and by grafting, but not by seeds.</td>
<td></td>
</tr>
</tbody>
</table>
## Symptoms

Plants in all growth stages may show symptoms. CMV causes a “shoestring” effect of young leaves with subsequent narrow, tendril-like leaflets. Plants with severe shoestring symptoms are stunted with little or no marketable fruit.

CMV symptoms may be misdiagnosed as tomato mosaic virus (ToMV) infection. ToMV infection produces “fern-like” leaves; both CMV and ToMV produce mosaic symptoms. Shoestring symptoms may also resemble injury caused by the herbicide, 2,4-D;

## Conditions for disease development

More than 80 species of aphids including the green peach aphid, *Myzus persicae*, are an important vector of CMV. The virus has a very wide host range and may infect many monocot and dicot plants including various cucurbits, tomato, pepper, and other crops. The large number of aphid vector species and natural host reservoirs accounts for the high incidence of CMV in field plants. Aphid vectors can acquire and transmit the virus after feeding for only one minute, but the ability to transmit it declines quickly. Tomato is not a preferred host of the green peach aphid, which normally colonizes various cucurbits and other plants. Most epidemics occur when the primary virus inoculum exists in reservoirs such as weeds. CMV is transmitted at low rates in tomato seeds as well as with other crop or weed seeds. CMV can be mechanically transmitted but because it is not as stable as TMV, workers handling infected tomato plants do not as readily transmit it.

## control measures

Grow seedlings under netting with mesh size of 32 or greater to prevent aphids from entering. Discard any young plants that show virus symptoms, being careful not to touch other seedlings while discarding them. Avoid touching or handling plants prior to setting them in the field. Dip hands in milk while handling plants. Do not clip young seedlings since this increases the possibility of mechanical transmission of the virus from contaminated tools or hands.

Scout fields for the first occurrence of virus symptoms. If affected plants are found, spray them with an insecticide like Confidor (Imidacloprid) @ 1ml/litre of water, first to prevent aphids from migrating to nearby healthy plants. Remove the affected plants and place in a plastic bag. Do not touch other plants nearby with hands, tools or clothing to prevent mechanical transmission of the virus.

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### Tomato fern leaf

**Causal agent:** Cucumber mosaic virus (CMV)

**Transmission:** Aphids
### Tomato mosaic

**Causal agent:** tomato mosaic virus (ToMV)

**Transmission:** Mechanical

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Conditions for disease development</th>
<th>Control measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptoms can be found during any growth stage and all plant parts are affected. Generally, infected plants have a light or dark green mottling or mosaic with distortion of younger leaves, and stunting to varying degrees. Severely affected leaves may have a &quot;fernlike&quot; appearance and may show raised dark green areas. Fruit set may be severely reduced in affected plants. There may be internal browning of the fruit wall, yellow blotches and necrotic spots may occur on green or ripe fruit. Some strains can cause yellow mottling of leaves, others cause dark necrotic streaks in stems, petioles, leaves or fruit, or other symptoms to occur. Symptoms are influenced by environmental conditions such as day length, temperature, and light intensity as well as by variety, plant age at infection, and virulence of tomato mosaic virus (ToMV) strain. On susceptible cultivars, symptoms may range from severe to none. Occasionally, dual infection with potato virus X in tomato causes severe symptom development known as &quot;double streak&quot;. Some symptoms caused by ToMV resemble symptoms induced by hormones such as 2,4-D</td>
<td>The virus is seed-borne. Infested tomato seeds can be the source of infection and the means by which the virus can be disseminated over large distances. The virus can be spread by horticultural workers on contaminated hands, clothing, and tools during routine horticultural operations such as transplanting, tying, pruning, grafting, pollinating, cultivating, spraying, watering, and picking. ToMV is a closely related strain of tobacco mosaic virus (TMV). The virus is quite stable under adverse environmental conditions and can persist in plant debris in dry soil for 2 years or in moist soil for 1 month or in root debris in fallow soil for 22 months. It can also persist in greenhouse structures for long periods of time. Healthy seedlings planted into contaminated soil can be infected through minor wounds caused by damage to roots. The virus may also be present in water used for irrigation. Dissemination of tiny particles of contaminated soil by wind is also possible.</td>
<td>Use seed from healthy plants only. Dry heating seed at 70°C for 4 days or at 82-85°C for 24 hr will help to eliminate surface-borne virus. ToMV on the seed coat can be eliminated by soaking seed for 15 min in 100 g/l of tri-sodium phosphate solution (TSP), rinsing thoroughly, and spreading seeds out to dry. Use a minimum 2-year rotation. Avoid following tomato crops with susceptible crops such as tobacco, pepper, eggplant, or cucurbits. Dip hands in milk while handling plants every 5 minutes (more often if different lots of plants are handled). Rubber gloves will protect hands. Remove diseased plants from the field as soon as virus symptoms are noticed. This will reduce the spread of the virus by direct contact between plants. Disinfect tools, stakes, and equipment before moving from diseased areas to healthy areas. This can be done by: (1) heating or steaming at 150°C for 30 minutes; (2) soaking 10 minutes in 1% formaldehyde or a 1:10 dilution of a 5.25% sodium hypochlorite. Work in diseased areas last after working in unaffected parts of a field. Wash clothing that comes into contact with ToMV-infected plants with hot water and a detergent.</td>
</tr>
</tbody>
</table>
### Tomato mottle

