Monroe J. Goode
University of Arkansas, Fayetteville

Myron Sasser
University of Delaware, Newark

Prevention–the Key to Controlling Bacterial Spot and Bacterial Speck of Tomato

Bacterial spot and bacterial speck of tomato, caused by *Xanthomonas vesicatoria* (Doidge) Dows. and *Pseudomonas tomato* (Okabe) Altstatt (*P. syringae*), respectively, affect the aerial portions of the plant and are sources of economic losses in the tomato industry. Lesions of either disease may make the fruit unfit for the fresh market and increase the costs of harvesting and grading. On tomatoes for processing, bacterial spot lesions may be deep enough to cause considerable grading out or loss of quality in the processed product. Even though more superficial and less often a cause of loss, speck lesions may be deep enough to reduce quality after mechanical removal of skins (9). In addition, fruit that develop after severe defoliation by either disease are sunscalded, small, and of poor quality.

Bacterial spot occurs annually to some extent in the humid tomato-producing areas of the United States. Sporadic serious outbreaks may be localized geographically or related to a period of rainy weather. The incidence of speck has been much lower, but the number of worldwide reports took a major upswing during the last decade (1,2,4,7,11) (Fig. 1). Such reports raise the question of whether dissemination of the pathogen suddenly increased or whether researchers became more aware of a long-standing problem. The first explanation seems most plausible.

Both diseases are greatly increased in severity by driving rains and by such wounds as those resulting from hail or blowing sand (12). Cool temperatures favor speck development (11) and warm temperatures, spot development.

Fig. 1. Worldwide reported incidences of bacterial speck during the last decade.

Symptoms—Similar and Different

Early leaf lesions of both diseases appear as small water-soaked areas with distinct borders (Figs. 2A and 3A). Spot lesions become sunken and turn from yellow or light green to black or dark brown with, ultimately, brown or gray centers as tissues become necrotic (Fig. 2B). After moist conditions, bacterial ooze may be visible and the surface of lesions and surrounding areas often appears reflective or shellacked (Figs. 2A and B). The lesions remain irregularly circular and ordinarily enlarge to 2–5 mm in diameter. Speck lesions usually have more distinct halos (Fig. 3A), and large areas of leaflets may become chlorotic (Fig. 3B). Holes frequently form in the center of lesions on young leaves (Fig. 3B), and older leaves may appear ragged (Fig. 3D). Speck lesions may develop randomly on leaflets but tend to form streaks of necrotic tissues (Figs. 3B and D). Otherwise, leaf symptoms of the two diseases are similar, and death of leaves and defoliation may occur with either.

Fruit symptoms may also overlap but usually are quite different. Speck is properly described by its name, with individual lesions ranging from a barely visible fleck of necrotic tissue to 1 mm in diameter (3) (Figs. 3C and E). Tissues around each speck may be a more intense green than those around nonaffected areas. Specks are primarily surface developments and tend to protrude just enough to be detected by touch. Lesions may coalesce in scabby areas covering one-fourth or more of the fruit surface (Fig. 3F). Spot lesions start as small water-soaked to yellowish areas that later turn brown to gray and scabby (Figs. 2C–F). Lesions tend to be depressed in the center and raised on the margin (Figs. 2E and F), although the entire lesion may be either raised or depressed. Lesions range from 2 to 10 mm in diameter (Figs. 2C–F), and some are surrounded by a narrow yellowish to white halo (Fig. 2E). Lesions are ordinarily shallow but may extend deep into the fruit wall.

Black to grayish, circular to elongate

0191-2917/80/09083104/$03.00/0

shallow lesions on stems, leaf petioles, peduncles, and calyx lobes may be associated with both diseases (Figs. 2C and 3D) but are not of critical diagnostic value because similar symptoms may be associated with bacterial canker and early blight. Early leaf symptoms of Septoria blight, early blight, and severe strains of spotted wilt virus could also be mistaken for those of either spot or speck disease. Similarly, fruit and leaf spot symptoms of bacterial canker may overlap those of spot or speck disease.

