

Pepper & Eggplant Disease Guide

Edited by
Kevin Conn





Pepper & Eggplant Disease Guide*

A PRACTICAL GUIDE FOR SEEDSMEN,
GROWERS AND AGRICULTURAL ADVISORS

Editor

Kevin Conn

Contributing Authors

Supanee Cheewawiriyakul; Chiang Rai, Thailand

Kevin Conn; Woodland, CA, USA

Brad Gabor; Woodland, CA, USA

John Kao; Woodland, CA, USA

Raquel Salati; San Juan Bautista, CA, USA

All authors are members of the Seminis® Vegetable Seeds, Inc.'s Plant Health Department.
2700 Camino del Sol • Oxnard, CA 93030
37437 State Highway 16 • Woodland, CA 95695

Last Revised in 2006

*Not all diseases affect both peppers and eggplants.

Preface

This guide provides descriptions and photographs of the more commonly found diseases and disorders of pepper and eggplant worldwide. For each disease and disorder, the reader will find the common name, causal agent, distribution, symptoms, conditions necessary for disease or symptom development, and control measures. The photographs illustrate characteristic symptoms of the diseases and disorders included in this guide. It is important to note, however, that many factors can influence the appearance and severity of symptoms.

The primary audience for this guide includes pepper and eggplant crop producers, agricultural advisors, farm managers, agronomists, food processors, chemical companies and seed companies. This guide should be used in the field as a quick reference for information about some common pepper and eggplant diseases and their control. However, diagnosis of these diseases and disorders using only this guide is not recommended nor encouraged, and it is not intended to be substituted for the professional opinion of a producer, grower, agronomist, pathologist and similar professional dealing with this specific crop. Even the most experienced plant pathologist relies on both laboratory and greenhouse techniques to confirm suspicions from the field. Moreover, this guide is by no means inclusive of every pepper and eggplant disease and pest. Rather, we present only those diseases that are prevalent worldwide.

A glossary of words used in the text can be found at the end of this guide, along with a list of references for further disease information.

Always read and follow directions for any herbicide, fungicide, insecticide or any other chemical used for treatment or control.



Thank You

The following individuals contributed photographs for this publication:

Boonlert Aphinaiprasit	Seminis Vegetable Seeds, Inc., (Thailand) Ltd., Pathumthani, Thailand
Giulio Bile	Seminis Vegetable Seeds, Inc., Italia S.r.l., Latina, Italy
Lowell Black	Seminis Vegetable Seeds, Inc., DeForest, WI, USA
Judith K. Brown	University of Arizona, Tucson, AZ, USA
Supanee Cheewawiriyakul	Seminis Vegetable Seeds, Inc., Chiang Rai, Thailand
Raquel De Mello	SVS do Brasil Sementes Ltda., Paulinia, SP, Brasil
Jeffrey Dodson	Seminis Vegetable Seeds, Inc., Oxnard, CA, USA
Robert L. Gilbertson	University of California, Davis, CA, USA
Scott Humphreys	Seminis Vegetable Seeds, Inc., Australia
Shaun Jackson	South Pacific Seeds, Australia
Carlos Lopes	EMBRAPA-CNPQ, Brasil
Gonzalo Sir	Seminis Vegetable Seeds, Inc., S.A. de C.V., México
L. M. Suresh	Seminis Vegetable Seeds (India) Ltd., Aurangabad, Maharashtra, India

Contents

Infectious Diseases and Pests

Bacterial Diseases	7
--------------------	---

- 8 Bacterial Canker
- 9 Bacterial Spot
- 11 Bacterial Stem and Peduncle Canker (Bacterial Soft Rot)
- 12 Bacterial Wilt
- 13 Syringae Seedling Blight and Leaf Spot

Fungal Diseases	14
-----------------	----

- 15 Anthracnose
- 16 Cercospora Leaf Spot (Frogeye)
- 17 Choanephora Blight (Wet Rot)
- 18 Damping-Off
- 19 Fungal Fruit Rots
- 21 Fusarium Wilt
- 22 Gray Leaf Spot
- 23 Gray Mold
- 24 Leaf Spots
- 25 Phomopsis Blight
- 26 Phytophthora Blight
- 28 Powdery Mildew
- 30 Southern Blight (Sclerotium Wilt)
- 31 Verticillium Wilt
- 32 White Mold (Pink Rot, Watery Soft Rot)

Insect Pests and Vectors of Viruses	33
-------------------------------------	----

- 34 Aphids
- 35 Beetles
- 35 Leafhoppers
- 36 Mites
- 36 Whiteflies
- 37 Thrips
- 38 Eggplant Fruit and Shoot Borer

Nematode Disease	39
------------------	----

- 40 Root-Knot

Parasitic Plant	41
-----------------	----

- 42 Dodder

Phytoplasma Disease	43
---------------------	----


- 44 Little Leaf Phytoplasma

Viral Diseases	45
----------------	----

- 46 Alfalfa Mosaic
- 47 Beet Curly Top
- 48 Chilli Veinal Mottle
- 49 Cucumber Mosaic
- 50 Geminiviruses
- 51 Pepper Mottle
- 52 Pepper Yellow Mosaic
- 53 Potato X
- 54 Potato Y
- 55 Tobacco Etch
- 56 Tobamoviruses
- 57 Tospoviruses

Contents

Noninfectious Disorders

 A dark green square icon with the text "Noninfectious Disorders" and a white line-art illustration of a plant stem.		58
	59	Blossom-End Rot
	60	Chemical Damage
	61	Chimera
	62	Cracking
	63	Nutrient Disorders
	65	Salt Toxicity
	66	Stip
	67	Sunscald

<i>Glossary</i>	68
-----------------	----

<i>Selected References</i>	72
----------------------------	----

Bacterial Diseases

INFECTIOUS DISEASES AND PESTS

Bacterial Canker

Causal Agent:

Clavibacter michiganensis subsp. *michiganensis*

Distribution:

Australia, Brazil, China, Israel, South Korea and USA (California, Indiana, Michigan and Ohio)

Symptoms:

Symptoms of bacterial canker in pepper include leaf and fruit spots and, less frequently, systemic wilt. In localized infections, symptoms first appear as small blisters or raised white spots on leaves and stems. Later, the centers of the leaf spots become brown and necrotic, and develop a white halo. Stem lesions often develop a crusty appearance and elongate to form cankers. Symptoms on fruit first appear as very small, round, slightly raised spots. These spots gradually increase in size and may develop a brown center and a white halo. When these are numerous, spots merge and take on a crusty appearance. In systemic infections, a gradual wilting occurs followed by plant death.

Conditions for Disease Development:

The bacterium enters the plant via wounds and stomata. *Clavibacter* may be seed-borne and may infest the seed externally or under the seed coat. High relative humidity and daytime temperatures between 25° and 30° C (77° and 86° F) generally favor the disease. Dense plant populations and overhead irrigation also provide an ideal environment to spread the bacterium. Insects, tools and human contact may also aid the spread.

Control:

Sow only tested seed and certified transplants. Do not transplant peppers into ground used for tomatoes during the previous season. Clean cultivation equipment before entering a new field, avoid entering fields when foliage is wet, and incorporate plant debris immediately after harvest to help reduce losses. Never harvest fruit from symptomatic plants. Rogue all symptomatic and adjacent plants. Rotate to a non-host for a minimum of three years if the disease is found in a field.



Lesions may merge and appear crusty.



Foliar symptoms in field.



Raised lesions on leaf undersurface.



Bacterial canker lesions on green fruit.



Bacterial canker lesions on red fruit.

Bacterial Spot

Causal Agent:

Xanthomonas euvesicatoria
(synonym: *Xanthomonas campestris* pv.
vesicatoria) *X. vesicatoria*, *X. gardneri*

Distribution:

Worldwide in warm, humid areas

Symptoms:

Symptoms develop on leaves, stems and fruit of sweet pepper and are less severe in hot pepper. Symptoms first appear on leaf undersurfaces as small, irregular, water-soaked areas. Later, lesions enlarge, turn dark-brown to black with a pale tan center and may develop a thin, yellow halo. Generally, lesions on upper leaf surfaces are slightly sunken, and those on lower leaf surfaces are slightly raised. Leaves that are severely infected often turn chlorotic and appear ragged. Defoliation occurs under heavy disease pressure. Stem lesions appear as narrow, light-brown, longitudinally raised cankers. Fruit spots begin as water-soaked areas that later turn necrotic. These spots are rough in appearance and crack as they develop.

Conditions for Disease Development:

Xanthomonas is seed-borne on the seed surface and within the seed. Infected seed and transplants moved over long distances can be the initial source of inoculum for epidemics. The bacterium also survives in crop debris, volunteer plants and in solanaceous weeds. High relative humidity and heavy dew formation on leaves, together with warm weather, favor infection and development of Bacterial Spot. The bacterium is readily water-splashed from infected transplants or debris to healthy plants. Fruit are infected through growth cracks, abrasions, insect punctures and other wounds. Secondary fruit rots often develop around Bacterial Spot lesions during damp weather.

Control:

Use only tested and treated seed and certified transplants. Once present, the disease is difficult to control. Commercial varieties with one or more genes for resistance to *X. campestris* pv. *vesicatoria* are available. Copper-based sprays can help reduce the rate of disease development. Clean cultivation equipment before entering a new field, avoid entering fields when foliage is wet, and incorporate plant debris immediately after harvest to help reduce losses due to Bacterial Spot.

Rotation to non-host crops and controlling weeds and volunteer plants are good preventive practices. When the disease is present, avoid overhead irrigation.



Foliar symptoms in the field.



Infected seedlings.



Dark-brown lesions with tan centers.

Bacterial Spot (cont.)



Water-soaked lesions on leaf undersurface.



Longitudinal stem cankers.



Large, rough lesions on green fruit.



Small lesions on peduncle.

Bacterial Stem & Peduncle Canker (Soft Rot)

Causal Agent:

Pectobacterium carotovora, *P. atrosepticum*,
Dickeya chrysanthemi

Distribution:

Worldwide

Symptoms:

This disease affects pepper stems and fruit. Internal discoloration appears on the stem, followed by hollowing-out of the pith and wilting. As lesions expand along the stem, branches break. Foliar chlorosis and necrosis may also develop. Symptoms of post-harvest decay start as sunken, water-soaked areas around the edge of wounds or on the stem end next to the peduncle. These areas may be light or dark and become soft as they rapidly expand. Often, the epidermis splits open, releasing watery, macerated tissue.

Conditions for Disease Development:

Soft rot bacteria are common inhabitants of soils. Under warm, humid conditions, infection through wounds or cut stems occurs. Splashing rain and irrigation water spread bacteria to foliage and fruit.

Control:

In greenhouse operations, provide adequate air circulation to help reduce relative humidity. Avoid injuries to plants during the growing season and on fruit during harvest. Improved sanitation in the field and in packing houses is effective in reducing losses. All harvest equipment, the packing line and packing boxes should be sanitized frequently. Dump tank water and packing line washers should maintain a minimum available chlorine concentration of 150 ppm at a pH of 6.0 to 7.5. Wet fruit should be dried promptly before packing and then cooled quickly to below 10° C (50° F).



Soft sunken lesions.



Fully macerated fruit.



Soft rot infected fruit.

Bacterial Wilt

Causal Agent:

Ralstonia solanacearum (synonym = *Burkholderia solanacearum*, *Pseudomonas solanacearum*)

Distribution:

Worldwide in the tropics, semi-tropics and some temperate regions

Symptoms:

In tropical and subtropical regions, affected plants may wilt and die within days of infection. Leaves may appear healthy or only slightly yellow prior to plant death. Under temperate conditions, infected plants develop a slower, progressive wilt in which leaves turn yellow. The lower stems of affected plants develop dark, vascular browning that often extends into the cortical and pith tissues. When stems of symptomatic plants are cut and placed in water, milky white streams of bacteria flow from cut ends.