**Causal agent:** tomato mottle Gemini virus  
**Transmission:** white fly

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Conditions for disease development</th>
<th>Control measures</th>
</tr>
</thead>
</table>
| Symptoms are more pronounced when plants are infected at an early stage. Stunting and reduced growth, upward curling and distortion of the upper and middle leaves, and chlorosis of yellowing of leaves are typical of this disease. Yield from infected plants is lower due to lack of fruit set and reduced fruit size. | Tomato mottle virus is transmitted by the silverleaf whitefly. The virus has a fairly narrow host range which includes common bean, tropical soda apple and a few solanaceous weeds, but not all bell pepper, the virus is easily and efficiently spread by the whitefly, and severe outbreaks of the disease can be associated with large populations of the insect. It is not easily mechanically transmitted, however, secondary spread by whiteflies is common within the crop. | Control solanaceous weeds and other alternative hosts in the vicinity of tomato fields. If possible plant the crop during a time of the year to avoid the highest whitefly populations. Regular use of mineral oil sprays may reduce the rate of disease spread by reducing virus acquisition and infection by the whitefly vector. The use of insecticides on a regular basis may provide some control, however, whiteflies can develop resistance to pesticides if used excessively. **Chemical control**  
1. Spray seedlings with Acephate (0.15%) or Monocrotophos (0.1%) prior to transplanting.  
2. Spray insecticides like Monocrotophos (0.15%), Acephate (0.15%), at fortnightly intervals after transplanting till flowering stage.  
3. Chemical spray followed by neem seed kernel extract (2%) is also effective in rotation with insecticides. |
### Tomato spotted wilt

**Causal agent:** Tomato spotted wilt virus  
**Transmission:** Thrips

#### Symptoms

Young leaves of slightly infected transplants turn bronze (purplish-brown) and later develop numerous small, dark spots. The bronzing of foliage may extend to large areas of the leaf surface. The bronzed areas may roll inward and the tissue often dies. Heavily infected transplants remain stunted. Shiny, dark brown streaks appear on stems and petioles. Growing tips of plants may die back. Affected fruit have spots about 1 cm in diameter with slightly raised, circular markings. Ripe fruit can be distorted and can have alternate red and yellow bands. Sometimes infected plants are killed by severe necrosis. Host plants and symptoms vary among TSWV strains.

#### Conditions for disease development

TSWV is found in many plants, including solanaceous crops (tomato, pepper, potato and tobacco), pea, lettuce, numerous weeds and ornamentals. The virus is generally spread by thrips (*Thrips* spp.) Thrips are tiny, they multiply quickly, feed on a wide range of plants, and may be easily blown into fields. Thrips feed on the leaf under surface. They puncture plants and suck the juices that flow from the injury. They feed on leaves, stems, fruits and flower parts. Feeding damage causes new growth to become deformed. Young (larval stage) thrips acquire TSWV when feeding from infected plants and then spread the virus as adults when they fly from plant to plant. The virus cannot be transmitted from one generation of thrips to another. Infected weeds or ornamental plants are generally the source of the virus. The life cycle of a thrips varies from 7 to 14 days so there are multiple generations on weed hosts and during the growing cycle of crop plants.