Transmission and Survival

Although isolates of *X. vesicatoria* from tomato may be poorly pathogenic on pepper and vice versa (5), movement from one crop to another has been reported, and this should be considered in disease control. *X. vesicatoria* grown on nutrient agar produces the characteristic xanthomonad yellow pigments (Fig. 4). *P. tomato* is often characterized in culture by fluorescence on King's medium B (Fig. 5), an oxidase-negative reaction, and utilization of D-(−)-tartaric acid.

P. tomato has been reported to live for considerable periods on asymptomatic plants other than tomato and pepper (11). *X. vesicatoria* may survive between seasons in the extreme southern United States on volunteer tomato plants. The bacterium persists in the soil for only a few weeks but may survive in plant debris from one season to the next (10). *P. tomato* may survive in the soil for long periods in the absence of tomato (11). The seedborne nature of *X. vesicatoria* has been known since the early 1920s (8). With *P. tomato*, however, some reports describe isolation of the bacterium from seed (4,7,9) and others state the pathogen is not seedborne (11).

Efforts at Regulation

Tomato transplants for northern states are commonly produced in concentrated areas in the southeastern United States. For this production, state regulatory agencies routinely assay seed lots for bacterial as well as fungal pathogens and inspect fields at regular intervals. Plants in a field showing intolerable disease symptoms may be rejected for interstate shipment. Recommendations to growers of tomato transplants have included rotation, seed sanitation, destruction of volunteer hosts, and avoidance of unnecessary wounding such as that caused by mowing to keep plants from being too tall. Spraying the plants with copper compounds just before pulling and shipping has also been recommended.

Despite these efforts, bacterial spot and speck continue to plague the industry. The problems with control are caused not by lack of technology but by lack of vigorous and uniform application of technology. The big problems result from seed production in humid areas, lack of effective seed treatment, and failure to eliminate volunteer hosts or infected crop plants.

It must be understood that the inoculum from a single infected plant may spread rapidly throughout a plant population because of the extremely high plant density in the beds and of the extensive handling involved in pulling, packing, shipping, unpacking, and transplanting. Thus, even small amounts of inoculum must not be introduced into the transplant growing beds.

Transplant lots are also inspected by regulatory personnel in receiving states. Although regulatory activities are valuable, infected transplants obviously are getting through. Inspectors have to decide rather rapidly whether to accept plants with symptoms that may indicate infection by bacterial speck or spot. Because the plants typically cannot be held long enough to isolate and identify the pathogens, decisions usually are based on a trained eye and possibly microscopic examination for bacterial streaming from lesion tissues. Rapid tests of potential value, such as serologic methods, are not used often because of difficulty in handling, expense, or unreliability.

High rejection rates by either shipping or receiving states could lead to a lack of plants to produce the crop and to serious

