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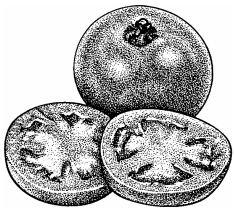
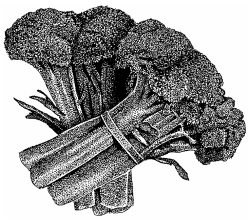


SELECTED BACTERIAL DISEASES OF VEGETABLES



Cool, wet growing seasons can be conducive for many diseases on vegetable crops in Connecticut. This update highlights some of the key bacterial problems that are often encountered and includes angular leaf spot and bacterial wilt of cucurbits, black rot of crucifers, bacterial canker and bacterial speck of tomato, and bacterial spot of pepper and tomato. Each year, weather plays a critical role in determining both the incidence and severity of disease. Temperature, rainfall, and relative humidity can influence the development of the disease agent, the host plant, or both. As a consequence, disease control programs must be adjusted every year to take the prevailing environmental conditions into account in order to achieve maximum control.

Commercial growers can refer to the current edition of the *New England Vegetable Management Guide* for specific information on current pesticide labels.

A. ANGULAR LEAF SPOT

1. Causal Agent: *Pseudomonas syringae* pv. *lachrymans*

2. Hosts: All members of the Cucurbitaceae family; susceptibility can vary between genera and species.

3. Symptoms: Initial symptoms appear as small, water-soaked lesions on the leaves and are often visible shortly after crop emergence. These spots expand until they are confined by the veins. This gives them an angular appearance for which the disease is named. Under conditions of high humidity, the spots may ooze droplets of liquid containing bacteria. The lesions eventually turn tan-brown, dry, and drop out. Heavily infected leaves develop a tattered, yellowed appearance. Lesions can also develop on petioles, stems, and fruit. These often appear as white, crusty patches. Affected fruit develop small, circular, water-soaked spots which can result in an internal rot and predispose fruit to bacterial soft rot pathogens.

4. Factors for Disease Development: The bacterium is seedborne and can also overwinter in diseased plant debris and in the roots of host plants. The bacterium can survive in up to 2½ years in

plant debris. Angular leaf spot is readily spread by rain, sprinkler irrigation, and human activities. It is also likely that insects have a role in spread of disease within and between fields. The optimum temperature for disease development is 74-80°F.

5. Management Strategies:

- Practice good sanitation (e.g., use clean equipment and tools, avoid work in fields when wet, locate cull piles away from production fields)
- Use pathogen-free seed or treat seed to eliminate the pathogen
- Use certified disease-free transplants
- Practice crop rotation (at least 2 years without cucurbits)
- Avoid overhead irrigation
- Use resistant varieties, when available
- Pesticide sprays (e.g., copper compounds)

B. BACTERIAL WILT

1. Causal Agent: *Erwinia tracheiphila*

2. Hosts: Most members of the Cucurbitaceae family although it is most prevalent on cucumbers and cantaloupes. It is an occasional problem on squash and pumpkins; watermelons are rarely affected.

3. Symptoms: Although the most obvious symptom is the wilting of individual leaves or vines, the disease first appears as dull-green patches on the leaves which quickly increase in size. Symptoms usually develop as a wilting of the leaf which is followed by a progressive wilting of the petioles and the stem. Although symptoms can develop at any stage of plant development, they are usually most severe early in the season when the plants are growing most rapidly. Cucumbers and cantaloupes are very susceptible and develop wilt symptoms very quickly after infection. Squash and pumpkins don't wilt as rapidly and can exhibit stunted, tufted growth or excessive branching. Watermelons are rarely affected. The bacteria grow and multiply in the vascular system of the plant and when populations are high enough, their presence blocks water movement through the plant. When this occurs, the plants wilt and eventually die. During the early stages of disease development, it is not uncommon for many wilted plants to appear to recover at night. Because the bacteria are systemic in the plant, infected plants cannot be cured of infection and they eventually yellow, collapse, and die. When wilted stems or petioles are cut in cross section and slowly pulled apart, milky "strings" may be observed due to the presence of the bacteria in the vascular system. This can be used in field diagnosis of the disease although it is not completely accurate since many infected plants don't have bacterial titers high enough to result in "string" formation.