#### Control measures

The presence of thrips in tomato fields can be monitored using yellow sticky cards. Consider planting a non-susceptible crop if TSWV and thrips populations throughout the area are very high. Maintain seedbeds away from cropped areas and from other susceptible plants. Protect transplants with mesh netting (40-mesh or higher) to exclude thrips. Remove crop debris, weeds and other sources of thrips at the end of each crop. Plow and keep fields fallow for 3–4 weeks to allow thrips to emerge and disperse. Reduce cultivation within the field to avoid movement of thrips from infected plants.

Several insecticide like Confidor (Imidacloprid) @ of 1 ml/litre of water, applications should be made at 5-day intervals to significantly reduce a thrips infestation. More than one application is necessary. Five-day application intervals are more effective than 7-day intervals. Ideally, insecticides should be applied with equipment that produces very small spray particles (<100 microns) to maximize spray coverage on plants, including in crevices of plants.
Tomato yellow leaf curl

Causal agent: Tomato yellow leaf curl virus (ToYLCV)

Transmission: White flies

<table>
<thead>
<tr>
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</tr>
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<tbody>
<tr>
<td>Plants are severely stunted with shoots becoming erect. Leaflets are reduced in size and pucker. Leaflets curl upwards, become distorted, and have prominent yellowing along margins and/or interveinal regions. Flowers wither. Plants will set very few fruit after infection occurs; therefore any plants infected before flowering stage will produce extremely low yields. The appearance of the fruit is unaffected.</td>
<td>The virus is not seed-borne. It is only transmitted by the whitefly, <em>Bemisia tabaci</em>, which is commonly found in tropical and sub-tropical regions, and in greenhouses in temperate areas. The whitefly can acquire the virus after feeding on infected plants for 15 to 30 minutes, and can transmit the virus to tomato plants after about 24 hours of incubation within the insect. A period of at least 15 minutes feeding on the new tomato host is subsequently required for transmission of the virus. The whitefly retains the virus for up to 20 days and does not transmit it to its progeny. Symptoms develop on young plants after 10 to 14 days. Hot and dry conditions favour the whitefly, and therefore, help the spread of TYLCV. Whitefly populations decrease after heavy rain showers. Under normal conditions whiteflies hover above the crop during the day or they are passively wind-driven over long distances. During the night they settle on the lower leaf surfaces. Disease incidence increases rapidly and can reach 100% infection at harvest. In the field, disease incidence varies with location rather than with season. Tobacco is a symptomless host and can therefore serve as a source for re-infection of tomato crops. Other hosts for the virus are weeds such as jimsonweed that can serve as a source of inoculum.</td>
<td>Grow seedlings in an insect-proof net house (50-mesh size or finer) or in a greenhouse, and maintain good control of whiteflies in these structures in order to prevent early infection of seedlings by whitefly feeding. Plant new tomato crops in isolated fields. If feasible, plant a tall border crop, such as maize, around the tomato crop. Use mulches of straw, yellow plastic or UV-reflective material to reduce landing of whiteflies. Other methods include a 1% soap solution carefully applied to the leaf under surface to control the adult vector. Care should be taken to avoid development of phytotoxicity if spraying occurs during very high temperatures. Oil sprays may also be effective in reducing levels of infestation. Neem tree seed extracts control young nymphs, inhibit the growth and development of older adults, and reduce egg-laying by adults. TYLCV-resistant and tolerant tomato varieties for some strains of the virus are commercially available. Chemical control methods include the application of systemic insecticides like Confidor (Imidacloprid) @1ml/litre of water as soil drenches or regular sprays during the seedling stage to reduce the population of the whitefly vector. A second application may be necessary to control adults that have emerged from the egg and nymph stage since the application of the first spray.</td>
</tr>
</tbody>
</table>
### Symptoms

The first indication of infection appears at the tips of the actively growing shoots. The Youngest fruit truss, instead of becoming recurved as in normal plants, assumes an upright position. The buds on the truss also point in a vertical direction, the calyx segments remain united almost to the tips, and the whole calyx enlarges to a form like a bladder with a toothed opening at the top. On pruned plants in the field, the growing points fail to develop normally. After a short time, the axillary buds grow out, forming shoots affected in the same way as the main shoot. Simultaneously, there is a gradual thickening of the stems of the affected parts due to the formation of an abnormal tissue, In cases where the growth of the terminal buds completely ceases, the thickening of the stems may become very marked. The disease appears initially on young developing. The affected leaves become yellow-green and roll along their margins. The size of the leaves reduces as the disease advances. Fruit that is well developed but still green at the time of infection becomes hard and tough and colours extremely slowly or not at all.

