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Three Soilborne Tomato Diseases Caused by *Ralstonia* and *Fusarium* Species and their Field Diagnostics[1]

Tim Momol, Pingsheng Ji, Ken Pernezny, Robert McGovern, and Steve Olson[2]

Introduction

Plant health management in Florida is particularly challenging because of the warm humid climate and global agricultural markets that cause the state to be very susceptible to the introduction of new pests. Available pest management options are diverse but virtually all of them rely on timely and accurate pest identification and disease diagnosis.

Among many diseases that reduce tomato yield, in this review we focus on three soilborne diseases and their field diagnostics (Table 1) and management recommendations: bacterial wilt, fusarium wilt, and fusarium crown and root rot.

Bacterial Wilt

Bacterial wilt caused by *Ralstonia solanacearum* is a serious soilborne disease of many economically important Florida crops, such as tomato, potato, tobacco, banana, eggplant, and some ornamental plants. Although diseased plants can be found scattered in the field, bacterial wilt usually occurs in discrete areas (foci) associated with water accumulation in lower areas. The initial symptom in mature plants under natural conditions is wilting of upper leaves during the hottest part of the day followed by recovery during the evening and early hours of the morning. The wilted leaves maintain their green color and do not fall off as disease progresses. Under conditions favorable to the disease complete wilt occurs. The vascular tissues in the lower stem of wilted plants show a dark brown discoloration. These symptoms are similar to those of some fungal diseases. A cross section of the stem of a plant with bacterial wilt produces a white, milky strand of bacterial cells in clear water (Figure 1). This ooze distinguishes the wilt caused by the bacterium from that caused by fungal pathogens.

In Florida, bacterial wilt of tomato is caused predominantly by race 1 biovar 1 of *R. solanacearum*. This race has a wide host range that guarantees a long-term survival of the pathogen in soil in the absence of the main susceptible crop. The pathogen

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2. Tim Momol, associate professor, North Florida Research and Education Center (NFREC), Quincy, FL 32351; Pingsheng Ji, post doctoral associate, NFREC, Quincy, FL 32351; Ken Pernezny, professor, Plant Pathology Departement, Everglades Research and Education Center, Belle Glade, Florida; Robert McGovern, professor, Plant Pathology Department; and Steve Olson, professor, Horticultural Sciences Department, North Florida Research and Education Center, Quincy, Florida 32351; Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611.
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Figure 1. A cross section of the stem of a plant with bacterial wilt produces a white, milky ooze of bacterial cells in clear water. Credits: (University of Georgia, Extension Plant Pathology.)

can survive in the rhizosphere (root surface) of non-host plants, including weeds. Soil factors also influence the survival of the bacterium. For example, bacterial wilt is an important disease of tomato in north Florida but it rarely occurs in calcareous soils with a high pH, the predominant soil in south Florida's Homestead area.

Infested soil and surface water, including irrigation water, are the main sources of inoculum. Disease-free areas can be infested through infected planting material, contaminated water or machinery. Laborers that get surface contamination from infested fields or other sources may also infest disease-free fields. *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 other common causes of root wounding which allows bacteria to enter the plant. After infection, the bacterium colonizes the cortex and makes its way towards the xylem vessel; from there it rapidly spreads throughout the plant. Bacterial masses prevent water flow from the roots to the leaves, resulting in plant wilting (Figure 2). Severity of the disease depends upon soil temperature, soil moisture, soil type (which influences soil moisture and microbial populations), host susceptibility and virulence of strains. High temperature (86-95°F) and high soil moisture are the main factors associated with high bacterial wilt incidence and severity (Figure 3). Under these conditions, high populations of bacteria are released into the soil from the roots as the plant wilts that can infest nearby plants or the next crops.

Figure 2. Plants wilting due to *Ralstonia solanacearum* infection.

Figure 3. Tomato with high incidence of bacterial wilt.

Since it is caused by a soilborne pathogen with a wide host range, bacterial wilt is very difficult to control after it is established in the field. No single measure prevents losses caused by the disease. Cultural practices, if judiciously used, may reduce disease incidence. Seedlings must be free from infection by *R. solanacearum*. Commercial producers

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must use treated or pathogen-free irrigation water. Fields should not be over-irrigated because excess soil moisture favors disease development. Crop rotation and cover crops with non-susceptible plants reduce soilborne populations of the bacterium. Shifting planting dates to cooler periods of the year can be effective to escape disease development. IFAS researchers have determined that thymol, a plant derived reduced-risk chemical, used as soil fumigant reduced the incidence of bacterial wilt and increased tomato yield significantly. Application methods for commercial use of thymol in the field is under development. Some resistant cultivars are available commercially. It has also been found that acibenzolar-S-methyl (Actigard® 50WG, Syngenta Crop Protection) on moderately resistant cultivars such as FL 7514 and BHN 466 enhances disease resistance producing significantly higher tomato yields than non-treated controls.