Conditions for Disease Development:

Ralstonia Solanacearum is soilborne and can survive for long periods in the soil on roots and debris. The bacterium infects roots through wounds caused by nematode feeding, transplanting and cultivation. High temperatures and high soil moisture generally favor the disease. Bacteria is spread in irrigation water, diseased transplants and in soil moved with cultivation equipment.

Control:

When possible, avoid land with a history of Bacterial Wilt. Commercial pepper and eggplant varieties with intermediate resistance to Bacterial Wilt are available. Resistant rootstocks are also available. A soil pH between 5.5 and 7.0, good soil drainage and raised beds help alleviate disease pressure. Rotate to non-host crops in order to lower the population of bacteria in the soil.



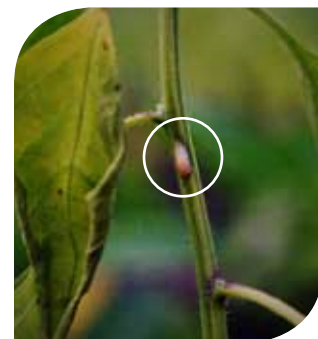
Bacterial wilt of hot pepper.



Susceptible eggplant between rows of intermediate resistant plants.



Wilted eggplant.



Bacteria oozing from pepper stem.



Mild (left) and severe (right) vascular discoloration of pepper.

Syringae Seedling Blight & Leaf Spot

Causal Agent:

Pseudomonas syringae pv. *syringae*

Distribution:

Southern and Southeastern Europe, Southern USA

Symptoms:

Affected leaves or cotyledons develop irregular, water-soaked lesions that later become necrotic, turning dark-brown with a light center. Lesions may coalesce to form relatively large necrotic areas. Lesions with chlorotic halos are rare. However, under heavy disease pressure, large areas of the leaf may be affected and the whole leaf may prematurely turn yellow and drop. Infected fruit develop brownish-black, watery lesions that expand and rot. Symptoms of Syringae Seedling Blight can be confused with those caused by Bacterial Spot. However, the lower temperatures at which Syringae Seedling Blight occurs can help differentiate these two diseases.

Conditions for Disease Development:

Temperatures between 16° and 24° C (60° and 75° F) and high humidity favor Syringae Seedling Blight. Bacteria is generally spread by splashing water that enters the plant through natural openings or wounds.

Control:

Avoid low temperature and high humidity conditions in nurseries. Inspect seedlings for symptoms before transplanting to avoid introducing the disease to the field. Avoid overhead irrigation whenever possible.



Discrete and coalescing lesions.



Coalescing lesions with light centers.

Fungal Diseases

INFECTIOUS DISEASES AND PESTS

Anthracnose

Causal Agent:

Colletotrichum capsici, *C. gloeosporioides*, *C. coccodes*, *C. acutatum*.

Distribution:

Worldwide

Symptoms:

Anthracnose affects all above-ground parts of peppers during any stage of growth. Seedling infection may be confined to cotyledons and not spread. Necrotic gray to brown spots may develop on leaves and stems. Fruit lesions are the most economically important aspect of this disease. Fruit symptoms begin as water-soaked areas that turn tan or brown. Lesions may be small and circular, or coalesce to cover large areas of the fruit. Under moist conditions, pink, salmon or orange masses of spores are formed, usually in concentric rings. Depending on the *Colletotrichum* species present, black or brown filamentous structures may be visible in the lesion. Anthracnose can affect both green and ripe fruit, but symptoms are usually not visible until fruit ripen and turn red.

Conditions for Disease Development:

Warm, wet weather generally favors infection and development of symptoms. Depending on the species of *Colletotrichum* present, optimal temperatures for infection range from 20° to 27° C (68° to 81° F). Free moisture is necessary for infection. Fog and dew are conducive to disease development. Rain disseminates the pathogen's spores and often leads to severe losses, especially if fruit are wounded. These fungi can survive in infected seed and persist in leaf or stem lesions in plant debris for long periods of time.

Control:

This disease can be managed by sowing good quality seed, rotating out of solanaceous crops for two to three years, removing weeds and infected debris, and choosing fields that drain well. Minimize fruit wounds by controlling insects. Copper fungicides are available, but have limited economical value for controlling this disease.



Stem lesion.



Concentric rings of spores.



Natural field infection.



Gray necrotic spots on cotyledons.



Anthracnose lesion on green fruit.



Coalescing lesions with salmon-colored spores.

Cercospora Leaf Spot (Frogeye)

Causal Agent:

Cercospora capsici, *C. melongenae*

Distribution:

Worldwide

Symptoms:

This disease affects the leaves, petioles, stems and peduncles of pepper and eggplant. Symptoms first appear as small, circular to oblong chlorotic lesions. Lesions later turn necrotic with a sporulating light-gray center and a dark-brown margin. Concentric rings may be observed as individual lesions expand. These lesions often resemble frog eyes, giving this disease its common name. As the lesions dry, the centers crack and drop out. When the disease is severe, defoliation and reduction in fruit size occur.

Conditions for Disease Development:

These fungi can survive for at least one year in infected plant debris. Wet, warm weather conditions favor disease development. Spores are spread by wind, rain and irrigation water or mechanically by equipment and people.

Control:

A calendar-based protectant fungicide spray program combined with cultural practices can help reduce losses from Cercospora Leaf Spot. Turn under or remove all plant debris and rotate to non-host crops to lower field inoculum levels. Mulch and furrow or drip irrigate to help reduce spread of the pathogen from splashing water.



Centers of lesions dry and crack on pepper.



Lesions with concentric rings on pepper.



Necrotic lesions on eggplant.



Sporulating center with chlorotic halo on pepper.

Choanephora Blight (Wet Rot)

Causal Agent:

Choanephora cucurbitarum

Distribution:

Worldwide in tropical regions

Symptoms:

Symptoms are visible on apical growing points, flowers and fruits. Initially, water-soaked areas develop on leaves, and apical growing points become blighted. Later, the fungus grows rapidly downward, causing dieback. Dark-gray fungal growth can be seen on some lesions. Close inspection will reveal silvery, spine-like fungal structures and dark spores. In seedlings, symptoms may be confused with Phytophthora Blight. A black soft rot can also develop in fruit.

Conditions for Disease Development:

The fungus is found throughout the tropics on many crops including beans, peas, squash, cucumber, eggplant and pepper. Extended periods of rain, high humidity and high temperatures generally favor fungal sporulation and disease development. The fungus is generally spread via wind and splashing water, and on clothing, tools and cultivation equipment.

Control:

There are few management techniques available; fungicide sprays may help reduce disease damage.



Wet rot of pepper seedlings.



Blight and dieback of pepper foliage and fruit.



Necrotic dieback and fruit rot of pepper.



Sporulation along pepper stem.



Sporulation on eggplant fruit.

Damping-Off & Root Rot

Causal Agent:

Pythium spp., *Rhizoctonia solani*, *Fusarium*

Distribution:

Worldwide

Symptoms:

Pre-emergence Damping-Off: Seeds may rot before germinating or seedlings may die prior to emergence.

Post-emergence Damping-Off: Young seedlings develop a rot at the crown. Later, the tissue becomes soft and constricted, and the plants wilt and fall over.

***Pythium spp.*:** This fungus is the most common cause of pre-emergence Damping-Off. Typical symptoms include dark-brown to black, water-soaked lesions that rapidly spread over the entire seedling. Brown, water-soaked lesions that start on the roots and later extend up the hypocotyl characterize post-emergence Damping-Off. Eventually, the lesions girdle the hypocotyl, causing seedlings to wilt and die. The root cortex becomes macerated and easily sloughs off.

***Rhizoctonia solani*:** Pre-emergence symptoms include reddish-brown lesions on hypocotyls and death of growing tips. Post-emergence Damping-Off is characterized by reddish-brown to black lesions that develop on roots and hypocotyls at or below the soil line. Later, hypocotyls collapse and seedlings wilt and die.

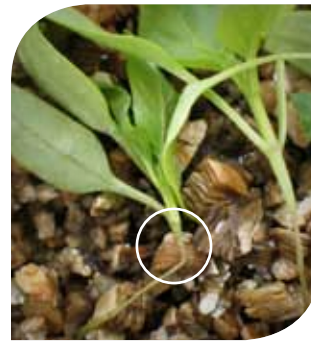
***Fusarium spp.*:** Dark-brown lesions on hypocotyls characterize pre-emergence Damping-Off. Post-emergence Damping-Off is characterized by dark-brown lesions on roots and hypocotyls at or near the crown. Lesions eventually girdle hypocotyls, killing the seedlings. Root lesions become soft and water-soaked.

Conditions for Disease Development:

These fungi have a wide host range and can survive for long periods in soil, plant debris and weeds. Damping-Off is generally most severe under conditions of high soil moisture and/or compaction, overcrowding, poor ventilation and cool, damp, cloudy weather. Water-splashing moves infested soil from diseased to healthy plants.

Control:

Improving drainage and moisture regulation to help prevent soil saturation reduces Damping-Off. Fungicidal soil drenches and seed treatments are available that help manage Damping-Off. Rotation to cereal crops and soil fumigation or solarization may help reduce Damping-Off in the field. Use pasteurized soil mixes in nurseries.



Girdled hypocotyl leads to seedling death.



Post-emergence Damping-Off in the field



Pepper (left) and eggplant (right) showing rot.

Fungal Fruit Rots

Distribution:
Worldwide

Alternaria Rot

Causal Agent:
Alternaria alternata

Symptoms:

Symptoms first appear as water-soaked, gray lesions that collapse and darken. Lesions turn velvety as spores are produced. Infection generally occurs at growth cracks, injuries or at the blossom-end of fruit. Internal colonization of pepper fruit without external signs of infection can occur when flowers are infected.

Anthracnose Fruit Rot (Ripe Fruit Rot)

Causal Agent:
Colletotrichum capsici, *C. coccodes*, *C. gloeosporioides*, *C. acutatum*

Symptoms:

These fungi may infect the epidermis of immature fruit and remain latent until harvest. Symptoms usually develop on ripe fruit, giving this disease its common name: "Ripe Fruit Rot." Fruit lesions first appear as small, indefinite, slightly sunken, water-soaked spots that may enlarge rapidly and coalesce. Later, fruiting bodies form in concentric circles to cover the surface of lesions. The lesions appear tan or brown and are covered with salmon to orange gelatinous spores. If the fruit rot extends to the seed cavity, it may infest and infect the seed.

Botrytis Fruit Rot (Grey Mold Rot)

Causal Agent:
Botrytis cinerea

Symptoms:

Initial infection occurs when fruit are in direct contact with the soil. The fungus also colonizes dying flowers and fruit through the stem end, growth cracks and wounds. *Botrytis* also infects cold-injured fruit. Soft rot may develop and consume the fruit entirely. Affected areas are gray to olive green, slightly sunken and have distinct margins. The epidermis peels away easily from lesions to reveal softened, watery underlying tissue. Under humid conditions, gray-brown mycelia develop on the surface, and grape-like clusters of spores can be seen with a hand lens.



Alternaria fruit rot.



Velvety sporulation of *A. alternata*.



Anthracnose fruit rot.



Botrytis fruit rot.

Fungal Fruit Rots

Phytophthora Fruit Rot

Causal Agent:

Phytophthora capsici, *P. nicotianae* var. *parasitica*

Symptoms:

Phytophthora rot occurs when fruit are in contact with the soil or mycelia grows through the peduncle into the fruit. Infected fruit tissue is water-soaked and dark-green at first; later, white mycelium and sporangia develop on the surface of the affected area and, within several days, consume the entire fruit. In contrast to infected tomato fruit, no concentric rings develop. Fruit affected by these fungi dry rapidly and shrivel, but do not drop.