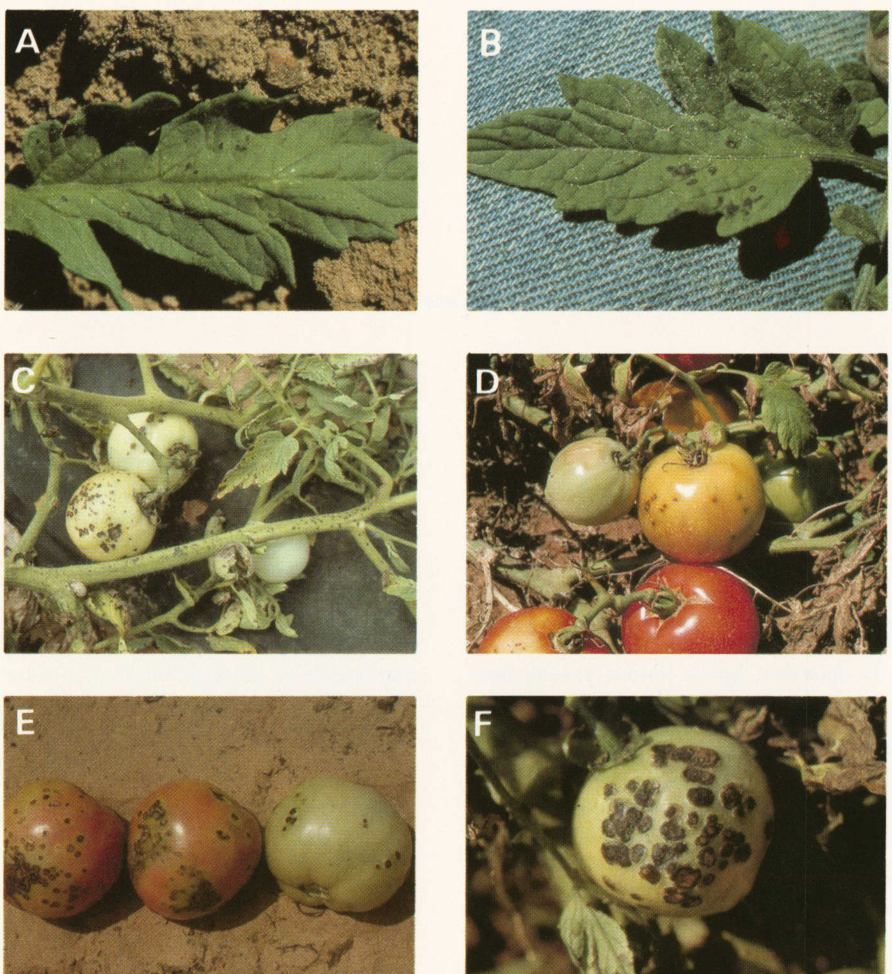


Fig. 2. Symptoms of tomato bacterial spot.

losses by transplant growers. Therefore, low tolerances have sometimes been allowed. Many transplant lots with infected plants have gone undetected either because of lack of symptom expression at the time of inspection or because of difficulties in distinguishing symptoms of bacterial spot and speck from those of other diseases or from damage related to pulling and shipping.