4. Factors for Disease Development: The bacterium is not seedborne. Primary spread of the bacterium is by insect vectors, mainly the striped cucumber beetle (*Acalymma vittatum*) and the spotted cucumber beetle (*Diabrotica undecimpunctata howardi*). These beetles are responsible for bacterial dispersal within and between fields. The pathogen is transmitted mechanically by contact with contaminated beetle mouthparts. Adult beetles usually feed on stems and leaves. When sufficient water is present on the surface of the plant tissue, the bacteria multiply in the wounds made by the beetles and enter the xylem vessels. Once in the xylem, the pathogen continues to multiply and plugs the vascular system. The incubation period from infection to symptom expression can range from several days to several weeks. This is influenced by the age of the plant and the location and types of tissues that were

inoculated. Disease develops most rapidly when plants are young, actively growing, and succulent. Although circumstantial evidence suggests that the bacteria overwinter in the intestinal tracts of the cucumber beetles, this has not been fully documented. Recent studies have suggested that symptomless weed hosts may also play a key role in the survival of the wilt pathogen from year-to-year. This bacterium is not seedborne and there is no evidence that it survives in soil. Optimum temperature for disease development is 52-60°F. The beetles are less active in wet weather so the disease is most commonly spread on dry days when the beetles are active. However, once the bacterium is spread, wet conditions favor its multiplication and spread within the plant host.

5. Management Strategies:

- Control cucumber beetle vectors
- Practice good sanitation (e.g., use clean equipment and tools, avoid work in fields when wet, locate cull piles away from production fields)
- Remove wild or volunteer cucurbits in vicinity
- Resistance (?)
- Scout and remove diseased plants (?)
- Use trap crops (?)

C. BLACK ROT

1. Causal Agent: *Xanthomonas campestris* pv. *campestris*

2. Hosts: All members of the Brassicaceae family are susceptible including broccoli, Brussels sprouts, cabbage, cauliflower, Chinese cabbage, kale, mustard, radish, rutabaga, and turnip. There are also numerous weed hosts (e.g., Shepherd's purse, wild mustard, yellow rocket).

3. Symptoms: Symptoms can develop on the aboveground parts of plants at any stage of growth. Bacteria enter and colonize natural openings (e.g., stomates, hydathodes) and wounds. On seedlings, cotyledons turn black and drop off. On true leaves, diagnostic symptoms appear at leaf margins as yellow, V-shaped lesions. The point of the V-shaped lesion is usually directed toward a vein. The lesions enlarge toward the base of the leaf and the affected tissues wilt and die. This is frequently accompanied by a distinct blackening of the veins. Severely infected plants may drop substantial numbers of leaves.

As the infection moves from the vascular tissue of the petiole, the bacteria become systemic and can spread up and down the stem of the plant and into the roots. On root crops (rutabaga, radish), foliar symptoms may be minimal but blackened vascular tissues may be present in the edible portions. On cabbage and Brussels sprouts, the symptoms can vary with age, host, cultivar, and environment. Many "weed" hosts don't exhibit any of the typical diagnostic symptoms. However, most hosts develop the common diagnostic symptom of black rot which is black veins in yellow lesions along leaf margins. Black rot infection is often followed by secondary soft rot organisms that substantially reduce the quality and storage life of the produce.

4. Factors for Disease Development: The primary means of survival and long-distance spread of the bacterium is on seed and this is considered the most important source of inoculum for infection. For example, as few as 3 infected seeds in 10,000 (0.0003%) can cause black rot epidemics. The pathogen can overwinter in plant debris in the field for up to 2 years before the residue is decayed but it can only survive 40-60 days as a free-organism in the soil (without plant debris). Studies have also shown that the bacterium can also persist in and on weedy hosts. Spread of the

pathogen within and between fields is thought to be accomplished by splashing rain, cultural activities, insects, and overhead irrigation. The optimum temperature for growth of the bacterium is 76-86°F. At these temperatures, symptoms can develop on plants 7-14 days after infection. At lower temperatures, symptom expression takes much longer.

