A Series on Diseases in the Florida Vegetable Garden: Tomato[1]

Gary Vallad, Ken Pernezny, and Tim Momol[2]

Many Floridians delight in maintaining a vegetable garden in their backyard. Others keep several pots of popular vegetables on patios or similar residential sites. Florida's long growing season and generally mild climate are ideal for the gardening enthusiast.

Health benefits of moderate gardening activity are well documented, and the supply of wholesome garden-fresh vegetables adds to quality of life in the Sunshine State.

Sometimes pest problems interfere with gardening pursuits. Some problems, such as weeds and certain insects, are relatively easy to identify as causing damage. However, another group of maladies, plant diseases, can cause serious damage and are underappreciated and not as well understood by many homeowners.

The majority of plant health problems categorized as plant diseases are caused by microorganisms. As the name implies, these disease-causing agents are extremely tiny; they ordinarily require a microscope to be seen. The very minute size of these disease-causing pathogens accounts for the mystery that often surrounds their presence and impact in the garden.

Fungi are seen (100–400x magnification) as threads (hyphae) that absorb food and water from their host (Figure 1). Many fungi reproduce by forming thousands and thousands of spores that are readily blown about by even light winds. These spores can alight on tomato plants and eventually cause disease. Some fungi have the capacity to survive very long periods of time (10 years or more) in soil in the absence of a host. Once tomatoes are planted in infested soil, these "resting" fungal structures can become viable again and attack plant roots, causing disease. The majority of tomato diseases likely to be found in a home garden are caused by fungi.

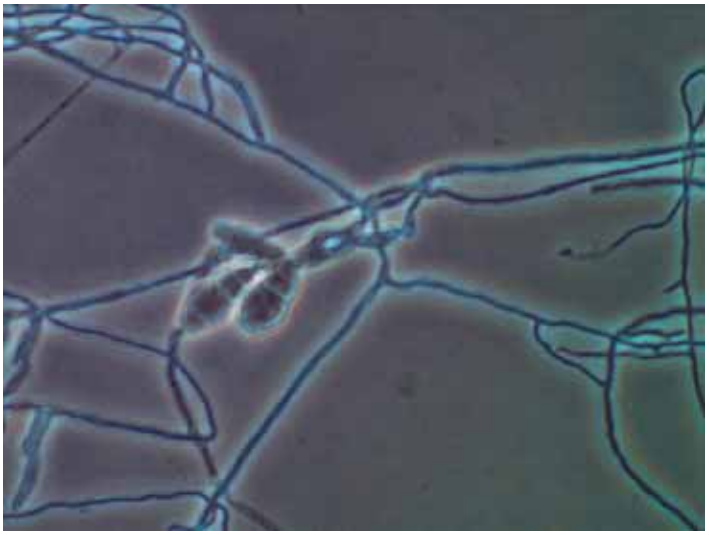

Figure 1. Microscopic threads (hyphae) and spores of a typical plant-pathogenic fungus.
Credits: J. B. Jones

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2. Gary Vallad, assistant professor, Plant Pathology, UF/IFAS Gulf Coast Research and Education Center; Ken Pernezny, professor, Plant Pathology Department, and associate center director, UF/IFAS Everglades Research and Education Center; and Tim Momol, professor, Plant Pathology Department; UF/IFAS Extension, Gainesville, FL 32611.

Bacteria are even smaller than fungi; a 1000x magnification with a special light microscope is necessary to see bacteria (Figure 2). They consist of only one cell and do not form the airborne spores that fungi do. Rather than being blown by the wind, bacteria are usually spread by splashing water, as in rainstorms or overhead sprinkler irrigation. Bacteria can also be spread by gardeners who touch diseased plants and healthy plants in succession without thoroughly washing their hands in between.

Figure 2. A bacterial cell.
Credits: J. B. Jones

Viruses are most strange, indeed (Figure 3). They are not "organisms" in the sense of the fungi and bacteria. Viruses are very large molecular structures consisting of a nucleic acid (DNA or RNA) wrapped in a protective coating of protein. Once viruses are inside a tomato cell, they take over the host cellular machinery and use it to produce more viruses. Most of the important tomato viruses are transmitted to garden plants by insects such as aphids, whiteflies, or thrips.