Rhizopus Rot

Causal Agent:

Rhizopus stolonifer

Symptoms:

Contamination and wounding of fruit during the packing process is the primary means of infection. Symptoms first appear as soft, water-soaked lesions that are not discolored. Lesions develop from wounds, the stem end or inner walls, and quickly enlarge to engulf the entire fruit. When the epidermis ruptures, liquefied tissue is released. Under high humidity, profuse, coarse mycelia cover lesions. Later, white sporangia develop that turn black as they mature, giving a peppery, speckled appearance to the mycelia. In storage, these fungi penetrate directly from nests of infected fruit into adjacent healthy fruit.

Conditions for Disease Development:

Rain splashes overwintering spores from soil and crop debris onto developing fruit. Symptom development is generally favored by high humidity. Botrytis fruit rot occurs during periods of cool, wet weather. The remaining four fruit rots occur during warm, wet weather.

Control:

Fruit injury during harvest and packing should be avoided. Improved sanitation in the field and in the packinghouse is effective at helping to reduce losses due to fruit rots. All harvest equipment, the packing line and packing boxes should be sanitized daily. Dump-tank water and packing-line washers should maintain a minimum available chlorine concentration of 150 ppm at pH 6.0-7.5. Culling infected and injured fruit during packing help reduce losses due to post-harvest decays. Wet surfaces should be dried promptly before packing, and fruit should be cooled quickly to 10° C (50° F).



Botrytis cinerea sporulating internally.



Phytophthora fruit rot.



Shriveled fruit infected by a *Phytophthora* species.



Rhizopus fruit rot.

Fusarium Wilt

Causal Agent:

Pepper: *Fusarium oxysporum* f. sp. *capsici*

Eggplant: *Fusarium oxysporum* f. sp. *melongenae*

Distribution:

Pepper: Argentina, Italy, Mexico and USA

Eggplant: Israel, Italy, Japan, Netherlands and USA

Symptoms:

Symptoms first appear as a slight yellowing of foliage and wilting of upper leaves. As wilting progresses, leaves may turn dull-green to brown and remain attached to the plant. When the stem and roots are cut diagonally, reddish-brown streaks are visible in the vascular tissues.

Conditions for Disease Development:

The fungus survives in the soil for several years and is spread by farm equipment, irrigation water and infected plant debris. Warm soil temperatures (33° C; 92° F) and high soil moisture generally favor rapid disease development.

Control:

Plant on raised beds to help promote soil water drainage away from roots. Thoroughly disinfect equipment before moving from infested to clean fields.



Leaves remain attached to wilted pepper plant.



Affected pepper plants wilt and die.



Fusarium Wilt symptoms on eggplant.



Initial symptoms on pepper include yellowing of foliage.



Vascular tissues with reddish-brown streaks.

Gray Leaf Spot

Causal Agent:

Stemphylium solani, *S. lycopersici* (synonym: *S. floridanum*)

Distribution:

Worldwide

Symptoms:

Small spots develop on pepper leaves, petioles, stems, peduncles and calyxes. Although mature plants can be infected, young seedlings are most susceptible. Infection begins as small red to brown spots that later expand into lesions with white to gray centers and red to brown margins. When numerous lesions develop, leaves turn yellow and drop. Gray leaf spot does not affect fruit.

Conditions for Disease Development:

These fungi survive in soil and on plant debris from one year to the next. In addition, volunteer pepper and tomato and solanaceous weeds can serve as sources of inoculum. Fungal spores are spread from the surface of infected tissues by wind and splashing water. Warm and humid or wet weather generally favor disease development. The disease also can be a problem in arid climates when dew periods are long.

Control:

Remove plant debris, provide adequate ventilation for seedling beds and treat with fungicides to help reduce losses from this disease.



Developing lesions.



Lesions with light centers and dark margins.



Numerous lesions with developing leaf chlorosis.

Gray Mold

Causal Agent:

Botrytis cinerea

Distribution:

Worldwide

Symptoms:

This fungus typically causes damping-off or tip dieback in young seedlings. However, it can infect through wounds in all above-ground parts of mature plants. On stems, initial infection appears as elliptical, water-soaked lesions that later expand, and can girdle and kill the plant. Leaf infections usually begin at points of injury and develop into V-shaped lesions. Under high humidity, stem and leaf lesions can be covered by sporulating gray mycelia. Fruit infection begins as water-soaked spots that increase rapidly in size to form gray-brown sporulating lesions.

Conditions for Disease Development:

This fungus has a wide host range. It is an efficient saprophyte and can survive as sclerotia in soil and infected plant debris for long periods. *Botrytis cinerea* is considered a weak parasite and typically infects plant tissues through wounds. Overcast, cool, humid weather is required for disease development. Under these conditions, gray masses of fungal spores are produced and are readily wind-disseminated. Close spacing and poor ventilation in greenhouses can lead to severe gray mold problems.

Control:

Prune plants to promote adequate ventilation, and apply fungicides to the pruning wounds to help reduce losses from this disease. Carefully manage irrigation and air circulation to avoid long periods of high relative humidity in greenhouses.



Lateral tip dieback.



Girdling of stem and sporulation.



Typical V-shaped lesion.

Leaf Spots

Causal Agent:

Alternaria spp., *Septoria melongenae*,
Cercospora spp.

Distribution:

Worldwide

Symptoms:

First visible symptoms of foliar infection are expanding necrotic spots with yellow to dark-brown margins. Infection usually starts on lower leaves and moves up the plant as the disease progresses. Leaf spots caused by *Stemphylium melongenae* later break apart, giving the appearance of "shot holes." Leaf spots caused by *Alternaria* spp. are irregular in shape with concentric rings that enlarge, and can cover the leaf blade. Early infections by *Alternaria* spp. may cause a seedling dieback known as "collar rot." *Cercospora* spp. can also cause small, irregular leaf spots that later are covered with gray sporulation. Fruit lesions start as necrotic spots and develop into sunken, scab-like lesions that extend into the flesh of the fruit, turning it hard and brown. Defoliation caused by extensive infection exposes fruit to direct sunlight, resulting in sunscald.

Conditions for Disease Development:

Disease development is generally dependent on high relative humidity. These fungi overwinter in or on infested debris and organic matter in the soil. Splashing irrigation water to the foliage facilitates spread of the disease. Wounding predisposes fruit to infection when these fungi are present.

Control:

Use field sanitation techniques such as crop rotation, weed control and removal of debris from previous crops to help reduce disease severity. Use mulching and furrow irrigation to reduce splashing and excess leaf wetness. Use good quality seeds.



Leaf spot of eggplant.

Phomopsis Blight

Causal Agent:

Phomopsis vexans

Distribution:

Worldwide, in tropical and subtropical areas

Symptoms:

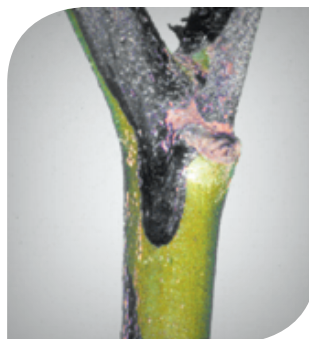
This fungus attacks seedlings soon after emergence. Dark-brown lesions develop on the stem above the soil line. Eventually, a dry rot or canker girdles the stem and the seedling collapses and dies. When older plants are infected, circular or irregular gray to brown lesions develop on lower leaves and stems. Lesions enlarge and coalesce, causing complete yellowing of foliage and severe defoliation. Cankers on stems can cause wilting and death of the upper plant. Fruit lesions start as soft, light-brown, sunken oval areas. Later, fruit lesions deepen, enlarge and coalesce to develop a soft, spongy rot. In dry weather, fruit may shrink and mummify. A diagnostic characteristic is the minute black fruiting bodies (pycnidia) that develop in a circular pattern in the center of mature lesions. Pycnidia are the inoculum source for later infections.

Conditions for Disease Development:

This fungus can survive in plant debris or in mummified fruit in the soil. Infection may occur when rain or overhead irrigation splash inoculum to foliage and stems. Seed produced on plants grown in affected fields can be infested with fungal spores and may initiate disease on seedlings. Phomopsis blight is generally favored by hot, wet weather.

Control:

Sow high-quality seed to help produce pathogen-free transplants. Remove and destroy all infected plant material, and establish a crop rotation to break the disease cycle. Mulch and furrow irrigate to help reduce splashing of water and soil. A regular schedule of protectant fungicide sprays may reduce damage in areas where the disease is known to occur.



Dark lesions on stem.



Progressive fruit rot.



Pycnidia form on mature lesions.



Pycnidia form in concentric rings.

Phytophthora Blight

Causal Agent:

Phytophthora capsici

Distribution:

Worldwide

Symptoms:

All plant parts can be infected. Root infection typically results in a rapid wilting of the plant. Infected roots turn dark-brown and the outer cortex sloughs off easily. Crown infections start as dark-green, water-soaked lesions that turn dark-brown as they expand. A cross-section through the infected crown reveals dark-brown discoloration that may extend throughout the cortex. Leaf symptoms start as small irregular, water-soaked lesions. As lesions expand, infected tissue dries and turns tan. Sporulation may be observed on leaf surfaces under conditions ideal for fungal growth. Infected stems may be girdled and later dieback. Fruit lesions initially appear dark-green and water-soaked. As infection expands, fruit shrivel, but typically do not drop. Fungal spores and mycelium may be observed on fruit surfaces.

Conditions for Disease Development:

Rainfall, wet soils and poor drainage generally favor disease development and spread. In climates where irrigation is used, extended periods of soil wetness also favor the root and crown rot, stage of *Phytophthora* Blight. Disease spread usually follows the direction of surface water run-off. In climates with heavy rainfall, foliar blight, as well as root and crown rot occur. Splashing rain and wind spread disease from plant to plant. Spread can also occur when soil is carried on equipment and footwear. *Phytophthora capsici* can survive in the soil for years in tropical, subtropical and temperate climates.

Control:

Use fungicide sprays in combination with cultural practices such as water management and crop rotation to manage *Phytophthora* Blight. Plant on raised beds to help promote water drainage away from plant roots.



Localized area of wilting and plant death in a field.



Wilt symptoms on pepper.



Leaf symptoms on pepper.



Leaf blight and stem dieback on pepper.

Phytophthora Blight (cont.)



Black stem lesions on pepper.



Blight and wilt on eggplant.



Root and crown rot on eggplant.



Sporulation on eggplant fruit.

Powdery Mildew

Causal Agent:

Leveillula taurica (anamorph: *Odiopsis sicula*) on pepper and eggplant, and *Golovinomyces cichoracearum* (synonym: *Erysiphe cichoracearum*) (anamorph: *Oidium cichoracearum*) on eggplant

Distribution:

Worldwide (*L. taurica*); Asia (*G. cichoracearum*)

Symptoms:

Leveillula taurica: During initial stages of infection, light-green to bright-yellow blotches appear on upper surfaces of leaves. These areas later turn necrotic. Infected leaves curl upward, and a powdery, white growth is visible on the underside of leaves. When lesions are numerous, they often coalesce, resulting in general chlorosis and leaf drop. The disease progresses from older to younger leaves. Fruits on affected plants are overexposed to sunlight and may develop sunscald.

Golovinomyces cichoracearum: Initially, small circular to irregular, whitish, powdery areas appear on upper and lower leaf surfaces. Infected areas can expand to cover leaves, petioles and stem tissues. Older leaves are affected first, and later, the disease progresses up towards new growth. Affected leaves eventually turn yellow and necrotic.

Conditions for Disease Development:

These fungi have a wide host range. Airborne conidia from previous crops or weeds can be carried long distances by wind and act as initial sources of inoculum. High relative humidity is not required for infection. Warm temperature and low light conditions generally favor disease development.

Control:

Apply protectant fungicides before an epidemic or immediately after the first symptoms are observed. Provide for air circulation around plants and light penetration through the canopy. Excessive fertilization has been reported to increase the severity of powdery mildew epidemics.



Initial symptoms of infection on pepper leaves.



