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Bacterial Wilt of Pepper [1]

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Introduction

Bacterial wilt is a serious soilborne disease of many economically important crops, including tomato, potato, tobacco, banana, and eggplant. Peppers, however, are less susceptible, and usually suffer economic losses only under special climatic conditions in certain tropical and subtropical regions of the world. The disease has gained importance in protected (plastic tunnel or greenhouse) cultivation, where temperatures are usually higher, and crop rotation is not properly performed for economical reasons.

Around 1940, bacterial wilt was serious problem in pepper in Florida, when peppers followed potatoes. For a treatise of bacterial wilt in pepper and other crops in Florida see University of Florida, IFAS Circular 1207 by Tom Kucharek.

Today, bacterial wilt on pepper is not a problem anywhere in the southeastern United States. This is apparently because prevalent strains from tomato and tobacco do not produce wilt symptoms on pepper. Bacterial wilt can however, be a problem in some countries outside of the United States. Efforts have been made to identify sources of resistance in peppers in Japan, Taiwan, and Brazil.

Symptoms

Although diseased plants can be found scattered in the field, bacterial wilt usually occurs in foci associated with water accumulation in lower areas. In furrow-irrigated crops, it is common to find several adjacent plants in a row to be wilted, due to inoculum spread through the water channel. The initial symptom in mature plants under natural conditions is similar to that observed in tomato or potato. Wilting of leaves, sometimes only few branches of the plant, occurs during hot days followed by recovery throughout the evening and early hours of the morning. The wilted leaves maintain their green color and do not fall as disease progresses. Under favorable conditions complete wilt will occur (Fig. 1). The vascular tissues in the lower stem of wilted plants show a dark brown discoloration (Fig. 2). These symptoms are very similar to those of Phytophthora blight, induced by *Phytophthora capsici*. However, an extensive external darkening of the lower stem is observed mostly for Phytophthora blight. Furthermore, a cross section of the stem of a plant with bacterial wilt produces a white, milky strand of bacterial cells in clear water (Fig. 3). This sign distinguishes the wilt caused by the bacterium from that caused by fungal pathogens.

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Figure 1. Wilting of pepper plants.

Causal Organism

Bacterial wilt is caused by *Ralstonia solanacearum* (E.F. Smith 1896) Yabuuchi et al. 1995. This species was known for many years as *Pseudomonas solanacearum* E.F. Smith. The new genus *Ralstonia* was established to accommodate *R. solanacearum* together with the closely related species within the rRNA homology group II, *R. picketii* and *R. eutropha*.

R. solanacearum is a gram-negative rod (0.5-0.7 by 1.5-2.5 µm) motile, aerobic, oxidase and catalase positive, which accumulates poly-beta-hydroxybutyrate. Colonies are non-fluorescent on complex media. Most strains produce nitrite from nitrate, except those of biovar 2.

R. solanacearum is an extremely complex and diverse bacterial species that enables it to be pathogenic to several hundred plant species in over 50 families. At the subspecies level, the pathogen was divided by Buddenhagen et al. into three races based on their ability to infect different plant species. Race 1 has a very wide host range and is known as the solanaceous race, race 2 as the *Musa* race, and race 3 as the potato race. Later, races 4 (mulberry race) and 5 (ginger race) were proposed. The grouping by races to differentiate strains of *R. solanacearum* has become less practical with the rapid increase of the number of host plants. A.C Hayward divided the species into five different biovars based on the ability of the bacterial isolates to utilize and /or oxidize three hexose alcohols and three disaccharides.

Disease Cycle and Epidemiology

Bacterial wilt of pepper is caused predominantly by biovars 1 and 3 of *R. solanacearum*. Since they belong to race 1, these biovars have a wide host range that guarantees long-term survival of the pathogen in soil in the absence of the main susceptible crop. The pathogen can survive in the rhizosphere of nonhost plants, including weeds. Soil factors influence the survival of the bacterium. For example, bacterial wilt is an important disease of tomato in Florida, but it does not occur in calcareous soils with a high pH, which is the dominant soil type in Homestead. Moderate pH and moderate-to-high temperatures are associated with longer bacterial survival in soil. Soils suppressive to bacterial wilt promote desiccation of the pathogen and/or microbial activity that favor antagonistic microorganisms.

Infested soil is the main source of inoculum. It is not uncommon to find bacterial wilt in the first crop in recently cleared land in tropical and subtropical regions. Disease-free areas can be infested through infected planting material (tomato and pepper transplants, potato tubers), contaminated water, or

Figure 2. Browning of vascular tissues.

machinery and laborers that are contaminated from infested fields. Transmission by seed is not considered important in pepper, even though *R. solanacearum* has been reported to be seed-transmitted in tomato, eggplant and peanut. Epiphytic colonization of the true leaves of pepper has been shown under high relative humidity. Within the field, the most significant method of pathogen dissemination is through contaminated irrigation water flowing among wilted plants.

R. solanacearum can infect undisturbed roots of susceptible hosts through microscopic wounds caused by the emergence of lateral roots. Transplanting, nematodes, insects, and agricultural equipment are also able to wound roots. Bacteria then colonize the cortex and advance towards the xylem vessel, from where it rapidly spreads in the plant. Bacterial masses prevent water flow from the roots to the leaves, resulting in plant wilting. Severity of the disease depends on soil temperature, soil moisture, soil type (which influences soil moisture and microbial populations), host susceptibility, and virulence of strains. High temperature (30-35 ^{o}C) and high soil moisture are the main factors associated with high bacterial wilt incidence and severity. Under these conditions, high populations of bacteria are released into the soil from the roots as the plant wilts.

Figure 3. White milky strand of bacterial cells.

Management

Because it is caused by a genetically diverse soilborne pathogen with a wide host range, bacterial wilt is very difficult to control after it is established in the field. No single measure totally prevents losses caused by the disease. In the southeastern United States, the prevalent biovar 1 isolates of *R. solanacearum* have not been found to cause any losses in pepper. Quarantine regulation must, therefore, be enforced to prevent introduction of exotic strains in this portion of the country.

Cultural practices, if judiciously used, can reduce disease incidence and severity, allowing the disease to be manageable. Seedlings must be free from infection by *R. solanacearum*. It is mandatory that commercial seedling producers use irrigation water not contaminated with the pathogen. Fields should not be over-irrigated, because excess soil moisture favors disease build-up. Crop rotation with non-susceptible crops reduces soilborne populations of the bacterium. The rotation period and the effective break crops should be identified locally for economic reasons, although grasses usually are preferred. Shifting planting dates to cooler periods of the year can help escape the disease. Soil amendments with inorganic and organic mixtures reduce wilt incidence in some locations, but more research is required to provide explicit and economically feasible types of material and doses for reliable disease management.

In Brazil and Taiwan, the breeding line MC-4 (*Capsicum annuum*), from Malaysia, was found to be very resistant to various isolates of biovars 1 and 3, and is being recommended for breeding programs in Brazil. In Japan, India and Taiwan other sources of resistance have been identified in sweet peppers. Since bacterial wilt-resistant tomato and potato cultivars have failed across locations due to variation in environmental factors and strains, resistance should be seen as an additional factor among other management practices.

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