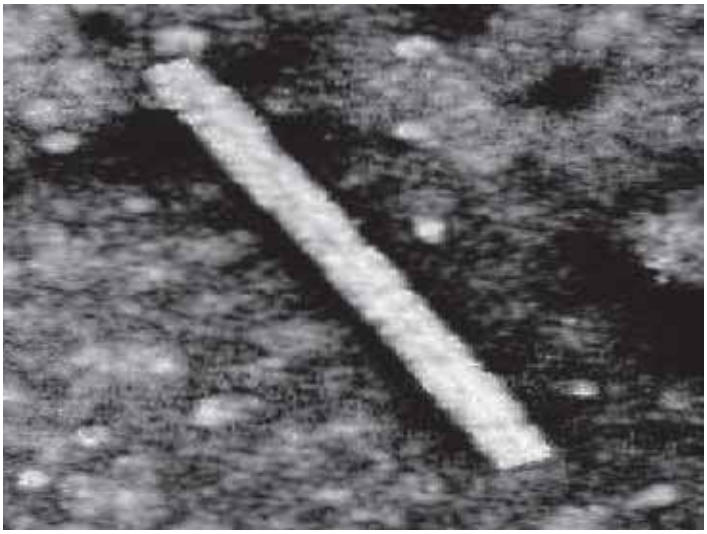

Figure 3. Typical rod-shaped virus as seen through a powerful electron microscope.
Credits: Scott Adkins, USDA

The following diseases are a few of the ones, in our experience, most likely to appear on garden tomatoes. This list of tomato diseases is not by any means exhaustive, but includes the diseases that occur most often in Florida home gardens.

If you have a problem that you think may be a plant disease not covered in this publication, search the EDIS database or the UF/IFAS Department of Plant Pathology Website for information on additional tomato diseases.

Legal uses and effectiveness of chemicals registered for control of plant disease change with time. Consult your local UF/IFAS Cooperative Extension office for current disease-management recommendations.

Bacterial Spot

One of the most common diseases of tomato in Florida is bacterial spot, a disease caused by the bacterium *Xanthomonas vesicatoria* or *X. perforans*. Bacterial spot is especially common in warm, rainy weather. All plant parts are affected, but the spots (lesions) on the leaves are most noticeable.

Dark brown leaf spots (lesions) appear as small (1/8 of an inch or so), wet-to-greasy areas on both upper and lower leaf surfaces (Figure 4). There may or may not be yellow halos around these spots. These lesions may run together to form rather large, blighted areas on leaves. It is not unusual for affected leaves to drop off plants prematurely.

Figure 4. Typical bacterial spot symptoms on tomato leaves.
Credits: Gary Vallad, UF/IFAS

Fruit lesions occur less frequently than leaf lesions, but are quite distinct. Fruit lesions often start as small brown-to-black spots with a light-colored halo. With time, the halos disappear, and the fruit spots become larger, raised, and scabby in appearance (Figure 5). Infected fruits are unappealing, and many home gardeners choose not to bring such fruit into the kitchen.

Figure 5. Bacterial spot on tomato fruit.
Credits: Gary Vallad, UF/IFAS

Bacterial spot of tomato, like most bacterial diseases, is difficult to control once introduced into a garden. Therefore, do all you can to prevent the introduction of the pathogen when the garden is established. If you start your plants from seed, purchase the seed from a reputable seed company. This will increase the likelihood that you have seed that is free of spot-causing bacteria. If you purchase transplants at a retail nursery outlet, be sure to inspect the plants carefully for symptoms of bacterial spot and avoid the purchase of diseased transplants.

Avoid overhead sprinkler irrigation as much as possible. Consider planting later in the fall in South Florida to minimize production in the warmer, rainy season. Copper-containing fungicide (bactericide) plus mancozeb sprays that can be purchased at garden centers may provide some control of bacterial spot, particularly if the spray program is initiated before too many spots are present.

Target Spot

Target spot is a fungal disease that has become increasingly important over the years on commercial tomato farms in Florida. This disease has become more prevalent in home gardens over the last several years, so it is a plant disease that homeowners should be aware of.

The causal fungus, *Corynespora cassiicola*, produces abundant spores that are readily dispersed on wind currents and may blow into gardens from remote locations.

On tomato leaves, the disease first appears as small, brown spots with light brown centers and darker brown margins (Figure 6). There can be yellow halos around these spots. Especially in early stages, target spot on the leaves is extremely difficult to differentiate from bacterial spot. Even experienced professionals can have difficulty telling these two diseases apart without laboratory tests. As the target spot disease develops, spots run together, and large blighted areas appear on leaves.

Figure 6. Target spot on tomato leaves.