Profuse sporulation on undersurface of pepper leaves.

Powdery Mildew (cont.)



Necrotic lesions develop in later stages of disease.



Sporulation on eggplant cotyledons.



Close-up of sporulation.



Initial symptoms on pepper plants.



Sporulating lesion on eggplant stem.

Southern Blight (Sclerotium Wilt)

Causal Agent:

Sclerotium rolfsii (teleomorph: *Athelia rolfsii*)

Distribution:

Worldwide

Symptoms:

This fungus infects emerging seedlings below or at the soil level and causes damping-off. Under favorable environmental conditions, *Sclerotium rolfsii* is able to infect any part of the plant. The first symptoms of disease in mature plants are dark-brown lesions on the stem at or just beneath the soil line. First foliar symptoms are progressive yellowing and wilting. Later, the fungus produces fan-like webs of whitish mycelium around the rotted stem. Small brown sclerotia form within the mycelial mass. As the disease progresses, infected plants wilt and die.

Conditions for Disease Development:

Sclerotium rolfsii has a wide host range. The fungus overwinters as mycelium or sclerotia in and on infected plant debris. Sclerotia can survive in soil for many years. Rainfall or irrigation following a period of drought generally stimulates germination of sclerotia and initiates the infection process. High humidity and warm temperatures generally favor rapid fungal growth and disease development. A soil pH between 3 and 5 is best for fungal growth. At a soil pH of 7 or above, germination of sclerotia is inhibited. Sclerotia spread short and long distances in infected transplants, plant debris, soil, surface water, and on farm equipment and poor quality seed.

Control:

Rotate with grasses and deep-plow to bury sclerotia to help reduce soil inoculum level. Grow plants in raised beds to promote soil drainage. In small-scale plantings, rogue infected plants when symptoms are first visible to reduce disease spread. Soil fungicides and biological control using *Trichoderma* spp. and *Gliocladium virens* offer some protection.



Irregular distribution in the field.



Yellowing and wilting of foliage.



Mycelia and sclerotia at the base of an infected pepper plant.

Verticillium Wilt

Causal Agent:

Verticillium dahliae, *V. albo-atrum*, *Verticillium* spp.

Distribution:

Worldwide

Symptoms:

These soilborne pathogens cause a wilt by blocking the vascular system of the plant. Although seedlings can be infected, symptoms usually are not observed until plants are older. In eggplant, symptoms of Verticillium Wilt infection progress slowly. A characteristic symptom of infection is a V-shaped lesion that develops on older leaf tips that later expands to cover the leaf. Infected peppers are stunted and lower leaves are slightly chlorotic. As the disease progresses in peppers and eggplant, stunting and chlorosis become severe with diurnal wilting. Wilting can be asymmetric, with sections of the plant remaining turgid. Permanent wilt and plant death follow. Dissecting through the crown of affected plants reveals dark-brown vascular discoloration, which can extend into the pith and up into the stem and branches. Fruit that form are small and deformed with internal discoloration.

Conditions for Disease Development:

These fungi have an extremely wide host range and can survive in soil and plant debris for several years. Temperatures between 21° and 25° C (70° and 77° F) generally favor disease development. *Verticillium* enters plants through root wounds caused by cultivation, secondary root formation and nematode feeding. Symptomatic plants may be few and restricted to one area, or occur throughout an entire field or greenhouse. Disease development is favored in heavy clay soils.

Control:

Soil fumigation, solarization and crop rotation to non-hosts help reduce disease incidence. Although no existing commercial varieties have resistance, grafting onto resistant rootstocks is practiced in some countries.



Discoloration extends into stems and branches.



Vascular discoloration of eggplant stem.



Yellowing of eggplant foliage.



Wilt and V-shaped leaf lesions on eggplant.



Exposed stem tissues of infected pepper (left) and healthy peppers (right)

White Mold (Pink Rot, Watery Soft Rot)

Causal Agent:

Sclerotinia sclerotiorum

Distribution:

Worldwide

Symptoms:

The first symptoms of white mold are dark-green, water-soaked lesions that develop on foliage, stems and fruit. Occasionally, the host may exhibit dry lesions on the stalk, stem or branches with a well-defined border between healthy and diseased tissues. Stem infections frequently girdle the stem at the soil line, causing plants to wilt and die. Petiole or bud infections proceed downward in the plant rapidly. Fruit infected directly from the soil surface or through the peduncle rot quickly and turn into a watery mass. In advanced stages, white, cottony mycelium blankets affected tissue, and sclerotia form on the surface. Sclerotia also may form within the stem pith and fruit cavities, becoming black and hard as they mature.

Conditions for Disease Development:

This fungus has a wide host range and survives from one season to the next as sclerotia in soil and in plant debris. White mold is most common in temperate regions but is also known to occur in hot, dry areas. Dew, fog and frequent rain generally favor disease development. The most important means of long-distance spread are airborne ascospores that erupt from sclerotia. Moving contaminated soil and fertilizing with manure from animals fed infected plant debris are two common ways of short-distance spread of sclerotia or mycelium. Irrigation water may also spread the fungus from field to field.

Control:

Plant in well-drained soil, use wide row spacing and water deeply, early in the day. Remove all plant debris from previous crops. Manure and plant mulches suspected to come from infected locations should not be used unless sterilized. Establish a crop rotation with non-host crops such as corn, small grains and grasses. Soil fumigation can be effective at helping to reduce soilborne inoculum.



Infections may girdle stem, causing wilt.



Mycelia and sclerotia on stem surfaces.



Fruit infected through peduncle.



Sclerotia within a stem.

Insect Pests & Vectors of Viruses

INFECTIOUS DISEASES AND PESTS

Insect Pests & Vectors of Viruses

Aphids, whiteflies, thrips and leafhoppers are among the more common vectors of viruses that cause severe damage in peppers and eggplant. The mode of transmission can be unique to each virus and vector combination. Transmission ranges from non-persistent or passive transport of viral particles on external mouth parts to the more complex internal virus-vector relationships characteristic of persistent movement.

In non-persistent movement, virus particles are acquired during feeding or probing of infected plants and carried on mouth parts to the next feeding site. Virus acquisition takes place within seconds and transmission lasts several hours to a day. Longer acquisition and transmission times characterize persistent movement. The virus is acquired during feeding, but before transmission can occur, the particles must move through the digestive system and into the salivary glands. New infections occur during feeding when viruliferous vectors inject viable virus particles with saliva into the phloem of healthy plants. In general, once they become infective, persistent vectors can transmit viruses for the duration of their adult lives.

Aphids:

Aphids are small, pear-shaped, gregarious insects. They can lay eggs and, in warm climates, produce live offspring without mating. Aphids can travel from leaf to leaf and plant to plant as wingless nymphs and as winged or wingless adults. They can also travel for miles when carried by wind. Aphids usually invade fields as winged adults. Once established, aphids can be found on the growing points and on the underside of newer leaves.

Aphids can cause significant damage to peppers and eggplant, causing spotting and chlorosis of leaves, leaf curling and distortion and abscission of flowers. The fungi that cause sooty mold can grow on the sugary honeydew excreted by aphids, reducing fruit quality. The potato aphid, *Macrosiphum euphorbiae*, and the green peach aphid, *Myzus persicae*, are two common pepper and eggplant pests.

The number and diversity of viruses vectored by aphids far exceed those moved around by other vectors. Aphids transmit viruses in both a persistent and non-persistent manner. There is no documented evidence to

suggest the viruses are carried to the next generation via eggs. The viruses carried passively by aphids to peppers and eggplant can be picked up and transmitted within seconds and include *Cucumber mosaic virus*, *Tobacco etch virus* and *Alfalfa mosaic virus*. Viruses persistently transmitted by aphids include *Potato leaf roll virus* and *Beet western yellows virus*, neither of which is a major problem in peppers or eggplant.



Aphis on eggplant



Nymphs of the green peach aphid.



Winged adult of the green peach aphid.



Sooty mold colonizing honeydew excreted by aphids or whiteflies.

Insect Pests & Vectors of Viruses

Beetles:

The Epilachna beetle is an eggplant pest in Asia. Adults are red to brown with black spots; larvae are brown with spines. Adults and larvae feed on leaves and new growth, leaving behind skeletonized areas of leaf tissue. Generally, larvae cause more damage to the crop than adults. The Diabrotica beetle is found throughout North America. Feeding damages foliage in pepper seedlings.

Leafhoppers:

Leafhoppers are found in warm, dry regions worldwide. They are wedge-shaped, can be up to 3 mm (1/8 inch) long and are green to greenish-yellow to brown in color. Leafhoppers have a very wide host range, including numerous weeds and vegetables. Leafhoppers feed on phloem, leaving pale, circular spots or peppery specks on leaves. Adult females make hatch cuts across leaf veins and stems to insert eggs. Their life cycle can be completed in 40 to 45 days under favorable environmental conditions. Nymphs are similar to adults in appearance, except they lack fully developed wings.

The beet leafhopper, *Circulifer tenellus*, transmits *Beet curly top virus* to pepper. The virus is acquired and transmitted persistently by immature and adult stages of leafhoppers. Once acquired, the virus can be transmitted throughout adult life, but it is not passed to the next generation via the egg.

The cotton leafhopper or jassid, *Hishimonus phycitis*, is an eggplant pest in Asia. Leafhoppers feed on the undersides of leaves causing small, yellow patches. In severe attacks, interveinal yellowing and necrotic areas that resemble nutrient deficiencies develop. Infestation also causes a reduction in yield. Leafhoppers may transmit a phytoplasma that causes little leaf disease.



Diabrotica beetle damage on pepper.



The cotton leafhopper or jassid.



Leaf symptoms caused by jassid feeding on eggplant.



Jassid feeding damage on eggplant.

Insect Pests & Vectors of Viruses

Mites:

Fine webbing is visible on and under eggplant and pepper leaves in mite-infested fields. The two-spotted spider mite (*Tetranychus urticae*) feeds on the underside of eggplant leaves, causing pale, stippled spots and bronzing in infested foliage. The broad mite (*Polyphagotarsonemus latus*) is particularly problematic in greenhouse pepper crops. They feed on new growth, flowers, fruit and the undersides of leaves. Infested leaves are elongated, curled, deformed and small. Broad mite feeding in flowers and fruit causes abortion and scarring of fruit.

Mites are more destructive under dry conditions. Elimination of this pest before flowering and fruit set is important. After fruit formation, mites can feed and lay eggs under the calyx, making them difficult to eradicate. Miticide applications and/or washing infested plants with water or insecticidal soaps can reduce damage.

Whiteflies:

The greenhouse whitefly (*Trialeurodes vaporariorum*), the sweet potato whitefly (*Bemisia tabaci*) and the silverleaf whitefly (*B. argentifolii*) are serious insect pests worldwide. Over 500 plant species, including weeds, vegetables, ornamental and agronomic crops, are attacked. Immature and adult whiteflies colonize the underside of leaves. The larval stages are sedentary, whereas the tiny (1 mm) adults fly short distances from leaf to leaf or plant to plant, or are carried for miles by wind. Once established, populations build up rapidly due to a life cycle of 20 days or less in dry, warm climates. Rain and cold weather reduce whitefly populations. Plant damage is similar to that caused by aphids. Whiteflies feed on phloem, and produce sugary honeydew on leaves and fruit. Sooty mold fungi colonize the honeydew, reducing fruit quality and yield. Whitefly infestations can also slow plant growth and cause stunting and defoliation.

In pepper and eggplant, *B. tabaci*, and *B. argentifolii* are important vectors of geminiviruses, such as *Pepper golden mosaic virus*, *Sinaloa tomato leaf curl virus*, *Pepper hausteco yellow vein virus*, *Tomato yellow mosaic virus* and other geminiviruses, found worldwide. These viruses are all carried persistently, generally throughout the adult life of the vector. There is no documented evidence to suggest that these viruses are passed to the offspring of infected adult whiteflies.