Fusarium Wilt

In the past, Fusarium wilt caused by *Fusarium oxysporum* f. sp. *lycopersici* was one of the most destructive plant diseases in Florida. The development of resistant cultivars has reduced this concern.

Infected transplants are stunted, the older leaves droop and curve downward, and the plants frequently wilt and die. Symptoms on older plants generally become apparent during the interval from blossoming to fruit maturation. Earliest symptom is the bright yellowing of older, lower leaves, often on only one side of the plant, and the leaflets on one side of the petiole frequently turn yellow before those on the other side (Figure 4). The yellowing process gradually includes more and more of the foliage and is accompanied by wilting of the plant during the hottest part of the day. The wilting becomes more extensive from day to day until the plant collapses (Figure 5). The vascular tissue of a diseased plant is dark brown (Figure 6). Browning often extends far up the stem and is especially noticeable in a petiole scar. This browning of the vascular tissue is characteristic of the disease and can be used for its tentative identification. Fruit infection occasionally occurs and can be detected by the vascular tissue discoloration within the fruit.

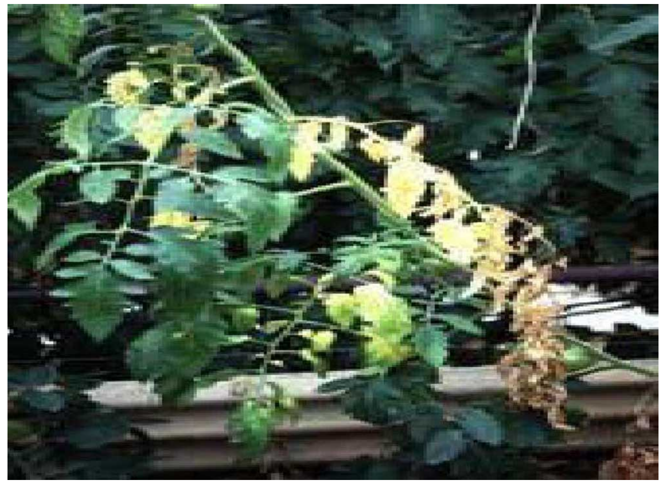

Figure 4. The earliest symptom of Fusarium wilt is the bright yellowing of the lower, older leaves. These yellow leaves often develop on only one side of the plant, and the leaflets on one side of the petiole frequently turn yellow before those on the other side.

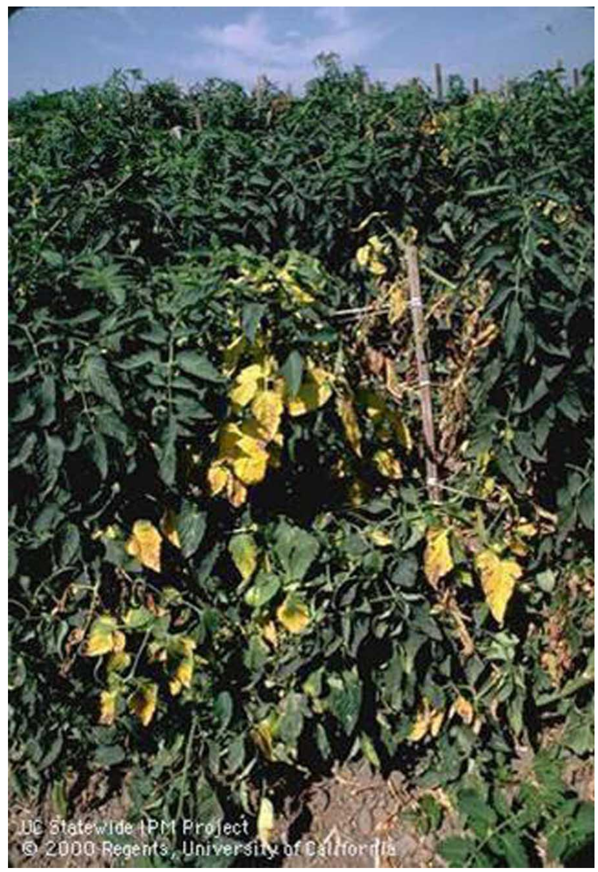

Figure 5. Fusarium wilt becomes more extensive from day to day until the plant collapses and dries up. Credits: University of California

Warmer weather (82-86°F) favors development of this pathogen, it is prevalent in acid and sandy soils. It is soilborne and remains in soils for several years. Long crop rotation (5-7 years) does not

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Figure 6. Browning of the vascular tissue is characteristic of Fusarium wilt and generally can be used for tentative identification.

eliminate the pathogen but greatly reduces yield losses. Ammoniacal nitrogen application enhances disease severity of the pathogen, but nitrate nitrogen reduces severity.