Fruit lesions caused by the target spot fungus are more distinct and easier to distinguish from bacterial spot than are lesions on leaves. At first, fruit symptoms appear as small, slightly sunken flecks. As the disease progresses, lesions become darker and deeper. These lesions may overlap, resulting in large, pitted areas (Figure 7). As fruit ripen, large sunken areas are evident, often with a gray or black growth of the fungus in the lesion center. Most home gardeners are reluctant to consume these damaged fruits.

If target spot is a recurrent problem in your garden tomatoes, you may have to apply broad-spectrum fungicide every 7–10 days to protect plants. Consult with the UF/IFAS Extension for recommended fungicides. Gardens

planted close to commercial tomato production fields may be more likely to be affected by target spot.

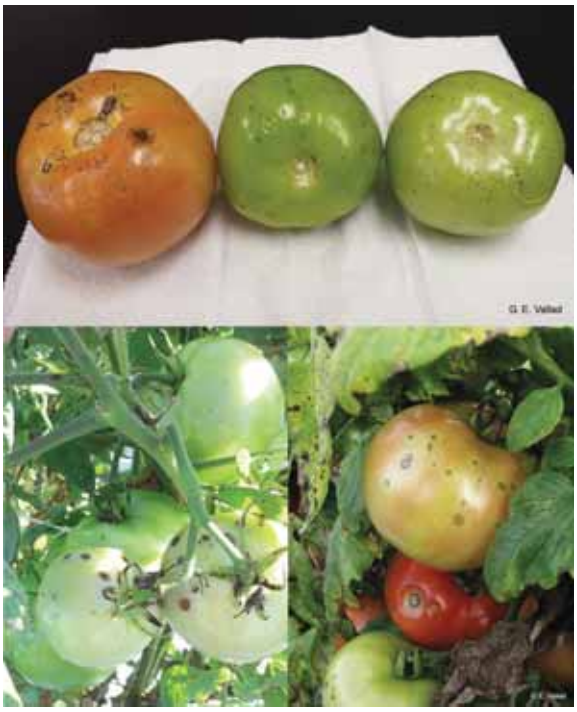

Figure 7. Target spot on tomato fruit.
Credits: Gary Vallad, UF/IFAS

Late Blight

Late blight is one of the most famous diseases in the history of agriculture. The causal fungus, *Phytophthora infestans*, was responsible for a devastating epidemic on potatoes in Ireland in the 1840s that led to widespread famine and starvation. The huge migration of Irish to North America was in great part a response to the impact of late blight on the most important crop in Ireland. Today, late blight is still a major concern to both potato and tomato growers on commercial farms in the United States.

We occasionally see late blight on garden tomatoes in Florida. The disease is usually associated with weather that is relatively cool (e.g., daytime highs in the 60s and lower 70s) and damp.

On tomato leaves, the symptoms of late blight initially consist of light brown to purplish spots that rapidly enlarge to purplish, blighted areas (Figure 8). Early in the morning and under wet conditions, a white growth of the fungus may be visible on the lower leaf surface. Stems may become infected, as well, with large purple to black sections that make stems look as if they were burned.

On infected tomato fruit, mahogany to purple blotches appear, sometimes in a ring pattern (Figure 9), and fruits often become overcome by a foul-smelling soft rot, as secondary bacteria follow the late blight infection.

Figure 8. Late blight symptoms on the lower leaf surface of tomato.
Credits: Gary Vallad, UF/IFAS

Figure 9. Late blight on tomato fruit.
Credits: Gary Vallad, UF/IFAS

To control late blight, begin with disease-free transplants. Next, space plants far enough apart in the garden so that plants will dry off quickly during the day. If late blight is a yearly problem in your garden, you may have to resort to periodic use of fungicide sprays.

Tomato Spotted Wilt

Tomato spotted wilt (TSW) is a viral disease. It is transported from diseased to healthy plants by thrips, an insect that commonly feeds inside many different types of flowers, including the blossoms of tomato.

The tomato spotted wilt virus (often abbreviated TSWV) has a wide host range, producing symptoms in at least 63 plants grown commercially in Florida. These include vegetables, field crops, and ornamentals. TSWV is of more concern in North Florida, presumably because the thrips species and weed hosts that are best adapted to the spread and survival of this virus are more abundant in the northern parts of the state. However, TSWV may occur in South Florida, too.