Distorted leaves caused by mites on pepper.



Russetting caused by mites on eggplant.



The silverleaf whitefly.



Leaf distortion caused by whitefly feeding.

Insect Pests & Vectors of Viruses

Thrips:

Three common species of thrips are serious pests of peppers and eggplant worldwide. The western flower thrips (*Frankliniella occidentalis*) are native to the western USA, but have been introduced into many regions worldwide. The onion thrips (*Thrips tabaci*) occur worldwide. The greenhouse thrips (*Heliethrips haemorrhoidalis*) are found in greenhouses worldwide where they cause damage to a wide range of ornamental and vegetable plants. Generally, thrips reproduce without mating. The larvae are relatively inactive, but the tiny adults (< 0.5 mm) are winged and mobile. Adults live up to 20 days, and populations can increase quickly. Thrips feed on new leaves and developing flowers, causing misshapen, twisted and cupped pepper leaves and browning of lower leaf surfaces in eggplant. Egg deposition and subsequent feeding by larvae causes scarring and discoloration in developing fruit. Yield losses can be severe for both peppers and eggplant. Though difficult to see in plants, thrips can be seen by shaking flowers and new foliage over a white sheet of paper.

Several species of thrips transmit tospoviruses. In eggplant and peppers, thrips transmit *Tomato spotted wilt virus* and *Peanut bud necrosis virus*. Thrips larvae acquire tospoviruses after short feeding periods and transmit these viruses primarily as adults. Occasionally, transmission occurs in nymphs. These viruses are not passed to the next generation, however, there is some evidence to support replication in the vector.



Leaf distortion from thrips feeding.



The western flower thrips nymph (left) and adult (right).



Thrips damage on pepper fruit.



Severe leaf distortion from thrips feeding.

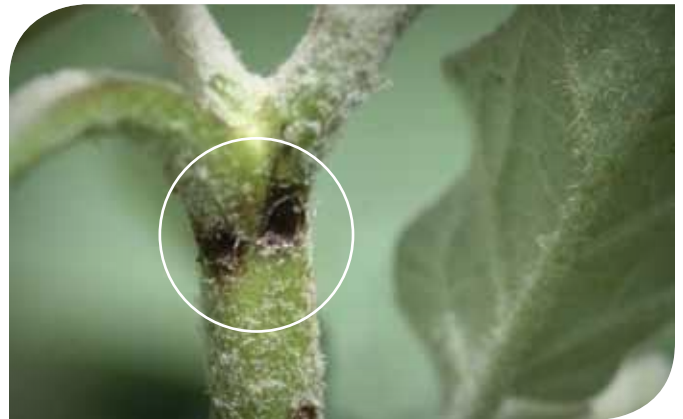
Insect Pests & Vectors of Viruses

Eggplant Fruit and Shoot Borer:

The eggplant fruit and shoot borer (*Leucinodes orbonalis*) is a serious eggplant pest in South and Southeast Asia. Adult moths fly in from adjacent fields or infested debris and deposit eggs on new leaves. Larvae emerge from eggs and travel a short distance to bore into new shoots or fruits. The first symptoms of infestation are freshly wilted shoots. Larvae feeding on fruit render them unmarketable. Yield losses can approach 100 percent. The best way to manage infestations is through good crop sanitation, use of pheromones to trap male moths and judicious use of insecticides to protect natural predators. Effective sanitation includes cutting, removing and destroying damaged shoots until the final harvest. Crop residues should be uprooted and destroyed to remove eggs and larvae.



The eggplant fruit and shoot borer.



Entry sites of the eggplant fruit and shoot borer.



Wilting caused by the eggplant fruit and shoot borer.

Nematode Diseases

INFECTIOUS DISEASES AND PESTS

Root-Knot

Causal Agent:

Meloidogyne incognita, *M. javanica*, *M. arenaria*

Distribution:

Worldwide

Symptoms:

Plants infected by root-knot nematodes are generally less vigorous than healthy plants. In foliage, symptoms of nutrient deficiency and diurnal wilting are visible due to reduced function of the root system. Diagnosis can be confirmed by carefully digging up the roots and observing the presence of bead-like galls. Galls are irregular enlargements of root tissue induced by nematode feeding and tend to be larger when multiple infections occur. Galls caused by different species of root-knot nematode may be similar in appearance.

Conditions for Disease Development:

The host range of these three nematode species is very wide and includes many agricultural crops and weeds. Disease is most severe in warm areas with long growing seasons. In general, lighter, sandy soils favor nematode infection and result in more severe damage to roots.

Control:

Fumigate infested soil and rotate to non-host grass crops to help reduce nematode populations. Plant root knot nematode-resistant varieties.



Root-knot nematode galls in eggplant.



Root-knot nematode galls in pepper.

Parasitic Plants

INFECTIOUS DISEASES AND PESTS

Dodder

Causal Agent:

Cuscuta spp.

Distribution:

Worldwide

Symptoms:

More than 100 species of *Cuscuta* occur worldwide. Dodder is an annual parasitic plant that can be identified by slender, white, yellow or red, leafless strands that twine around the host plant. Dodder has no chlorophyll and depends on the host plant for its nutrition. As a result, infected plants appear weak and discolored. Growth and yield can be significantly reduced. Under heavy dodder infestations, small host plants may die. As the season progresses, dodder grows down a row to cover plants with a mass of vines. Heavily infested fields appear yellow.

Conditions for Disease Development:

Generally, dodder has a very wide host range and is adapted to a wide range of environments. After germination, the seedling depends on nutrients stored for its survival. If a suitable host is not found within a few days, it will die. Once a seedling makes contact with a host, it forms sucker-like projections (haustoria) that penetrate plant tissues. Dodder produces small, inconspicuous flowers (often white) that mature and produce two to four yellow to black seeds.

Irrigation water and cultivation equipment are common modes of long distance dispersal. Dodder seeds are small and can remain viable in the soil for up to 10 years. Seeds usually germinate in late winter and spring in cold climates, however, germination can continue through the summer. Environmental conditions that favor pepper and eggplant growth are also beneficial to dodder.

Control:

Immediately remove or burn dodder, along with infested plants upon detection. Contact herbicides can be used to help control localized infestations. If an infestation is widespread, apply pre-emergence herbicides, deep-plow crop debris and rotate to grasses.



Dodder infestation in the field.



Yellow strands of dodder covering pepper plants.



Flowers produce seeds that may remain viable many years.

Phytoplasma Disease

INFECTIOUS DISEASES AND PESTS

Little Leaf Phytoplasma

Causal Agent:

Little leaf phytoplasma

Vector:

The cotton leafhopper or jassid
(*Hishimonus phycitis*)

Distribution:

India, Bangladesh

Symptoms:

Infected plants produce tiny, pale-green leaves on very short petioles. Stem internodes are short, and plants are stunted and bushy due to stimulation of axillary buds. Excessive root branching is common. Flowers formed after infection are leaf-like and sterile. Yield losses can approach 100 percent.

Conditions for Disease Development:

Little leaf disease is widespread in India, where overlapping crop cycles and weeds ensure high populations of leafhoppers and provide reservoirs for the phytoplasma. Eggplants can be infected at any stage of growth when phytoplasma-carrying leafhoppers are present. Grafting also can spread the disease.

Control:

Eradicate solanaceous weeds that harbor the vector, and spray insecticides to help reduce leafhopper populations to control the spread of this disease. Rogue symptomatic plants as soon as they are detected to reduce secondary spread of this disease.



Plants remain stunted and bushy.



Infected plants develop shortened internodes and distorted leaves.



Late infections only affect new growth.

Viral Diseases

INFECTIOUS DISEASES AND PESTS

Alfalfa Mosaic

Causal Agent:

Alfalfa mosaic virus (AMV)

Vector:

Many species of aphids

Distribution:

Worldwide

Symptoms:

A distinctive bright-yellow mosaic develops on leaves. Often fruits are mottled and distorted.

Conditions for Disease Development:

AMV has a wide host range among dicotyledonous plants. Infections generally occur when peppers are grown near alfalfa fields. The virus is transmitted by many aphid species in a non-persistent manner. Viruliferous aphids spread the disease rapidly within a field for very short periods of time.

Control:

To best manage AMV, avoid planting peppers near alfalfa fields. There is no effective chemical control of this disease because aphids immediately transmit the virus by feeding on infected plants. This virus can be transmitted mechanically and by seed. There is currently no resistance in commercial pepper cultivars.



Bright-yellow mosaic on foliage.



Distorted fruit and mosaic symptoms in leaves.



Mosaic symptoms in leaves.

Beet Curly Top

Causal Agent:

Beet curly top virus (BCTV)

[synonym: *Curly top virus* (CTV)]

Vector:

The beet leafhopper (*Circulifer tenellus*)

Distribution:

Worldwide, in arid and semi-arid regions

Symptoms:

When seedlings are infected, leaves turn yellow, twist and curl upward, and thicken to become stiff and crisp. Petioles may curl downward. Fruit set is reduced. Fruit appear dull and wrinkled, and tend to ripen prematurely. This virus is not mechanically transmitted.

Conditions for Disease Development:

This virus has a wide host range, affecting more than 300 species. Common hosts are tomatoes, beets, peppers, squash, beans, cucurbits, spinach, potatoes, cabbage and alfalfa. The beet leafhopper transmits BCTV in a persistent manner. Warm temperatures and dense leafhopper populations are conducive to the spread of BCTV. Viruliferous leafhoppers migrate seasonally and can be moved long distances by wind.

Control:

Transplant virus-free seedlings. Rogue infected plants to help avoid transmission in the field. Control weeds near pepper fields to reduce vector and virus reservoirs. Transplant early or late to escape leafhopper infestations, and increase plant density to compensate for losses due to BCTV. Insecticides are generally not effective in controlling Beet curly top.



Foliage and fruit symptoms in the field.



Thickened leaves curl upward.



Affected plants have shortened internodes.

Chilli Veinal Mottle

Causal Agent:

Chilli veinal mottle virus (ChiVMV)

Vector:

Many species of aphids

Distribution:

Asia

Symptoms:

Typically, leaves of infected plants develop a mottle or mosaic with dark-green vein banding. Plants infected when young usually are stunted, with dark-green streaks on stems. Most flowers drop before fruit set. Affected fruit may be mottled and deformed. Symptom severity is dependent upon the variety, infecting strain and age of the host at the time of infection. Eggplant can be infected, but remains asymptomatic.

Conditions for Disease Development:

Peppers, tobacco, tomatoes and weeds such as *Physalis* spp. are hosts of ChiVMV. Tropical climates support the continuous presence of ChiVMV and its vectors. ChiVMV is transmitted by several species of aphids in a non-persistent manner and can also be transmitted mechanically through pruning and grafting. There is no evidence of seed transmission.

Control:

Use resistant varieties and virus-free transplants. Manage aphid populations using reflective mulches, stylet oil sprays and insecticides. Controlling the aphid vector population with chemical treatment is very difficult and generally provides limited control. In mature plants, it is difficult to achieve complete insecticide coverage of leaves to effectively eradicate all aphids.



Chlorotic mosaic with dark-green vein banding.



Close-up of mosaic and vein banding.



Dark-green streaks on stems.

Cucumber Mosaic

Causal Agent:

Cucumber mosaic virus (CMV)

Vector:

Many species of aphids

Distribution:

Worldwide

Symptoms:

Symptoms can vary greatly depending upon the affected variety, age of the plant at the time of infection and the strain of the virus. Leaves may become narrow, distorted and mottled. In peppers, defoliation may occur when mature plants are infected. Tip dieback and leaf discoloration in an "oak-leaf" pattern may develop. Infected plants are usually stunted and the fruits distorted with occasional concentric rings. Infection of young plants results in unmarketable fruit and severe yield losses.

