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report on
PLANT DISEASE

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BACTERIAL CANKER, BACTERIAL SPECK, AND BACTERIAL SPOT OF TOMATOES

Three bacterial diseases of tomatoes occur every year in Illinois. These diseases are: bacterial canker caused by *Clavibacter michiganensis* subsp. *michiganensis*; bacterial speck caused by *Pseudomonas syringae* pv. *tomato*; and bacterial spot caused by *Xanthomonas perforans* and *X. gardneri*. Prior to 2012, bacterial canker and bacterial speck occurred widely in Illinois. In the recent years, however, we have been experiencing frequent outbreaks of bacterial spot, especially in southern Illinois, and more on foliage rather than fruits.

Figure 1. Bacterial canker of tomato, caused by Clavibacter michiganensis susp. michiganensis.

To develop effective management strategies of bacterial spot disease of tomatoes, we conducted a 3-year research with following objectives: (1) assess incidence and severity of bacterial spot on foliage and fruits in southern, central, and northern Illinois; (2) identify species of the pathogen causing bacterial spot; (3) determine genetic variation of the isolated pathogens of bacterial spot; and (4) evaluate effectiveness of chemicals and biocontrol agents for managing bacterial spot disease.


Figure 2. Tomato fruit infected by Clavibacter michiganensis susp. michiganensis.

Four species of genus *Xanthomonas*, including *X. vesicatoria*, *X. euvesicatoria*, *X. gardneri*, and *X. perforans*, have been reported as the causal agents of bacterial spot of tomatoes worldwide. Our research showed that bacterial spot in Illinois commercial fields are caused by two species: *X. gardneri* (prevalent in northern Illinois) and *X. perforans* (prevalent in southern Illinois). Also, the results showed

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that fruit infection of tomatoes in Illinois is caused by *X. gardneri*. Additionally, the results revealed considerable genetic variation among isolates of both *X. gardneri* and *X. perforans*. Among all potential chemicals and biocontrol agents tested, copper hydroxide (Kocide-3000) + mancozeb (Manzate PRO Stick) provided the best protection to tomato plants against bacterial spot in the field testing.

Figure 3. Bacterial speck lesions on tomato leaves, caused by Pseudomonas syringe pv. tomato. Photo courtesy APS.

Symptoms

Bacterial canker. The major symptom of the bacterial canker is a systemic wilt of the plant. Early symptoms include a downward turning of lower leaves, marginal necrosis of leaflets, and wilting of leaflets. Initially, the leaf petioles remain turgid as the leaflets wilt and become distorted (Figure 1). Stems may display external discolored streaks, with stem cankers forming under some conditions . In the staked plants, canker symptoms may obvious first on the stem where the string has caused an abrasion. Initially, the vascular tissues of the infected stems exhibit light yellow to brown streaks, which later turn reddish brown and are prominent at the nodes (Figure 1). Eventually, the pith becomes discolored and "mealy." The fruit symptoms have been referred to as bird's eye spot: lesions with raised brown centers that are surrounded by a white halo (Figures 2 & 7). When present, bird's eye spots, 3-6 mm in diameter, are a helpful diagnostic aid.

Figure 4. Tomato fruit infected by *Pseudomonas syringe pv. tomato*.

Bacterial speck. All above-ground parts of plants can be infected. Lesions on leaflets are round and dark brown to black. A halo is lacking in the early stages but develops with time (Figure 3). The lesions develop throughout the entire leaf but are most prominent on the abaxial surface. Spots may coalesce, killing large areas of leaf tissue. Stems, petioles, peduncles, pedicels, and sepals are also affected. Lesions on these plant parts are oval to elongated. On fruit, minute lesions or specks develop that are dark and rarely larger than 1 mm in diameter (Figures 4 & 7). The tissue around each speck may be more

intense green than unaffected areas. The lesions are slightly raised or flat when. In some instances, the spots are sunken.

Bacterial spot. The bacterium affects all aboveground plant parts. Brown, circular spots develop on leaves, stems, and fruit spurs (Figures 5 & 6). The spots are water-soaked during rainy periods or when dew is present. Lesions rarely develop to more than 3 mm in diameter. When conditions are optimal for disease development, spots on the leaves, petioles, and rachis coalesce to form long dark streaks. A general yellowing may occur on leaflets with many lesions (Figure 5). In Illinois a more common symptom of bacterial spot caused by *X. perforans* is streaks of flower stems, which result in no fruit development. Blighting of the foliage occurs with the coalescing of lesions, and the plants become huddled in appearance because of severe epinasty. Often the dead foliage remains on the plant, giving it a scorched appearance. Fruit lesions begin as minute, slightly raised blisters. As a spot increases in size, it becomes brown, scablike, and slightly raised (Figures 5 & 7). A developing lesion may have a faint to prominent halo, which eventually disappears. Bacterial canker, bacterial speck, and bacterial spot of tomato can be diagnosed from each other on the base of fruit lesions (Figure 7).