Three physiological races, based on differential cultivars, (1, 2, and 3) of this pathogen exist in Florida. Using resistant cultivars where available for race 1 and 2 is recommended. There are some race 3 resistant cultivars available commercially. Movement of infected plants and/or infested soil clinging to machinery, hand tools, vehicles, trellising and staking implements, and field crates into areas free of this pathogen should be prevented. Since flooding will spread the fungus it is not recommended. Do not irrigate with surface water that may be contaminated with the fungus. It is recommended that Fusarium-free transplants be used; if transplant trays are reused these should be steam-treated between uses. Using pre-plant soil fumigants may reduce disease incidence.

Fusarium Crown and Root Rot (FCRR)

Crown and root rot caused by *Fusarium oxysporum* f.sp. *radicis-lycopersici* (FCRR) is most frequently observed in the Florida's east and west central and southwest tomato production areas. The fungus can attack both tomato seedlings in the transplant house and mature plants in the field. Early symptoms of the disease in seedlings include stunting, yellowing, and premature loss of cotyledons and lower true leaves (Figure 7). A pronounced brown lesion that girdles the root/shoot junction (crown) and root rot, wilting, and death are advanced symptoms.

Figure 7. Early symptoms of Fusarium crown and root rot in seedlings include stunting and yellowing.

External symptoms of FCRR in mature plants include brown discoloration and rot at the soil line in the crown and roots. Infected plants in the field may be stunted. As plants begin to bear fruit heavily, their lower leaves turn yellow and wilt (Figure 8). Wilting first occurs during the warmest part of the day, and plants appear to recover at night. Infected plants may either wilt and die, or persist in a weakened state, producing fewer and inferior fruit. The tap root of infected plants often rots entirely. When diseased plants are sectioned lengthwise, extensive brown discoloration and rot are evident in the cortex and water conducting tissue (xylem) of the crown and roots (Figure 9). Unlike Fusarium wilt, the browning observed in the xylem of the stem does not generally extend more than 8-12 inches above the soil line.

The disease is favored by low soil pHs and soil temperatures (50-68°F), ammoniacal nitrogen, and waterlogged soil. Integrated management of Fusarium crown and root rot includes: use disease-free transplants (reused transplant trays should be steam-treated); use preplant fumigation; avoid ammoniacal nitrogen; do not reuse tomato stakes; maintain soil pH at 6 to 7; rotate with nonsusceptible hosts including grass crops; and use biological control and resistant cultivars. Several cultivars with resistance are now available.

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Figure 8. *Fusarium oxysporum f.sp. radicis-lycopersici* infection may cause stunting and wilting.

Figure 9. When diseased plants are sectioned lengthwise, extensive brown discoloration and rot are evident in the cortex and water conducting tissue (xylem) of the crown and roots due to *Fusarium oxysporum f.sp. radicis lycopersici* infection.

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Table 1. Comparitive field diagnostics for bacterial wilt, fusarium wilt and fusarium crown and root rot.

	Bacterial Wilt	**Fusarium Wilt**	**Fusarium Crown and Root Rot**
Pathogen	*Ralstonia solanacearum*	*Fusarium oxysporum* f.sp. *lycopersici*	*Fusarium oxysporum* f.sp. *radicis-lycopersici*
Symptoms	Under favorable conditions quick and complete wilt, vascular tissue becomes brown, ooze from cross-wise cut stem.	Yellowing of older leaves, usually starts on only one side of the plant, gradual wilting as disease progresses, vascular tissue becomes dark brown which often extends far up the stem.	Symptoms usually first appear during cool season around the time of first harvest as lower leaf yellowing, symptoms progress upward, some plants may be stunted and wilt quickly, stem cankers develop at and slightly above the soil line, and stem vascular discoloration extends less than 12 in. above the soil line.
Favorable Conditions	High temperature (85-95°F) and high soil moisture are the main factors associated with high bacterial wilt incidence and severity.	The disease is favored by soil and air temperature at 82- 86°F.	The disease is favored by cool soil temperature (50-68°F).