Conditions for Disease Development:

The host range of CMV includes as many as 800 plant species. The virus is acquired by aphids and is transmitted from plant to plant in a non-persistent manner. CMV often remains in infected alternate hosts near agricultural areas and is transmitted to peppers and eggplant when environmental conditions support disease development. This virus is also mechanically transmitted.

Control:

Control aphids, and rogue-infected plants to reduce the incidence of CMV in greenhouse crops. In field-grown peppers and eggplant, eliminate adjacent weeds and ornamentals, and use reflective mulches to deter aphids and a combination of stylet oil and insecticide sprays to reduce losses caused by this virus. Controlling the aphid vector population with chemical treatment is very difficult and generally provides limited control. In mature plants, it is difficult to achieve complete insecticide coverage of leaves to effectively eradicate all aphids. Resistant varieties are available in pepper.



Stunted plants with distorted foliage.



Leaf mottling and distortion.



Vein banding and mottling in eggplant.



Distorted and mottled fruit.



Characteristic "oak-leaf" pattern.

Geminiviruses

Causal Agent:

Pepper Golden Mosaic Complex: *Pepper huasteco yellow vein virus (PHYVV)* [synonym: *Pepper huasteco virus (PHV)*]. *Sinaloa tomato leaf curl virus (STLCV)* and additional uncharacterized begomoviruses

Vector:

Sweet potato whitefly (*Bemisia tabaci*), Silverleaf whitefly (*B. argentifolii*)

Distribution:

Worldwide

Symptoms:

Symptoms vary depending on the variety infected, the viruses present, environmental conditions and age of plant at the time of infection. Early symptoms may include yellow vein-etching and clearing, and distortion of young leaves. As infection progresses, symptoms of chlorosis, mosaic and mottling develop, and distortion is more prominent. Infected plants are stunted, and fruit are small, discolored and distorted. This family of viruses can cause significant yield reductions in peppers and eggplant.

Conditions for Disease Development:

The pepper golden mosaic complex is comprised of closely related viruses that infect in many combinations. Pepper huasteco yellow vein and Sinaloa tomato leaf curl are serious diseases of pepper grown in Mexico, where large areas of hot peppers are grown and whiteflies are established. Geminiviruses are spread from host to host by whiteflies in a persistent manner and are not mechanically transmitted. These viruses also infect tomatoes, which are a preferred whitefly host. Consequently, tomatoes can be a source of vector and virus to nearby pepper fields.

Control:

Overlapping cropping systems make control of these viruses and their vectors very difficult. Exclude whiteflies from nurseries using protective netting or screen-houses to grow virus-free transplants. Apply systemic insecticides early to reduce whitefly populations and limit the spread of these viruses. In mature plants, it is difficult to achieve complete insecticide coverage of leaves to effectively eradicate all whiteflies. Even low whitefly populations efficiently transmit geminiviruses. Destroy residual crops after harvest and maintain a host-free period to help manage whiteflies and geminiviruses.



Severe distortion of pepper leaves.



Twisted and distorted leaves.



Mosaic caused by the pepper golden mosaic complex.



PVH-infected fruit (left) and healthy fruit (right).



Rough and distorted fruit.



Developing mottle in eggplant.



Chlorosis and mottling of foliage.



Bright leaf discoloration in eggplant.

Pepper Mottle

Causal Agent:

Pepper mottle virus (PepMoV)

Vector:

Many species of aphids

Distribution:

Southern United States, California, Mexico and Central America

Symptoms:

Symptoms vary depending on the pepper variety infected, isolate of the virus present, age of plants when infected and environmental conditions. Affected field plants may develop a systemic mottle, distortion, and may be stunted. Infected greenhouse plants first develop vein-clearing followed by chlorotic mottle in newer leaves. Fruit may be distorted, mottled and small. Field plants often are infected with more than one virus. Multiple infections usually result in symptoms different from those caused by PepMoV alone and may appear more severe.

Conditions for Disease Development:

Like TEV, PVY and CMV, PepMoV can be transmitted by many species of aphids. PepMoV is transmitted on the mouthparts of aphids in a non-persistent manner. Weeds, such as *Datura*, and other solanaceous plants can harbor the virus and vector. Aphids may spread infection within a crop, or the virus may be transmitted mechanically through cultural practices such as staking, pruning or handling of infected plants.

Control:

Remove crop residues and weeds that serve as a reservoir for both virus and vector. Use reflective mulches to deter aphids, and combine the use of stilet oils and insecticide sprays to reduce losses in young plants. Controlling the aphid vector population with chemical treatment is very difficult and generally provides limited control. In mature plants, it is difficult to achieve complete insecticide coverage of leaves to effectively eradicate all aphids. Resistant varieties are available in both hot and sweet peppers. However, resistance in available commercial varieties may not be effective against all isolates of PepMoV found



Mottling and distortion of foliage.



Typical mottle symptoms in leaves.



Deformed and mottled fruit.

Pepper Yellow Mosaic

Causal Agent:

Pepper yellow mosaic virus (PepYMV)
[synonym: *Potyvirus Y - montemor (PVYm)*]

Vector:

Many species of aphids

Distribution:

Brazil

Symptoms:

Typical symptoms of Pepper yellow mosaic include vein banding, blistering and a bright-yellow mosaic. Leaves also may be distorted and develop epinasty. Generally, plants are stunted. Fruit develop a mosaic and may be distorted.

Conditions for Disease Development:

Aphids transmit this virus in a non-persistent manner. The widespread use of *Potyvirus Y* resistant cultivars in commercial vegetable production in the 1970s may have contributed to emergence of PepYMV as a serious pepper pathogen in Brazil. Pepper yellow mosaic also affects tomato.

Control:

Plant PepYMV-resistant pepper varieties. Use of insecticides to control the disease is generally not efficient due to the short times for acquisition and transmission of this virus by aphids. Cultural practices that may delay infection include use of reflective mulches to deter aphids and weed control to help remove virus and vector reservoirs.



Foliar symptoms of Pepper Yellow Mosaic Virus.



Mosaic and distortion of foliage.



Close-up of affected leaf.

Potato X

Causal Agent:

Potato virus X (PVX)

Vector:

Mechanically transmitted with no known insect vectors

Distribution:

Worldwide

Symptoms:

Foliar symptoms of infection include necrotic spots, distortion and ringspots. Mosaic symptoms may also develop in eggplant. Affected leaves are small and may eventually drop. Plants appear stunted and bushy. Fruit that develop are small and distorted, and yield can be reduced.

Conditions for Disease Development:

Potatoes, tomatoes and Brassica spp. are common hosts of this virus, and often serve as sources of infection from adjacent fields or volunteer plants. Introduction and spread of PVX is largely due to movement of personnel and equipment. Cultural practices such as transplanting, grafting, staking and pruning, as well as plant-to-plant contact, contribute to the spread of this disease.

Control:

Problems in peppers are infrequent. Roguing infected plants, and sanitation of equipment and tools can help reduce the spread of this virus in peppers and eggplant. Do not follow a field of potatoes with peppers or eggplant.



Vein necrosis.



Necrosis and distortion of foliage.

Potato Y

Causal Agent:

Potato virus Y (PVY)

[synonym: *Brinjal mosaic virus (BMV)*]

Vector:

Many species of aphids

Distribution:

Worldwide

Symptoms:

Symptoms are variable in appearance and severity depending on the variety infected, the isolate of the virus present, age of the plant at the time of infection and environmental conditions. Leaf symptoms include mottling, vein-banding and clearing, and distortion. Plants may be stunted with necrosis of the stems and apical buds. Infected eggplants may show concentric rings on the foliage. Affected fruits may be distorted, discolored and small. Field plants are usually infected by more than one virus. Multiple infections result in symptoms more severe in appearance and more complex than those caused by PVY alone.

Conditions for Disease Development:

Many weed species serve as alternate hosts for this virus. Like *Tobacco etch virus*, *Cucumber mosaic virus* and *Pepper mottle virus*, PVY can be transmitted by many species of aphids. All four viruses are transmitted in a non-persistent manner on the mouth parts of aphids moving into fields from nearby host plants (including peppers, tomatoes, eggplant, tobacco, potatoes and solanaceous weeds). Aphids can cause secondary spread of infection within a crop, or the virus may be transmitted mechanically through staking, pruning or handling infected plants.

Control:

Remove crop residues and weeds that can help harbor the virus, and rogue symptomatic plants to help reduce disease spread. Use reflective mulches to deter aphids and stilet oils or insecticides to reduce losses in young plants. Chemical control of the aphid populations is very difficult and provides limited control. In mature plants, it is difficult to achieve complete insecticide coverage of leaves to effectively eradicate all aphids. Resistant varieties are commercially available in both hot and sweet pepper. However, new strains may emerge that overcome existing resistance genes.



Mottling and distortion on pepper.



Mosaic and distortion on eggplant.



Mosaic symptoms on eggplant.



Vein banding and distortion on eggplant.



Necrotic rings on eggplant leaves.



Necrotic streaks on eggplant stem.

Tobacco Etch

Causal Agent:

Tobacco etch virus (TEV)

Vector:

Many species of aphids

Distribution:

North and South America

Symptoms:

The appearance and severity of symptoms may vary with the pepper variety infected, the isolate of virus present, age of the plant at the time of infection and environmental conditions. Plant and leaf symptoms include mottling, distortion and stunting. Unlike sweet peppers, infected hot pepper plants can develop severe wilting. Affected fruits may be distorted with chlorotic streaks or mosaic patterns. In the field, plants are usually infected by more than one virus. Multiple infections result in symptoms more severe and complex than those caused by TEV alone.

Conditions for Disease Development:

Many weed species serve as alternate hosts for this virus. Like *Tobacco etch virus*, *Cucumber mosaic virus* and *Pepper mottle virus*, TEV is transmitted by aphids in a non-persistent manner as aphids move into pepper fields from nearby host plants (peppers, tomatoes, tobacco and weeds). Secondary spread occurs as aphids move from plant to plant. The virus may also be transmitted mechanically through activities such as staking, pruning or handling infected plants.

Control:

Remove crop residues and weeds that can harbor the virus. In young plants, use reflective mulches to deter aphids and stilet oil and insecticide sprays to help reduce losses. However, controlling the aphid vector population with chemical treatments provides limited control. As plants increase in size, it is difficult to achieve complete insecticide coverage of leaves to effectively kill all aphids. Moreover, aphids can acquire and transmit the virus after very short feeding periods. Resistant varieties are commercially available in both hot and sweet peppers. However, commercial resistance is not effective against all isolates of this virus.



Leaf mottling and distortion.



Distortion of young leaves.



Resistant (left) and susceptible (right) pepper plants.

Tobamoviruses

Causal Agent:

Tobacco mosaic virus (TMV), *Tomato mosaic virus (ToMV)*, and *Pepper mild mottle virus (PMMV)*

Vector:

Mechanically transmitted with no known insect vectors

Distribution:

Worldwide

Symptoms:

Symptoms of infection by TMV and ToMV in peppers and eggplant can vary greatly with the strain of virus, temperature, light intensity, day length, age of the plant when infected and cultivar. Foliar symptoms include chlorotic mosaic, distortion and, at times, systemic necrosis and defoliation. Plants infected as seedlings can be stunted and are generally chlorotic. Infected plants produce disfigured fruit that are usually small with distinct chlorotic and/or necrotic areas. Foliar symptoms of PMMV in peppers are also variable but are generally mild. Plants infected as seedlings remain stunted. Leaves develop a subtle mosaic, can be crinkled, and remain small. Symptoms may first appear on fruit. Fruit can be mottled and necrotic, are usually small and distorted, and have a rough or wrinkled appearance.

Conditions for Disease Development:

TMV and ToMV have very wide host ranges and infect over 200 plant species, including varieties of peppers, tomatoes, eggplant and tobacco. PMMV can infect all species of peppers, but not tomatoes, tobacco or eggplant. Infected transplants, seed and debris are common sources of inoculum. These viruses can be found on and under the seed coat and in the endosperm. Tobamoviruses are very stable, and extensive spread can occur through handling, tools, trays, pots, stakes, twine and clothing, as well as pollination, pruning and other cultural practices. Tobamoviruses can remain viable for several years in plant debris, but generally lose their ability to infect as debris decomposes.