5. Management Strategies:

- Practice good sanitation (e.g., use clean equipment and tools, avoid work in fields when wet, locate cull piles away from production fields)
- Use pathogen-free seed or treat seed to eliminate the pathogen
- Use certified disease-free transplants
- Practice crop rotation (2-3 years without cruciferous crops)
- Avoid overhead irrigation
- Use resistant varieties, when available
- Pesticide sprays (e.g., copper compounds)

D. BACTERIAL CANKER

1. Causal Agent: *Clavibacter michiganensis* subsp. *michiganensis* (formerly *Corynebacterium michiganense)*

2. Hosts: Tomato. There are also many solanaceous weeds hosts (e.g., nightshades, horsenettle, jimsonweed)

3. Symptoms: This disease can occur on field and greenhouse tomatoes. Symptoms are variable and included stunting, wilting, vascular discoloration, cankers on stems, and lesions on fruit. Plants can be infected at any stage of growth. A key initial symptom often appears as marginal wilting of leaflets. Infected seedlings may be quickly killed or may develop into weak or stunted plants. Sometimes plants appear to be apparently healthy until they are set into the field and favorable weather conditions cause symptoms to develop. Affected leaves become brown, flaccid, wither, and die. In the later stages of disease, cankers, necrosis of the pith, and adventitious roots may develop on the stems. Affected stems frequently have numerous longitudinal brown streaks. Cankers typically have a dark and water-soaked appearance. Pith necrosis is recognized when the stems are split longitudinally and reveal a darkened center. These tissues have many cavities and have a mealy consistency.

Although fruit symptoms don't always develop, they are quite diagnostic when they do appear. The spots are called bird's-eye spots. Lesions develop as small areas approximately ¼ inch in diameter. These are raised and have brown centers which are surrounded by snow-white haloes. Fruit infection is much more common in greenhouse-grown than in field-grown tomatoes.

4. Factors for Disease Development: The bacterium is seedborne and can also persist in plant debris, weed hosts, volunteer tomatoes, or on contaminated stakes and equipment. However, infested seed and infected transplants are considered to be the primary means of long-distance spread of the disease. The pathogen may survive on seed for up to 5 years. Spread within and between fields is accomplished by splashing water from rain or overhead irrigation, handling of infected plants, and other cultural activities. Disease development is favored by warm temperatures (85-89°F) and wet weather.

5. Management Strategies:

- Practice good sanitation (e.g., use clean equipment and tools, avoid work in fields when wet, locate cull piles away from production fields)

- Use pathogen-free seed or treat seed to eliminate the pathogen
- Use certified disease-free transplants
- Practice crop rotation (use at least a 2 year rotation)
- Avoid overhead irrigation
- Control solanaceous weeds in vicinity
- Scout and remove symptomatic plants
- Pesticide sprays (e.g., copper compounds)

E. BACTERIAL SPECK

1. Causal Agent: *Pseudomonas syringae* pv. *tomato*

2. Host: Tomato. There are also many solanaceous weeds hosts.

3. Symptoms: Symptoms develop on leaves, petioles, stems, and fruit. On the leaves, symptoms appear as tiny, black specks, no more than $1/10^{th}$ inch in diameter and are surrounded by yellow haloes. When the spots are numerous, they coalesce and give the leaf a distinctly chlorotic appearance. Heavily affected leaves drop prematurely. Excessive leaf drop frequently results in sunscalding of the fruit. Symptoms on the stems and petioles are not as common but appear as oval or elongate black lesions.

Symptoms also develop on tomato fruit although only green fruit are susceptible. Symptoms consist of small, black spots about $1/16^{th}$ inch in diameter. These spots can have a slightly sunken appearance. These symptoms can be confused with those of bacterial spot but speck lesions are usually much smaller. The black specks persist on the fruit as they ripen but are usually very superficial and don't crack or become as corky as the spots associated with bacterial spot.