A wide range of symptoms can occur with TSWV. Small, light brown flecks first appear on leaves. These spots later turn brown (Figure 10), followed by a general browning of leaves that die and appear drooped on stems. Brown to purple brown streaks form on stems. Plants are often stunted and, with the droopy leaves, appear wilted. Green fruit show concentric rings of yellow or brown alternating with the background green color (Figure 11). Striking brown rings occur on red-ripe fruit.

Figure 10. Leaf symptoms caused by TSWV.
Credits: Gary Vallad, UF/IFAS

Figure 11. Fruit symptoms caused by TSWV.
Credits: Gary Vallad, UF/IFAS

Vigilant weed control may reduce the incidence of TSWV on your garden tomatoes but will not eliminate TSWV. Control of thrips with insecticides may help to reduce late infections (secondary cycle). However, in controlled experiments, insecticides have not been all that successful. Ultraviolet (UV) reflective mulch (Figure 12), used as a physical repellent, can reduce TSWV incidence. UV-reflective mulches are available commercially in small packages for homeowners.

Figure 12. Ultraviolet (UV) reflective mulch.
Credits: Steve Olson

Tomato Yellow Leaf Curl Virus (TYLCV)

This virus was first introduced into Florida in Miami-Dade County in 1997. It is a constant problem in commercial fields throughout Florida. We have observed it in gardens throughout southern Florida, especially in areas with significant commercial tomato production.

This virus is transmitted by a species of whitefly. Severe symptoms occur on tomato, especially when young plants are infected. Young, diseased plants are severely stunted. Leaf edges curl upward and appear mottled (i.e., show alternating areas of light and dark green) (Figure 13). The tops of plants appear bushy. Often, fruit set is poor or nonexistent.

Figure 13. Extremely stunted tomato plant infected with TYLCV.
Credits: Gary Vallad, UF/IFAS

Control of TYLCV is difficult. Varieties with resistance to TYLCV are available at local garden centers and should be used, especially if you reside in areas with significant commercial tomato production. Susceptible varieties can be grown, but successful control of this virus begins with the purchase of TYLCV-free transplants. An isolated, infected tomato plant or two can be removed and destroyed in an effort to eliminate sources of virus that might infect other tomatoes. A lengthy period of time between plantings in the garden will help break the cycle that can lead to repeated virus infection. For example, in South Florida, it makes sense to have a tomato-free period in the garden for three to four months in the summer. (Tomatoes don't set fruit particularly well anyway during this time.) While the control of whiteflies is essential to prevent the virus from spreading from diseased to healthy tomato plants, this may not be practical in a home garden.

Fusarium Wilt

Fusarium wilt was one of the first diseases known to affect tomato in Florida. As long ago as 1899, entire fields of tomatoes in Florida were wiped out by *Fusarium oxysporum* f. sp. *lycopersici*. It can be an extremely difficult disease to control, in large part because it can survive indefinitely in the soil. Rather than primarily spreading by spores on wind currents, *F. o.* f. sp. *lycopersici* forms highly resistant structures that persist in the soil, are stimulated to develop when in the vicinity of tomato root systems, and attack plants through the roots.

Once the fungus is inside the tomato plant, the water-conducting (vascular) system is colonized and becomes plugged, accounting for wilt symptoms. As the name implies, progressive wilt is the predominant symptom. The wilt cannot be overcome by simply watering the tomatoes thoroughly (Figure 14).

Figure 14. Tomato plants exhibiting one-sided wilt and bright yellowing of foliage characteristic of Fusarium wilt.

At first, the wilt may be more evident during the warmest part of the day. However, the plants soon express a permanent wilt that is evident throughout a 24-hour period. In the early stages, infected plants show a characteristic "one-sided" wilt (i.e., wilting on only one side of the plant), which helps differentiate Fusarium wilt from other wilt diseases of tomato.

To confirm Fusarium wilt, make a vertical cut of the lower stem of suspect plants and examine the water-conducting tissue. This is a narrow column of solid-appearing tissue to the outside of the stem. If it is brown (Figure 15), Fusarium wilt is likely.

Figure 15. Internal browning of water-conducting tissue in tomato stem of plant with Fusarium wilt.

Control of Fusarium wilt for the home gardener is primarily by use of tomato varieties with resistance to the disease. Commercial farmers have used primarily *Fusarium*-resistant varieties and have had great success doing so. Unfortunately, home gardeners often plant "old" varieties, or heirloom tomatoes, that are not resistant to this pathogen.