Control:

Enforce strict sanitation practices during production and harvest to minimize infection and prevent spread. Restrict access to the crop, wash hands and equipment with a soap solution between plants or rows of plants and before entering a greenhouse. There are reports of successful prevention of tobamovirus spread by coating hands, plants and equipment with a solution of powdered non-fat milk. Rogue symptomatic and adjacent plants, and rotate to non-solanaceous crops to manage disease. Use seed tested and treated for

tobamoviruses. Many hot pepper varieties contain hypersensitive resistance to TMV and ToMV. Use resistant varieties in greenhouse production where tobamoviruses are a problem. Some strains of PMMV may overcome the commercial resistance.



Yellowing and mottling in peppers.



Yellow mosaic in peppers.



Mosaic symptoms in eggplant.



Chlorotic mottle in eggplant.



Rough surfaces of infected fruit.



Fruit blotches.



Necrotic lesions on pepper fruit.



Deformed and mottled pepper fruit.

Tospoviruses

Causal Agent:

Tomato spotted wilt virus (TSWV), *Peanut bud necrosis virus (PBNV)* (synonym: *Groundnut bud necrosis virus*)

Vector:

Western flower thrips (*Frankliniella occidentalis*), Tobacco thrips (*F. fusca*), Melon thrips (*Thrips palmi*) and others

Distribution:

TSWV: Worldwide; PBNV: Asia and Australia

Symptoms:

These viruses are related and can be differentiated by vector, host range, serology and genetic analysis. Infection is particularly severe in seedlings that usually remain stunted and unproductive. Foliar symptoms include yellow or necrotic concentric ring patterns, and mosaic with chlorotic and necrotic spots. Necrotic streaks can develop on stems and extend to the top of the plant. In some cultivars, the apical shoot dies and leaves drop. In pepper, reduced laminal growth can cause a shoestring appearance to leaves. Pepper and eggplant fruit are deformed and often drop. Usually small chlorotic or discolored spots develop that later turn necrotic. Fruit scarring and distinct concentric rings can also develop. In pepper fruit, red, green and yellow discoloration is often present. Seeds inside affected fruit may turn black.

Conditions for Disease Development:

These viruses and their vectors have a very wide host range. The presence of infected weeds or mature plants in adjacent fields can pose a threat to newly planted crops. Larvae acquire the virus after short feeding periods. Once infected, adult thrips transmit these viruses for the duration of their lives. Temperatures above 22° C (72° F) accelerate the hatching of eggs, resulting in explosive spread of these vectors and viruses. Tospoviruses are not seed transmitted.

Control:

Use virus-free transplants. Exclude thrips from plant nurseries. Monitor thrips populations during the growing season to determine when insecticide applications are necessary. Rogue infected plants and control weeds that serve as reservoirs for viruses and vectors in and around all crops.



Necrotic spots on pepper foliage.



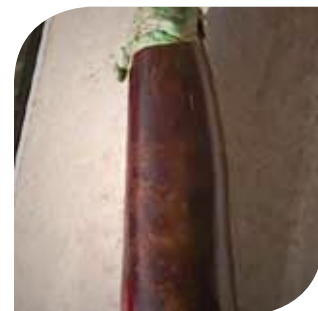
Ring spots on pepper leaf.



Yellow concentric rings on pepper leaf.



Chlorotic spots on eggplant.



Concentric rings on eggplant.



Deformed and discolored pepper fruit.



Chlorotic spots on pepper fruit.

Noninfectious Disorders

NONINFECTIOUS DISORDERS

Blossom-End Rot

Causal Agent:

Imbalance of calcium in the fruit

Distribution:

Worldwide

Symptoms:

The first visible symptom of blossom-end rot is a water-soaked area near the blossom scar of the fruit. This area later develops into a tan to brown, leathery lesion. Saprophytic fungi often colonize these lesions, which gives them a gray to black, velvety appearance.

Conditions for Disease Development:

Blossom-end rot is associated with insufficient calcium uptake and alternating periods of wet and dry soil. Though blossom-end rot often is associated with mature fruit, young, rapidly growing fruit are most prone to calcium deficiency. Sudden and extreme changes in water availability may induce fruit growth fluctuations that lead to blossom-end rot. Stress associated with root damage, mild drought, high soil salinity or excess nitrogen (excess ammonium) also may cause Blossom-end rot.

Control:

Drip irrigate to supply an even amount of water, and apply lime to soils low in calcium. Avoid using ammonium sources of fertilizer or excess magnesium. Fertilize with calcium nitrate in areas where blossom-end rot is known to occur.



Lesions commonly develop near the blossom scar.



Symptoms of blossom-end rot.



Saprophytic fungi often colonize lesions.



Colonization of sunscald (left) and blossom-end rot (right) lesions by saprophytic fungi.

Chemical Damage

Causal Agent:

Herbicides and insecticides

Distribution:

Worldwide

Symptoms:

Symptoms of chemical damage differ depending on the dosage and plant growth stage at time of exposure. Contact herbicides, which affect only the plant tissues directly exposed, typically cause chlorotic or necrotic spots on leaves, stems and fruit, but might kill small seedlings. Systemic herbicides, which are translocated throughout the plant, cause a variety of symptoms that range from interveinal yellowing and vein necrosis to general foliar chlorosis. Necrotic spots, leaf margin necrosis, leaf twisting and cupping may also develop. Stems may be deformed, swell or crack. Fruit may be excessively large or small and irregular. Insecticide damage may show as leaf margin necrosis or necrotic lesions on the foliage.

Conditions for Disease Development:

Chemicals labeled for use on peppers or eggplant generally do not cause damage unless they are applied at excessive rates, at high temperatures, at the wrong stage of plant growth, or during unfavorable weather conditions. Some pre-plant herbicides may remain active in the soil long enough to cause injury to later plantings. Damage may occur from herbicide drift when adjacent crops or weeds have been sprayed. Usually, damage from drift is most severe at the edge of the field closest to the chemical application. Contaminated spray equipment can cause damage if the correct cleaning procedures are not followed after each chemical application.

Control:

Always use herbicides and insecticides as directed by the label, and apply during appropriate weather conditions only. Always store herbicides and insecticides according to label recommendations.



Mottling and distortion caused by pyrethrin.



Acephate damage on leaves.



Bleaching caused by glyphosate.



2,4-D damage on pepper.



Carbofuran phytotoxicity on pepper.

Chimera

Causal Agent:
Genetic mutation

Distribution:
Worldwide

Symptoms:

Changes in color or shape of leaves and fruits are associated with spontaneous genetic mutations. Typical symptoms of chimera are leaf variegation, absence of chlorophyll, filiform leaves and distorted growing points and fruit. Symptoms may be confused with those caused by viruses and herbicides.

Conditions for Disease Development:

Chimeras are caused by genetic changes in the plant.

Control:

Use the best quality seed available.



Genetic variegation.



Absence of chlorophyll.



Leaf and fruit distortion.

Cracking

Causal Agent:

Environmental, genetic

Distribution:

Worldwide

Symptoms:

Superficial cracks are characteristic of jalapeño peppers, but are considered problematic in other pepper fruit types. Splitting of the epidermis occurs in fruit under stress, near maturity. Fine superficial cracks on the fruit's surface give a rough texture to the fruit, and deeper cracks are commonly colonized by secondary pathogens, which cause postharvest decay.

Conditions for Disease Development:

The severity of fruit cracking is related to stress sustained by fruit during stages of rapid growth. In the field, wide differences in day and night temperatures or heavy rain or water availability promote cracking. During periods of rapid fruit expansion, high relative humidity at night in greenhouse production systems can also cause fruit cracking.

Control:

Proper irrigation and nutrition management can help reduce cracking. In greenhouse operations, avoid high relative humidity and temperature fluctuations at night to reduce plant stress. Some cultivars are less susceptible to fruit cracking than others.



Surface cracks on jalapeño fruit.



Surface cracks on bell pepper fruit.

Nutrient Disorders

Causal Agent:

Insufficient or excessive nutrients

Distribution:

Worldwide

Symptoms:

Nitrogen (N): Plants under low N stress are smaller than normal and have an overall light-green color, especially in the lower leaves. Fruits are small with thin walls. Excess nitrogen fertilizer can cause leaf and fruit burning, especially if applied as an ammonium formulation.

Phosphorus (P): Leaves on deficient plants are smaller than normal and dark-green. Older leaves are affected first and, in severe cases, may senesce.

Potassium (K): Symptoms of K deficiency begin on older leaves and progress to younger leaves. Foliage develops bronzing and/or burning of leaf margins and may develop chlorosis. Plants are smaller than normal and produce less fruit.

Calcium (Ca): Interveinal chlorosis and leaf margin necrosis occur at the growing points in Ca deficient plants. Later, growing points die. Leaves can be distorted. Fruit may develop blossom-end rot. Excess Ca can cause white spots below the surface of pepper fruit. Open-pollinated peppers may develop stip.

Magnesium (Mg): Magnesium deficient plants develop interveinal chlorosis on older leaves, which later progresses to young leaves. Interveinal tissue may become necrotic

Sulfur (S): Older leaves of S deficient plants turn light-green and spindly.



Marginal burn due to excessive nitrogen.



Chlorotic nitrogen deficient pepper seedlings (foreground).



Phosphorus deficient (left) and healthy (right) pepper seedlings.



Interveinal chlorosis typical of magnesium deficiency.

Nutrient Disorders (cont.)

Causal Agent:

Insufficient or excessive nutrients

Distribution:

Worldwide

Symptoms:

Boron (B): When B is deficient, older leaves turn yellow and brittle, and the growing points become necrotic and die. Margins and leaf tips of mature leaves become necrotic. Fruit may also be affected and develop scattered corky areas and exposed ovaries.

Copper (Cu): Copper deficiency starts as a wilt of young leaves that later turn bluish-green and curl upwards. Severely affected plants are stunted and chlorotic.

Iron (Fe): Young leaves of Fe-deficient plants develop interveinal chlorosis, followed by a general yellowing. The leaf midrib usually remains green.

Manganese (Mn): Young leaves deficient in Mn develop interveinal chlorosis, followed by speckling or necrosis. Midribs of affected leaves remain green.

Zinc (Zn): Leaves deficient in Zn thicken and curl downward. Petioles may twist, and older leaves develop an orange-brown chlorosis.

Conditions for Symptom Development:

Nutrient deficiencies are most common in acid or alkaline soils due to immobilization of nutrients. Low temperatures, soil compaction or excessive soil moisture may also affect nutrient availability. Nutrient disorders may also be caused by excessive or unbalanced use of fertilizer. Plant diseases that affect plant roots can induce nutrient deficiency symptoms due to reduced nutrient uptake.

Control:

Conduct soil and foliar nutrient analyses regularly to verify nutritional needs, design a balanced fertilizer program and correct nutrient imbalances. Alter soil pH with the addition of lime to acid soils or sulfur and acid-forming fertilizers to alkaline soils to increase nutrient availability.



Exposed ovaries typical of boron deficiency.



Nitrogen deficient eggplant seedlings (foreground).



Phosphorus deficient (left) and healthy (right) eggplant seedlings.

Salt Toxicity

Causal Agent:
Excessive salts

Distribution:
Worldwide

Symptoms:

Capsicum species are sensitive to salt toxicity. Emergence after direct seeding may be slow and patchy. Seedlings are stunted. The growing point may desiccate and collapse to cause seedling death. Older leaves develop tip burn, marginal chlorosis and scorching. In severe cases, leaves wilt and drop. Roots may appear slightly discolored, feeder roots may be poorly developed, and root tips are usually stubby and necrotic. Symptoms of salt toxicity are similar to symptoms caused by drought or fertilizer burn. Leaf tissue analysis may be necessary to confirm a diagnosis of salt toxicity.