### Conditions for disease development

The disease infects all the plant parts. The big bud of tomato is transmitted by leaf hopper (*Orosius argenatatus*). This phytoplasma can survive in crops such as hot pepper, lettuce, eggplant and potato, as well as weeds such as dock, lamb's quarter, nightshade, sow thistle and jimsonweed, and is readily transmitted to tomato by the common brown leafhopper. Transmission occurs when leafhoppers carrying the phytoplasma migrate to tomato and feed.

### Control measures

Big bud is generally only of occasional importance. Removing host weeds adjacent to tomato plants and controlling the leafhopper vectors with an insecticide program are usually sufficient. Foliar application of Confidor (Imidacloprid) 1ml/litre of water 21 to 45 days apart are recommended on coarse soils or where the longest periods of protection is required. Make the first application between bud break and pea-berry stage.

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**Tomato big bud**

**Causal agent:** MLO

**Transmission:** Brown Leaf hopper
The diagnostic symptom is a light tan lesion turning to a dark brown sunken area at the blossom end of the fruit. The lesion typically enlarges and becomes more sunken and leathery, and is often accompanied by a dry rot. A black mold may grow on the surface of the lesion. Sometimes there is an internal black rot of tissue in the centre of the fruit with little or no external symptoms. Normally, fruit that are about half developed are the first to show symptoms.

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<td>In general, any soil or growing condition affecting the uptake of calcium may result in this disorder. Blossom end rot often occurs during alternating periods of high and low soil moisture as well as rapid plant growth. Other conditions which could cause blossom end rot include excessive soil salinity and root damage.</td>
<td>The use of tolerant varieties may help reduce the occurrence of this disorder. Application of calcium fertilizers before planting are commonly used to reduce the incidence of blossom end rot. Irrigation during dry weather or applications of mulch to provide a constant moisture supply to the plant can help prevent this problem. The use of excessive nitrogen, especially in the ammonium form should be avoided since this increases the demand for calcium by the plant and reduces the availability of calcium in the soil. Fields which are difficult to irrigate uniformly or those with high salinity should be avoided. Root injury caused by mechanical damage or disease can exacerbate this condition and should be avoided.</td>
</tr>
</tbody>
</table>
Contact herbicides, those that affect only the tissues they contact, typically cause chlorotic or necrotic spots on all parts of the plant. Multiple spots can result in deformation of the affected tissues. Systemic herbicides, those that are translocated in the plant, tend to cause a variety of symptoms including stunting. These range from a general yellowing of the foliage to yellowing or necrosis of tissues in the centre of the leaf, to a yellowing or necrosis of the leaf veins that may expand to the interveinal tissues. Systemic herbicides may also cause necrotic spots, leaf margin necrosis, twisting and upward or downward leaf cupping, as well as mild to severe deformation and swelling of the stem and petiole. Root growth may be inhibited and the roots may become stubby. Fruit symptoms range from the development of excessively large or small irregular shaped fruit, to the development of flat or nippled blossom ends or internal deformations.

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<td>Generally, foliar damage occurs when the herbicides and insecticides are applied at excessive rates, at the wrong stage of plant growth or during unfavourable weather conditions. Damage often occurs from herbicide drift when crops or weeds adjacent to the tomatoes have been sprayed. Damage from drift is usually most severe at the edge of the field closest to where the herbicide was applied, with the damage decreasing with increasing distance from the source.</td>
<td>Use herbicides as directed and apply during the appropriate weather conditions.</td>
</tr>
</tbody>
</table>
### Symptoms

Edema (Oedema) is a common physiological disorder. Symptoms vary depending upon the plant species or cultivar affected. Bumps, blisters, or water-soaked swellings form on the underside of leaves. These blisters are first small, about 1 to 2 mm in diameter. They then turn tan or brown and become corky. Severely affected leaves turn yellow and drop from the plant. Sometimes, stems and petioles become infected.

Edema is often confused with two-spotted mite or thrips feeding damage. Symptoms that often spread to the youngest leaves. Stippling from mite feeding is not seen on ivy geraniums. To distinguish mite feeding injury from edema, use a 10x to 20x hand lens, to look on the underside of leaves for the two-spotted mites. Edema can also be confused with thrips injury. Use a hand lens to look for the small, yellow thrips larvae on the underside of the leaves. As thrips feed upon the ivy geraniums, white scarring and leaf distortion may be noticeable, especially on the youngest leaves.