4. Factors for Disease Development: This bacterium is seedborne and can also overwinter in plant debris in soil and on the roots of many perennial weedy hosts. Long-distance spread is believed to occur via infested seed and transplants. Spread of the disease within and between fields is accomplished by splashing rain, overhead irrigation, and cultural activities. Optimum conditions for disease development are high humidity and relatively cool temperatures (65-75°F). This temperature range is substantially lower than that for bacterial spot.

5. Management Strategies:

- Practice good sanitation (e.g., use clean equipment and tools, avoid work in fields when wet, locate cull piles away from production fields)
- Use pathogen-free seed or treat seed to eliminate the pathogen
- Use certified disease-free transplants
- Practice crop rotation (at least a 2 year rotation)
- Avoid overhead irrigation
- Scout and remove symptomatic plants
- Pesticide sprays (e.g., copper compounds, combination products of copper, mancozeb, and maneb)

F. BACTERIAL SPOT

1. Causal Agent: *Xanthomonas vesicatoria* (formerly *X. campestris* pv. *vesicatoria*); numerous physiological races have been identified;

2. Hosts: Pepper, tomato, and several of weedy members of the Solanaceae family.

3. Symptoms: Symptoms vary with host plant and can develop on the leaves, stems, and fruit. On tomato, initial symptoms on leaves and stems appear as tiny, water-soaked, black, circular spots. These lesions are often surrounded by a yellow halo. The spots are very similar to and often confused with those caused by bacterial speck. As the spots become more prevalent, they coalesce into large, irregular, dead areas. The leaves then dry up and die. Similar symptoms can develop on stems or fruit pedicels. Symptoms also occur on tomato fruit although only green fruit are susceptible to infection. Initial symptoms appear as small, water-soaked spots on the green fruit. They gradually change into dark brown to black, slightly raised spots which are often surrounded with a white halo. These spots enlarge to about ¼ inch in diameter and become scabby. As the spots mature, they develop a corky appearance and turn gray or brown.

On pepper, foliar symptoms are slightly different from those on tomato. Initial symptoms appear as small, yellow-green, circular lesions surrounded by yellow haloes. These spots appear water-soaked under wet conditions. As the lesions mature, the centers become brown to black and sunken. They eventually dry, break away, and fall out. This gives the leaves a shot-holed appearance. When spots are numerous, they coalesce and form large, irregular, dead patches. When these tissues drop, it gives the leaf a distinctly ragged or tattered appearance. Heavily infected plants often drop a substantial number of leaves. Pepper fruit are susceptible at any stage in development which is unlike the situation with tomatoes where only green fruit are susceptible. Symptoms develop as brown to black, raised or sunken, wart-like lesions and are very similar to those on tomato fruit. Secondary fruit rots often develop on affected fruit in wet weather.

4. Factors for Disease Development: The bacterium is seedborne and persists on the surface of infested seed. This is considered to be the primary source of inoculum. However, the pathogen can survive in diseased plant debris for at least one year as well as in tomato volunteers. Spread within and between fields is accomplished by wind-driven rain, overhead irrigation, insects, and human activities. Optimum conditions for disease development are high moisture, high relative humidity, and temperatures in the range of 75-90°F. This temperature range is considerably higher than that for bacterial speck.

5. Management Strategies:

- Practice good sanitation (e.g., use clean equipment and tools, avoid work in fields when wet, locate cull piles away from production fields)
- Use pathogen-free seed or treat seed to eliminate the pathogen
- Use certified disease-free transplants
- Practice crop rotation (at least a 2-3 year rotation)
- Deep plow to bury plant debris
- Eliminate wild hosts in vicinity
- Avoid overhead irrigation
- Use resistant varieties (available for pepper)
- Scout and remove symptomatic plants
- Pesticide sprays (e.g., copper compounds, combination products of copper, mancozeb, and maneb)

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