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Bacterial Wilt – a Threatening Disease of Tomato Cultivated under Warm Temperatures

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The importance of the disease

Bacterial wilt is one of the most important diseases of solanaceous crops in tropical and subtropical countries. In Brazil, it is a limiting factor for tomato production the North Region (Amazon Basin). Even in recently cleared areas, there is a substantial risk that susceptible plants will succumb to bacterial wilt, with frequent occurrence of losses up to 50%. Under this environment and in contaminated soil, usually after the first tomato crop, the pathogen's population builds up to a point that deters further tomato cropping in the area unless sterile substrate is used. In other regions of the country, it is also a constraint whenever temperatures are high (above 25°C), such as in lowland areas or under protected cultivation.

The symptoms

The typical symptom of bacterial wilt is a quick plant collapse, not rare in groups of plants situated in moister field spots or carryover inoculum. Initially, there is a drooping of younger leaves in the warmest periods of the day (Figure 1). Plants may recover their turgor at night or in case of temperature drop below 20°C; if temperatures remain high, the whole plant wilts and dies. Plants usually wilt in the beginning of fruit set stage, when they are driving their energy for propagation purposes.

Bacterial wilt is a vascular disease and induces darkening of the xylem vessels, which is apparent upon removal of the bark in the low portion of the stem of wilted plants (Figure 2). Because other pathogens, especially fungi (such as *Fusarium* spp. and *Verticillium* spp.), also cause plant wilt, the exudation test (Figure 3) is a quick and reliable test to indicate the presence of the bacterial wilt pathogen. A definitive diagnosis, however, should be carried out in laboratory facilities upon isolation of the pathogen followed by a pathogenicity test.

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Figure 1. Typical symptom of bacterial wilt on a tomato plant.

Figure 2. Darkening of the vascular system of a tomato plant infected with bacterial wilt.

Figure 3. Bacterial oozing from a stem section of a tomato plant infected with bacterial wilt.

The pathogen

Bacterial wilt is caused by *Ralstonia solanacearum*, a gram-negative soil-inhabiting bacterium capable of infecting a wide host range within more than 50 botanical families (HAYWARD, 1994). The most susceptible plant species are in the Solanaceae family, which includes, besides tomato, other important cash crops such as potato, eggplant, peppers, and tobacco. Banana, which is also cultivated under warm environments, can be infected only by the specific race 2 of *R. solanacearum* (Moko disease). However, there are evidences that the bacterium can naturally undergo modifications that make banana isolates infect tomatoes.

Ralstonia solanacearum is a highly variable pathogen, traditionally documented in **races**, based on the ability to infect different hosts (BUDDENHAGEN et al., 1962), or in **biovars**, based on their ability to utilize a set of sugars and alcohols a sole carbon source (HAYWARD, 1991). More recently, Fegan e Prior (2005), based on molecular studies, suggested that *R. solanacearum* should be considered a complex species. These authors proposed a new classification scheme within four taxonomic levels equivalent to species, subspecies, infra-sub specific and clonal lines. At the subspecies level, the already-accepted term **phylotype** is associated to the origin of the bacterium. Presently, there are four phylotypes, distinguished by multiplex PCR. The term **sequevar** is used for infra-sub specific levels. In Brazil, tomato bacterial wilt has been naturally associated to races 1 and 3, biovars 1, 2, and 3. In the new classification, phylotype 2 prevails, although phylotype 1 has been consistently found in the North Region.

The disease onset and development

High temperatures and high soil humidity favor bacterial wilt, conditions that prevail in crops established in wet summers. Plants usually escape disease when grown under low temperatures (below 20°C), even in the presence of the pathogen. In drip-irrigated crops, disease appears in soil spots associated to leaking which supply excessive water to the plant rhizosphere. The popularization of protected tomato cultivation in Brazil has resulted in a substantial increase of bacterial wilt frequency in the last years. This is explained by the gradual inoculum build-up associated to successive cropping, for economic reasons, and higher temperatures under greenhouses. Greenhouse soils may become so infested that they are abandoned after few years of sequential tomato cultivation. Similar situation has been observed in nonprotected drip-irrigated table or processing tomatoes not subject to a proper crop rotation (MAROUELLI et al., 2005).

When bacterial wilt occurs in areas recently cleared or subject to crop rotation, the source of inoculum can be a plantlet produced in an infested soil or substrate, contaminated water or contaminated machines or implements that transited through infested areas. Alternatively, the soil may harbor *R. solanacearum* populations associated with a wide host range and bacterial survival for as long as 10 years in the absence of a host. From the initial foci, the pathogen spreads from running water or machinery within the field.

The resistance to bacterial wilt

Planting resistant varieties is the most efficient way to control diseases. However, even though resistance to bacterial wilt of tomatoes has been one of the priorities in many breeding programs for decades, a variety with a reliable level of resistance is not available for commercial use (SCOTT et al., 2005). The main reasons for that is the high variability of the pathogen, what requires breeding efforts to gather resistance genes effective against local isolates of the pathogen. In addition, the sources of resistance confer only partial protection against the disease, and this level of protection might not be enough under environmental conditions favorable to the disease, such as high temperature and high soil humidity. Because it has been difficult to incorporate bacterial wilt resistance into commercial varieties, resistant genotypes have been explored in the breeding programs for developing rootstocks for grafting purpose (LIN et al., 2008).

The control

Bacterial wilt control must be preventive; after disease occurrence in the field, usually nothing can be done to prevent losses. An integrated control approach needs to be applied, since no single measure is efficient enough to halt the disease (LOPES, 2001). Some management measures to be considered in order to control the disease are:

1. Prefer winter crops (low temperature and humidity), which are less subject to bacterial wilt incidence. It is the most important measure to produce tomatoes where *R. solanacearum* is endemic. Plants usually escape disease when night temperatures remain below 20°C for several days. This condition should be explored especially for organic production.

2. Choose the area to install the crop. Infested soils, previously planted with a susceptible species, should be avoided. The pathogen remains in the soil for many years even in the absence of a host. Crop rotation, preferentially with grasses, is a mandatory practice for soilborne plant pathogens, including *Ralstonia solanacearum*. The time to get back to an infested area depends on the soil type, the environmental condition and the variant of the pathogen present in the area.

3. Solarize infested soil for at least two months. Solarization drastically reduces the inoculum in the top layer of the soil, but does not eliminate the pathogen protected in deeper layers. It is recommended for regions subject to many consecutive days of direct incidence of sunlight (BAPTISTA et al., 2006).

4. Use commercial varieties grafted onto rootstocks resistant to bacterial wilt. However, keep in mind that their resistance may be overcome by a combination of high inoculum pressure and favorable environmental conditions. Highly virulent local isolates of *R. solanacearum* also play a role in inducing an unexpected susceptibility of resistant genotypes to bacterial wilt (LOPES et al., 1994; WICKER et al., 2007).

5. Avoid the use of chemicals empirically recommended, such as disinfectants, on the plants or to the soil. They might be phytotoxic and are usually ineffective in controlling bacterial wilt. Most products with antibacterial action do not reach, in adequate concentrations, deeper soil layers where bacterial cells are present. Be sure that they were adequately tested and registered before using them.

6. Be aware of ongoing advances in resistant varieties, plant-resistance inducers and biological control products, in order to promote better and more stable control (HAI et al., 2008; LIN et al., 2008; MOMOL et al., 2014; PRADHANANG et al., 2005; TRIGALET; TRIGALET-DEMERY, 2005).

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