### Conditions for disease development

Edema is thought to be caused by an imbalance of the plant’s water uptake and water loss. It develops when the plants roots absorb water at a faster rate than it is transpired through the leaf cells. The enlarged leaf cells divide, and then rupture. This rupturing of the leaf epidermis and inner cells causes the raised blisters commonly seen on the underside of leaves. This is where the air is most humid with poor air circulation that reduces the plant’s transpiration rate. During cool, cloudy weather conditions, humidity levels are high whereas transpiration rates are low. So, environmental conditions are ideal for Edema to develop, even when growers modify their cultural practices in an attempt to prevent this disorder.

### Control measures

Growers can try to prevent Edema by changing some of their cultural practices. Select a growing medium that drains well. Space plants further apart so they receive more light. Keep plants on the dry side during cool, cloudy growing conditions. Water when air temperature is rising and humidity is low. Do not water susceptible varieties or crops on cloudy days. Reduce humidity levels in the greenhouse by heating and venting in the evening and early morning. Use horizontal air flow (HAF) fans to keep air moving in the greenhouse. Place plants with similar water needs on the same irrigation line to reduce the probably of over watering.

### Causal agent

Environmental
Symptoms

Sunscald first appears as light patches on green or ripening fruit.

Most often, sunscald develops on the side of the fruit that faces the sun.

As the patches grow, they may blister and may become grayish-white.

Affected sunscald tomatoes can develop black mold.

Conditions for disease development

Sunscald occurs when tomatoes or peppers are exposed to the direct rays of the sun during hot weather. It is more apparent on plants that have sparse foliage or those that may have previously lost a good deal of leaves to a leaf-defoliating disease. Sunscald is especially prevalent on previously shaded plant parts that have been suddenly exposed to the sun. The damaged areas are vulnerable to attack by insects, fungi, and bacteria.

control measures

Don't over-prune tomato plants, especially in hot climates. If you leave extra branches on plants, you’ll provide extra shade for fruit.

Practice controls for leaf diseases in order to prevent defoliation that leaves the fruits more vulnerable to sunscald. These practices may include crop rotation, proper sanitation, and the use of fungicides.

Plant varieties that are tolerant to disease. Select varieties that tolerate Septoria leaf spot and early blight, two of the most common defoliating diseases.
### Table 1: Relative Effectiveness of various chemicals for tomato diseases control

<table>
<thead>
<tr>
<th>Fungicides</th>
<th>Preharvest interval(days)</th>
<th>Bacterial speck</th>
<th>Bacterial spot</th>
<th>Early blight</th>
<th>Late blight</th>
<th>Powdery mildew</th>
<th>Septoria leaf spot</th>
<th>Target spot</th>
<th>Anthracnose</th>
<th>Blackroot rot</th>
<th>Buckeye fruit and root rot</th>
<th>Cercospora leaf mold</th>
<th>Didymella stem rot</th>
<th>Gray leaf spot</th>
<th>Chlamydospore Leaf mold</th>
<th>Phoma rot</th>
<th>Pythium damping off</th>
<th>Southern blight</th>
<th>White mold</th>
<th>Botrytis gray mold</th>
</tr>
</thead>
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<tr>
<td>Chlorothalonil</td>
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<td>-</td>
<td>++</td>
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Key to fungicide groups:

11=quinone outside inhibitors; 27=cyanoacetamideoximes; 28=carbamates; 33=phosphonates; M=Multisite activity; 3=demethylation inhibitors; 15=cinnamic acids

R= Pathogen resistance to this fungicide has been reported, greatly reducing its efficacy. Combine with a protectant fungicide like Chlorothalonil to extend the usefulness of the product
References:

3. Integrated pest Management for tomatoes, 1982, University of califronia, Agricultural Sciences Publication3274.
5. Tomato Diseases Fact Sheet, 2004, The World Vegetable Center; P.O. Box 42, Shanhua; TaiwanAVRDC Publication 04-611
"For better or for worse, Plant Pathology had its genesis in fields and granaries more than in halls of ivy. Society needed agriculture and agriculture need plant pathology."

"Plant pathology has helped reveal profound and useful truths. It was among the pioneers in revealing the vast and variable world of microorganisms and in identifying man's friends and foes amongst them. It has shown how to combat many of the bad ones and how to utilize some of the good ones."

E. C. Stakman. 1959