Conditions for Symptom Development:

Excess concentration of salts in soil or irrigation water usually causes toxicity. Accumulation of salts in the root zone occurs as a consequence of alternating cycles of wetting and drying that move salts to the soil surface. Concentration of soluble salts in irrigation water varies with the source, season and annual rainfall. Drought and high evapotranspiration rates contribute to the development of salt toxicity.

Control:

Test the salt content of soil and irrigation water prior to planting. Irrigation water should be tested periodically throughout the growing season. When excess soil salinity is suspected, use pre-plant amendments such as gypsum to lower pH and leach salt. Prevent accumulation of salt using the correct type, amount and placement of fertilizer. Salt accumulation patterns in planting beds vary according to the water delivery system used. Plant or transplant to avoid zones of salt accumulation. In greenhouses, leach accumulated salts with excess irrigation.



Peppers are susceptible to high soil salinity.



Phytotoxicity caused by saline irrigation water.



Salt toxicity affects growth and appearance of roots and shoots.

Stip

Causal Agent:
Physiological

Distribution:
Worldwide

Symptoms:

Gray to black spots develop when fruit are approximately 7.5 cm (3 in) in diameter. Spots occur singly or in groups. As fruit mature, the spots turn green to gray-brown to yellow, which renders the fruit unmarketable. Stip can develop in all types of peppers but is more common on mature, red fruit harvested in the fall.

Conditions for Symptom Development:

Stip is a physiological disorder believed to be caused by a calcium imbalance. It most commonly develops in older, open-pollinated varieties. Stip generally occurs during fall months when days are short and cool. Stip is most common and severe in varieties grown on soils farmed with low calcium and/or high nitrogen and potassium fertilization rates. Tissue analysis reveals that stip resistant varieties have higher calcium and lower nitrogen and potassium concentrations than affected varieties.

Control:

Grow stip-resistant hybrids, and avoid open pollinated varieties in the fall. Calcium applications can significantly help reduce the occurrence and severity of stip.



Gray to black spots render fruit unmarketable.



Stip is more common on mature fruit harvested in the fall.



Discoloration extends below the surface.

Sunscald

Causal Agent:
Environmental

Distribution:
Worldwide

Symptoms:

Sunscald occurs on the side of fruit exposed to direct sunlight. It first appears as a wrinkled area that can be soft and lighter in color than surrounding tissue. In peppers, this area later collapses and turns white and paper-like. The affected area often turns black due to colonization by saprophytic fungi. Sunscald primarily affects fruit, but leaves and stems also can be injured. Fruit near maturity are more sensitive to sunscald injury than immature fruit. Symptoms are similar in appearance to those of blossom-end rot, but they are consistently associated with exposure to direct sunlight.

Conditions for Symptom Development:

Fruit suddenly exposed to direct sunlight due to defoliation from disease, pruning or stem breakage are most likely to develop sunscald. Sunscald occurs when internal fruit temperature increases and tissue is damaged.

Control:

To prevent sunscald, the internal temperature of the fruit should not rise above 35° C (95° F). Encourage abundant, healthy foliage with proper fertilization and irrigation. In greenhouse operations, shade plants during summer to help reduce the incidence of this disorder. Use disease-resistant varieties, and follow an effective disease and pest management program to help reduce losses due to sunscald.



Sudden direct exposure of pepper to sunlight may cause sunscald.



Close-up of dry, papery, sunken lesion on pepper fruit.



Tan-brown lesion on eggplant.

Anamorph	The asexual form in the life cycle of a fungus. Asexual spores (conidia) are usually produced.
Anthesis	The duration of life of a flower from the opening of the bud to the setting of the fruit.
Ascospore	Sexually derived fungal spore within a sack-like structure (ascus).
Bacterium	(pl. bacteria) Microscopic, single-celled organism.
Blight	Sudden and severe necrosis of the above-ground portions of a plant.
Calyx	The external green, leafy part of a flower consisting of sepals.
Canker	Localized, necrotic areas on roots or stems. Tissue may be sunken and/or cracked.
Chlorosis	(chlorotic) The yellow or white discoloration of healthy green tissue.
Coalesce	Merging of individual lesions.
Concentric	More than one circle in a lesion with a common center.
Conidium	(pl. conidia) A fungal spore formed asexually.
Cotyledon	The first foliar structure to emerge from a seed.
Damping-off	A rotting of seedlings at or below soil level.
Debris	Remnant plant material.
Defoliation	The loss of leaves.
Distal	Located far from the point of attachment.
Diurnal	Occurring or active during the daytime.
Epicotyl	The part of the stem above the cotyledons.
Epidermis	The outer layer of cells occurring on plants.
Fumigation	Sterilization by chemical volatilization.
Fungicide	A chemical used to control fungi.
Fungus	(pl. fungi) A microscopic organism with thread-like cells that grows on living and/or dead plants.
Gall	Swelling of roots, stems or leaves caused by abnormal growth of tissue.
Girdle	The encircling of a root or stem by a pathogen that results in disruption of the phloem.

- Haustorium** (pl. haustoria) The penetrating feeding structure of fungi and parasitic plants.
- Herbicide** Chemical substance used to control weeds.
- Host** A plant from which a parasite obtains nutrition.
- Hydathode** A leaf structure that eliminates unused salts, sugars and water from a plant through a pore at the leaf margin.
- Hypersensitive** A localized plant response that results in sudden death of the infected cells.
- Hypocotyl** The lower stem of a plant between the cotyledons and the roots.
- Immunity** Not subject to attack or infection by a specified pest or pathogen.
- Indicator** A plant that produces specific symptoms to certain viruses or environmental factors and is used for their detection and identification.
- Infection** The process by which an organism attacks a plant.
- Inoculum** The pathogen or its parts that can cause disease.
- Insecticide** A substance used to control insects.
- Instar** An insect stage between molts before adulthood.
- Intermediate resistance:** The ability of a plant variety to restrict the growth and development of the specified pest or pathogen, but may exhibit a greater range of symptoms compared to resistant varieties. Intermediate resistant plant varieties will still show less severe symptoms or damage than susceptible plant varieties when grown under similar environmental conditions and/or pest or pathogen pressure.
- Interveinal** The area of leaf tissue bordered by veins.
- Lesion** A well-defined, but localized, diseased area on a plant.
- Microsclerotia** Microscopic, dense aggregate of darkly pigmented thick-walled hyphal cells specialized for survival.
- Mosaic** Variegated patterns of light and dark areas on a plant often caused by viruses.
- Mottle** Irregular light and dark areas on leaves or fruit surfaces symptomatic of viral diseases.
- Mycelium** (pl. mycelia) The mass of thin, microscopic, hair-like structures that forms the vegetative part of a fungus.
- Necrotic** Dead and discolored plant tissue.
- Nematode** Microscopic worms that can live in plants, animals, soil or water.

Nymph	Juvenile stage of an insect.
Pasteurization	The process of partial sterilization by heating at controlled temperatures to kill undesirable microorganisms.
Pathogen	An organism or agent that is capable of causing disease.
Pedicel	The stalk of a flower or fruit.
Petiole	The stalk of a leaf.
Phloem	The food-conducting tissue of a plant.
Phytoplasma	A pleomorphic, obligate single-celled organism that lacks a cell wall. Formerly referred to as a Mycoplasma-like organism (MLO).
Pith	Soft, spongy tissue in the center of a plant stem.
Pustule	A small blister-like elevation of the epidermis that forms as fungal spores develop and emerge.
Pycnidium	(pl. pycnidia) A spherical or flask-shaped asexual fruiting structure that gives rise to fungal conidia.
Race	A subspecific group of pathogens with distinct pathological or physiological properties.
Reservoir	Infected plants that can serve as a source of inoculum for further infection of other plants.
Resistance	The ability of a plant variety to highly restrict the growth and development of a specified pest or pathogen, and/or the damage they cause when compared to susceptible plant varieties under similar environmental conditions and pest or pathogen pressure. Resistant varieties may exhibit some disease symptoms or damage under heavy pest or pathogen pressure.
Rootstock	Portion of stem and associated root system onto which a bud or scion is inserted by grafting.
Saprophyte	An organism that lives on dead organic matter.
Saturation	Being completely filled with liquid, generally water.
Sclerotium	(pl. sclerotia) A compact mass of hyphae capable of surviving unfavorable environmental conditions.
Solanaceous	Plants in the nightshade family, including tobacco, tomatoes, potatoes, peppers, eggplant and others.
Solarization	Exposure to direct sunlight to raise soil temperature to levels that kill pathogens.
Spore	A reproductive structure of fungi and some bacteria.
Stomata	A pore in a leaf surface.

- Strain** A general term referring to (a) an isolate; descendent of a pure culture of pathogen, (b) a race; one of a group of similar isolates or (c) one of a group of virus isolates that have common antigens.
- Susceptibility** The inability of a plant variety to restrict the growth and development of a specified pest or pathogen.
- Systemic** Spreading internally throughout a plant.
- Teleomorph** The sexual form of a fungus.
- Tolerance** The ability of a plant variety to endure abiotic stress without serious consequences for growth, appearance and yield.
- Toxin** A compound produced by an organism that is injurious to plants.
- Translocation** The transfer of nutrients or a virus through the plant.
- Transpiration** The loss of water vapor via stomata.
- Variegated** Distinct areas, patches or spots of different colors.
- Vascular** The conductive system of a plant combining the xylem and phloem.
- Vector** An agent able to transmit a pathogen.
- Vein banding** Pattern of light or dark green areas surrounding the veins often caused by viruses.
- Viruliferous** Containing or carrying a virus.
- Virus** A sub-microscopic obligate disease-causing agent.
- Water-soaked** Tissue having the appearance of being soaked with water.
- Xylem** The water-conducting tissue of a plant.
- Zonate** Distinguished from adjacent parts by a distinctive feature (such as concentric rings).

References

Compendium of Pepper Diseases. 2003. K. Pernezny, P.D. Roberts, J.F. Murphy, N.G. Goldgerg (eds.). APS Press. The American Phytopathological Society. St. Paul, Minnesota.

Disease and Pests of Vegetable Crops in Canada. 1994. R.J. Howard, J.A. Garland and W.L. Seaman. The Canadian Phytopathological Society and the Entomological Society of Canada. M.O.M. Printing Ltd. Ottawa, Ontario, Canada.

Field Guide: Insect pests of Selected Vegetables in Tropical and Subtropical Asia. 1995. B. L. Parker, N. S. Talekar, M. Skinner. Asian Vegetable Research and Development Center, Shanhua, Tainan, Taiwan, ROC. AVRDC Publication no. 94-427.

Northeast Pepper Integrated Management (IPM) Manual. 2001. T. J. Boucher, R. A. Ashley (eds.). University of Connecticut. Cooperative Extension Publication.

Nutritional Deficiencies and Toxicity's in Crop Plants. 1993. William F. Bennett. APS Press. The American Phytopathological Society. St. Paul, Minnesota.

Pepper Diseases: A Field Guide. 1991. L.L. Black et al. Asian Vegetable Research and Development Center. Shanhua, Tainan, Taiwan, ROC. AVRDC Publication no. 91-374.

Suggested Cultural Practices for Eggplant. N.C. Chen et al. Last update 2002. Asian Vegetable Research and Development Center AVRDC Learning Center. Publications and Fact Sheets on Eggplant. <http://www.avrdc.org/LC/eggplant/publications.html> February 8, 2005.

Vegetable Diseases and their Control. 1986. A. F. Sherf, A. A. Macnab. John Wiley & Sons Inc.



For questions, comments or more information,
please call 1-855-733-3834 or visit www.seminis.com.

Seminis® is a registered trademark of Seminis Vegetable Seeds, Inc. ©2013 Seminis Vegetable Seeds, Inc.