Figure 5. Tomato leaves and fruit infected by Xanthomonas perforans (leaves) and X. gardneri (fruits).

Disease Cycle

Bacterial canker. Sources of inoculi for bacterial canker include over-seasoning in plant debris in soil, weed hosts, volunteer plants, contaminated wooden stakes, and seed. Secondary spreads of the bacterium can occur by means of splashing water, contaminated equipment, and workers' hands. The disease is also spread by pruning plants and clipping transplants. Plants infected from seed may die, fail to set fruit, or display no symptoms at all. Secondary dissemination often

Figure 6. Flower stems of 'Red Duce' tomato infected by Xanthomonas perforans.

results only in foliar symptoms, bird's eye fruit spots, or both. Also, secondary dissemination by clipping in transplant fields results in systemic infection and death of the plant after transplanting.

Bacterial speck. *P. syringae* pv. *tomato* is a seed-borne pathogen. The bacterium is disseminated by splashing rain and by equipment used in the clipping of transplants. It has been reported that *P. syringae* pv. *tomato* survives in crop residue for up to 30 weeks. Weed species support population of the bacterium. Both high humidity and low temperatures 64-75°F (18-24°C) fav0r bacterial speck development.

Bacterial spot. The pathogen survives on tomato volunteers and infected plant debris. The bacterium may also be disseminated by seed. Disease development is favored by temperatures of 75-86°F (24-30°C) and by high precipitation. The pathogen is disseminated within fields by wind-driven rain droplets, the clipping of transplants, and aerosols. It penetrates through stomates and wounds created by wind-driven sand, insect punctures, or mechanical means.

Figure 7. Tomato fruits infected by bacteria. A, bacterial canker (Clavibacter michiganensis subsp. michiganensis). B, bacterial speck (Pseudomonas syringe pv. tomato). C, bacterial spot (Xanthomonas gardneri).

Disease Management

Bacterial canker. Bacterial canker is one of the most difficult tomato diseases to control. First, there is the problem of detecting infected plants, due to the wide variability of symptom expression. Second, the highly infectious nature of the pathogens, the number of sources of inoculum, and the absence of effective chemicals for treatment mean that sanitation and preventive measures must be enforced.

1. Only certified, pathogen-free seed from canker-free plants should be planted. Saving seed from a source known to have had bacterial canker should be avoided. Acetic acid extraction or fermentation process of seed eliminates seed coat contamination, but it does not completely control embryonic infection. Only certified disease-free transplants that have been produced under an inspection program should be planted. It is usually not possible to distinguish between infected and healthy seedlings at the time of transplanting.

2. Greenhouse seedbeds and soils must be sterilized to destroy the bacteria. Steam sterilization is preferred.
3. Proper sanitation of transplant production greenhouses is necessary.
4. If the disease is suspected or confirmed in a greenhouse crop, every effort must be made to isolate affected areas from the rest of the crop. Hands, shoes, and tools should be disinfested.
5. Crop rotation with non-solanaceous crops for at least 3 years should be considered.
6. Weeds belonging to the Solanaceae family should be controlled.
7. Fixed copper sprays may help in protecting healthy plants. Also, application of Tanos fungicide may help suppress bacterial diseases.
8. Tillage of the field after harvest is recommended.

Bacterial speck and bacterial spot. The same methods are used to manage these two diseases.

1. Only pathogen-free seed should be planted.
2. Only certified disease-free transplants should be planted.
3. Crop rotation with non-host plants for $\geq$ 2 years.
4. Effective weed control should be seriously practiced.
5. Plant resistant cultivars, if available. Some tomato cultivars are more susceptible than others.
6. Spray-application of copper plus mancozeb can suppress disease development and spread.
7. Actigard, Agri-mycin 17, copper, mancozeb, Serenade Max, and Tanos are labeled for management of these diseases. Strains of the bacterium that cause bacterial spot on tomato that are resistant to copper products have been reported. Present recommendations for managing bacterial spot and bacterial speck of tomatoes are spraying plants beginning bloom time (or at the first sign of the disease), at 7-day intervals or more often, with copper (i.e., Kocide-3000) + mancozeb (Manzate PRO Stick) alternated with either Regalia or Double Nickle + Cueva. For additional information refer to the “Midwest Vegetable Production Guide for Commercial Growers.”