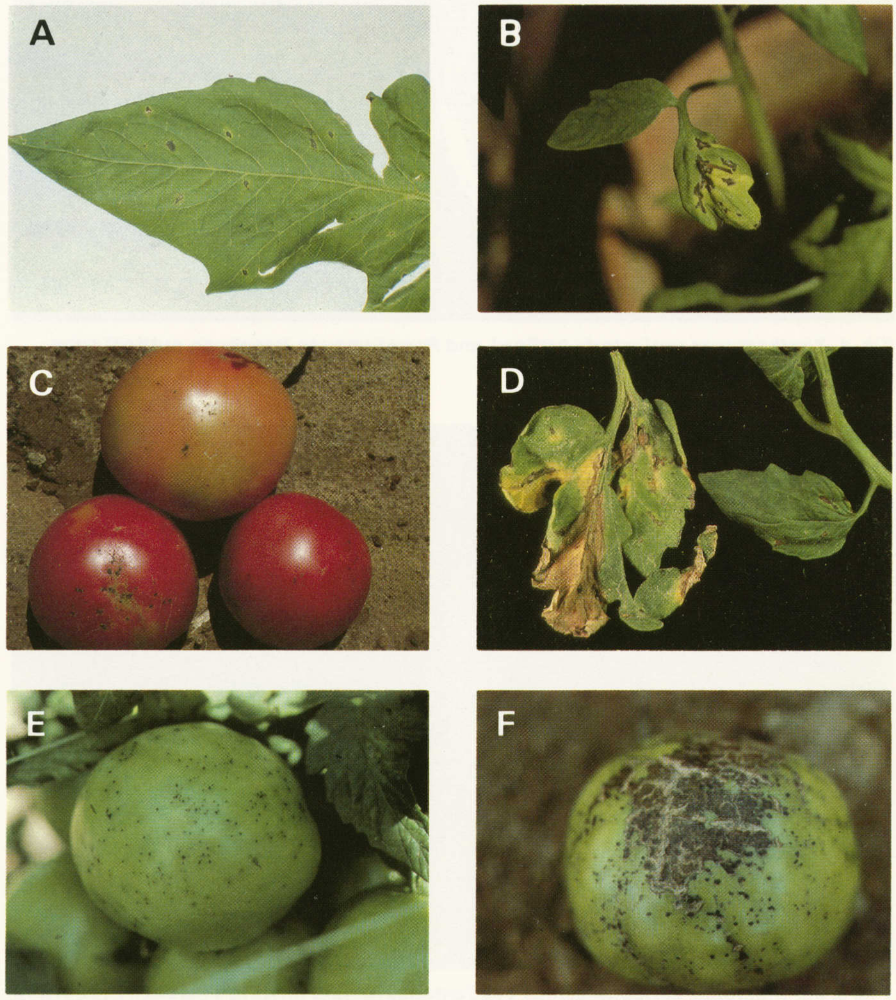


Fig. 3. Symptoms of tomato bacterial speck.

Steps Toward Zero Tolerance

The establishment of a zero tolerance at this time may not be realistic, but a program that aims for less does not give fair consideration to biological realities. Adoption of production procedures and practices approaching a zero tolerance program is essential if practical control of bacterial speck and spot is to be realized.

The first consideration is obtaining pathogen-free seed, and the first step in lowering the probability for contamination is to produce seed in dry climates without overhead irrigation. The next step is to treat all seed with hot water. The classic treatment has been 50 C for 25 minutes, but a soak at 56 C for 30 minutes eliminates *Corynebacterium michiganense* (Smith) Jensen more effectively and should be used. Seed germination of some cultivars has been lowered as much as 10% by the longer treatment at higher temperature, but this is a welcome trade-off for the benefits derived. The resistance of a cultivar to heat treatment should be determined before the method is used for commercial seed lots.

Because seedborne tomato mosaic virus, which may be associated even with seed produced in arid areas, is not eliminated by the hot-water soak, seed should also be treated with either hydrochloric acid or trisodium orthophosphate plus sodium hypochlorite. These treatments are less effective than hot water in eliminating bacterial pathogens, but they are useful and act as double insurance. These chemical seed treatments are not registered for use in all states, however. Seed treated with sodium hypochlorite should be used the same season, as the chemical may reduce longevity.

Although the use of pathogen-free seed is essential, the sources of inoculum from living plants must also be eliminated. Of concern are volunteer hosts and infected crop plants in the immediate vicinity. Isolation, crop rotation, and sanitation practices that eliminate volunteer tomato and pepper plants must be included in the program. The value of crop rotation to control bacterial speck and spot is a moot point, however, since rotation is basic to controlling *C. michiganense* and other tomato pathogens that can survive in soil and crop debris. Measures to control speck and spot should be in harmony with those for the other diseases, and tomato should appear no more often than every third year in rotations with nonhosts. The crop rotation sequence applies to fruit production fields as well as to plant beds.

Wounding of transplants should be avoided and every effort made to shorten the time between packing for shipment and transplanting in the field. If bacterial speck or spot begins to develop in production fields, regular spray applications of copper may be effective; copper-maneb mixtures may give even greater protection. For maximum effectiveness, applications should be started as soon as disease is detected. During continuous rainy, windy weather, when the diseases are likely to be most destructive, the chemicals tend to be less effective. Although antibiotics have been effective, streptomycin-resistant strains of *X. vesicatoria* made the use of that antibiotic short-lived for field applications. Concerns of federal regulatory agencies regarding widespread use of antibiotics for control of plant diseases also limit the likelihood of these compounds being used in the future.