If *Fusarium* is a problem in your garden, try to purchase VFN tomato varieties. These letters stand for (in order) *Verticillium* (a wilt fungus similar to *Fusarium*), *Fusarium*, and nematodes (tiny worms in the soil that attack and damage roots). VFN tomato varieties are sensible choices for the high disease pressure that is typical in Florida.

Gardens planted on residential properties that were developed from land with a past history of tomato farming may be ill-suited for tomatoes. Homeowners with this situation may have to bring in topsoil that is free of *Fusarium* and use a raised-bed system to be successful. Of course, potted tomatoes that use a "clean" soil mix should be free of the *Fusarium* fungus.

Early Blight

Early blight is another fungal disease that damages the leaves and fruit of tomato. Spores of the causal fungus, *Alternaria solani*, are blown on the wind, alight on leaves or other plant parts, and produce lesions.

On leaves, symptoms begin as small, pencil-point-size, dark brown to black spots. The spots enlarge up to a half inch in diameter and usually have readily visible, concentric rings that look somewhat like a bull's-eye (Figure 16). These leaf spots are distinctive enough to make early blight one of the easier tomato diseases to diagnose.

Figure 16. Early blight on tomato leaves.
Credits: Gary Vallad, UF/IFAS

Similar concentric rings are seen in lesions that develop on stems and fruit. When the fungus attacks young stems, complete girdling of the stems may occur with subsequent plant death. Fruit lesions are usually at the junction of the fruit and fruit stem or on the portions of the fruit nearer the stem and are conspicuously sunken.

To control early blight, start with disease-free transplants and fertilize plants adequately. Inadequate nitrogen levels, in particular, make tomatoes more susceptible to early blight. A persistent problem with early blight might require periodic sprays with an appropriate fungicide.

Bacterial Wilt

Bacterial wilt, caused by *Ralstonia solanacearum,* is a serious soilborne disease of many economically important crops, such as tomato, potato, tobacco, and geranium in the southeastern United States. *R. solanacearum* is an extremely complex and diverse bacterial species; it is pathogenic to several hundred plant species belonging to more than 50 families.

Although diseased plants can be found scattered in the field, bacterial wilt usually occurs in foci associated with water accumulation in lower areas. The initial symptom in mature plants under natural conditions is wilting of upper leaves on hot days followed by recovery throughout the evening and early hours of the morning. The wilted leaves maintain a green color and do not fall as disease progresses. Under favorable conditions, complete wilt will occur (Figure 17).

Figure 17. Bacterial wilt symptoms on tomato.

The vascular tissues in the lower stem of wilted plants show a dark brown discoloration. A cross section of the stem of a plant with bacterial wilt produces a white, milky strand (ooze) of bacterial cells in clear water (Figure 18). This feature distinguishes the wilt caused by the bacterium from that caused by fungal pathogens (e.g., Fusarium wilt).

Figure 18. Bacterial ooze due to *Ralstonia* infection.
Credits: University of Georgia, Plant Pathology Extension

In the southeastern United States, bacterial wilt of tomato is caused predominantly by race 1 of *R. solanacearum.* These strains have 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 can survive in the rhizosphere of nonhost plants, including weeds.

Soil factors also influence the survival of the bacterium. For example, although bacterial wilt is an important disease of

tomato in Florida, the disease rarely occurs in calcareous soils with a high pH, which is the dominant soil type in Homestead, Florida. Moderate pH and moderate-to-high temperatures are associated with longer bacterial survival in soil.

Infested soil is the main source of inoculum. In recently cleared land in tropical and subtropical regions, it is not rare to find bacterial wilt in the first crop. Disease-free areas can be infested through infected planting material (tomato transplants), contaminated irrigation or surface water, machinery, and other cultural practices.

Bacterial wilt is very difficult to control after it is established in the field. No single measure totally prevents losses caused by the disease. The race 1 strains of *R. solanacearum* have been found to cause significant losses in tomato, especially in North Florida and in other southeastern states.

Cultural practices might reduce the disease incidence. Seedlings must be pathogen free. It is essential that gardeners use irrigation water that is not contaminated with the pathogen. Pond water in North Florida was found to be contaminated with this pathogen. Gardens should not be overirrigated because excess soil moisture favors disease buildup. Crop rotation with nonsusceptible crops reduces soilborne populations of the bacterium. Shifting planting dates to cooler periods of the year can also be effective to escape disease development. Soil amendments with inorganic and organic mixtures reduce wilt incidence in some locations. Bacterial wilt-resistant tomato cultivars (Neptune and FL 7514) could be used to reduce the impact of this disease. FL 7514 is available commercially.