In the final analysis, the tomato industry has been troubled with bacterial spot and bacterial speck because of insufficient resolve to control the diseases. Since sufficient levels of resistance do not exist in commercial cultivars (6), control programs must be built around the concept of prevention. Even though at present no formula can

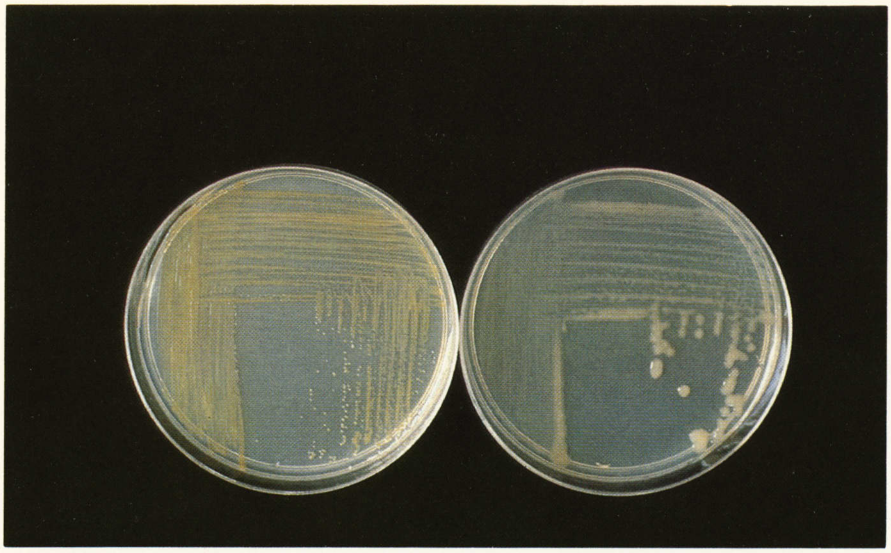


Fig. 4. ***Xanthomonas vesicatoria*** **(yellow) and** ***Pseudomonas tomato*** **on nutrient agar.**

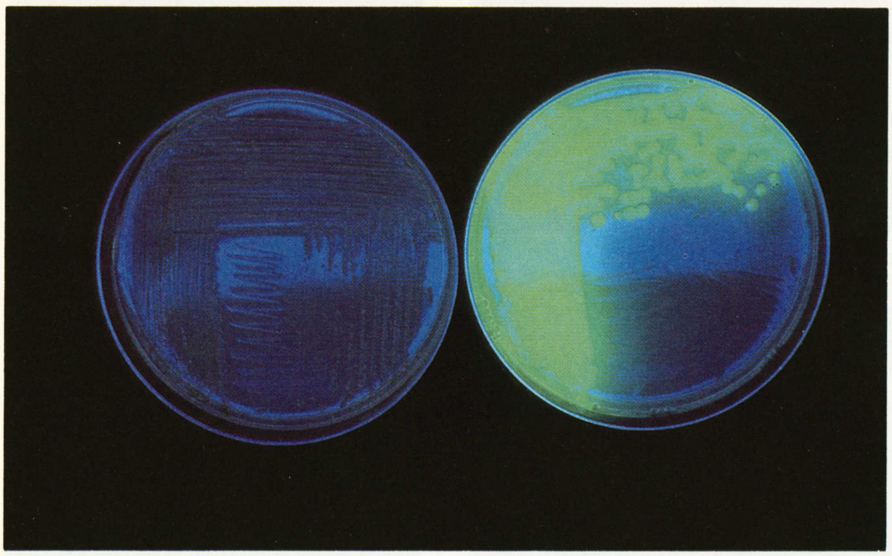
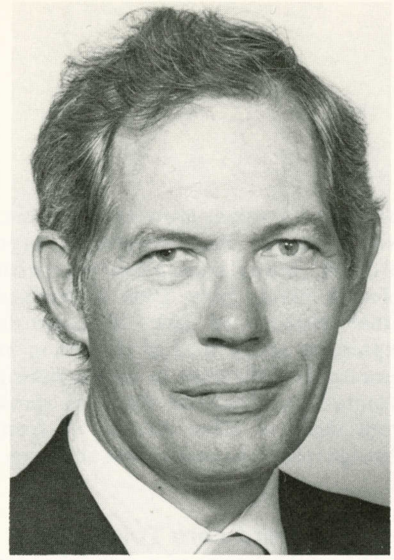
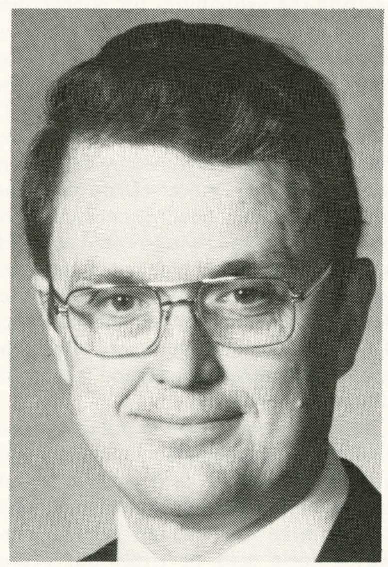


Fig. 5. ***Xanthomonas vesicatoria*** **and** ***Pseudomonas tomato*** **on King's medium B, showing fluorescence of** ***P. tomato*** **under ultraviolet light.**



Monroe J. Goode

Dr. Goode is professor of plant pathology at the University of Arkansas, Fayetteville. He has been responsible for research on diseases of vegetable crops in Arkansas since 1957. He received his Ph.D. from the Department of Plant Pathology at North Carolina State University, Raleigh.



Myron Sasser

Dr. Sasser is associate professor of plant pathology at the University of Delaware, Newark. In addition to teaching, he has been involved in research on bacterial diseases in Delaware since 1968. He received his Ph.D. from the Plant Pathology Department of the University of Florida, Gainesville.

assure that these diseases will never occur, widespread application of preventive technology could remove spot and speck as diseases that undermine production stability.

Literature Cited

1. BASHAN, Y., Y. OKON, and Y. HENIS. 1978. Infection studies of *Pseudomonas tomato*, causal agent of bacterial speck of tomato. Phytoparasitica 6:135-143.
2. BOSSHARD-HEER, E., and J. VOGELSANGER. 1977. Uberlebenfahigkeit von *Pseudomonas tomato* (Okabe) Alsatt in verschiedenen Boden. Phytopathol. Z. 90:193-202.
3. BRYAN, M. K. 1933. Bacterial speck of tomatoes. Phytopathology 23:897-904.
4. CHAMBERS, S. C., and P. R. MERRIMAN. 1975. Perennation and control of *Pseudomonas tomato* in Victoria. Aust. J. Agric. Res. 26:657-663.
5. COOK, A. A., and R. E. STALL. 1969. Differentiation of pathotypes among isolates of *Xanthomonas vesicatoria*. Plant Dis. Rep. 53:617-619.
6. CRILL, P., J. P. JONES, and D. S. BURGIS. 1972. Relative susceptibility of some tomato genotypes to bacterial spot. Plant Dis. Rep. 56:504-507.
7. ERCOLANI, G. L. 1968. Effettivita e misura della transmissione di *Xanthomonas vesicatoria* e di *Corynebacterium michiganense* attraverso il seme del pomodora. Ind. Conserve 43:15-21.
8. GARDNER, M. W., and J. B. KENDRICK. 1921. Bacterial spot of tomato. J. Agric. Res. 21:123-156.
9. KIM, S. H. 1979. Dissemination of seedborne *Pseudomonas tomato* by transplants. (Abstr.) Phytopathology 69:535.
10. PETERSON, G. H. 1963. Survival of *Xanthomonas vesicatoria* in soil and diseased tomato plants. Phytopathology 53:765-767.
11. SCHNEIDER, R. W., and R. G. GROGAN. 1977. Bacterial speck of tomato: Sources of inoculum and establishment of a resident population. Phytopathology 67:388-394.
12. VAKILI, N. S. 1967. Importance of wounds in bacterial spot (*Xanthomonas vesicatoria*) of tomatoes in the field. Phytopathology 57:1099-1103.