

## Dooryard Citrus Production: Citrus Canker Disease<sup>1</sup>

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Citrus canker is a bacterial disease of citrus caused by the pathogen *Xanthomonas axonopodis* pv. *citri*. The bacterium causes necrotic lesions on leaves, stems and fruit of infected trees. Severe cases can cause defoliation, premature fruit drop, twig dieback and general tree decline. Considerable efforts are made throughout the world in citrus-growing areas to prevent its introduction or limit its spread.

### History of Citrus Canker in Florida

Not surprisingly, citrus canker is believed to have originated in the native home of citrus, Southeast Asia and India. From there, the disease has spread to most of the citrus-producing areas of the world, including Japan, Africa, the Middle East, Australia, New Zealand, South America and Florida. Eradication efforts have been successful in South Africa, Australia, the Fiji Islands, and New Zealand.

The first known outbreak of citrus canker in Florida occurred around 1910. It is believed that the disease was brought into the United States on infected rootstock material from Japan. The causal organism was unknown at the time and it was not until 1915 that the pathogen was determined to be a bacterium. After the failure of all control measures, an

eradication effort was begun in 1913, by which time the disease had spread throughout the Gulf States. In 1915, quarantine banned the import of all citrus plant material. The last known infected tree was removed from Florida in 1933, and the disease was declared eradicated from the United States in 1947. Since that time, citrus canker has been the focus of regulatory rules to prevent its re-introduction into the United States.

Despite regulatory efforts, citrus canker was found on residential trees in Hillsborough, Pinellas, Sarasota and Manatee counties in 1986. Shortly after these detections the disease was found in nearby commercial groves. Infected trees were immediately removed. The last tree with citrus canker from this outbreak was detected in 1992. Citrus canker was once again declared eradicated in 1994.

Citrus canker was detected for the third time in a residential area near the Miami International Airport in September 1995. An initial survey found that there were thousands of infected trees within a 14 square mile area. Eradication efforts began immediately. New molecular genetic tools enabled researchers to determine that the specific strain of citrus canker responsible for this new outbreak was different from

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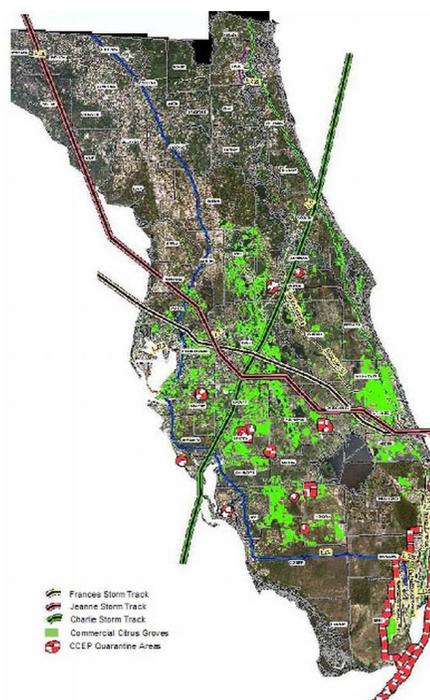
the 1986-1992 outbreak. State and federal eradication efforts proved to be inadequate, and by 2001 the disease had moved northward from Dade County and was being detected in Broward and Palm Beach counties.

In 1997, a separate outbreak of citrus canker occurred in Manatee County in commercial and residential citrus. Again, molecular genetic tools were used, and it was determined that the strain of citrus canker responsible for this outbreak was the same as that of the 1986-1992 outbreak in the same area. This data suggested that some infections had gone undetected during the earlier eradication efforts.

Another simultaneous outbreak was detected in the Immokalee area of southwest Florida in 1998. As new outbreaks occurred, the bacteria were genetically characterized by researchers. With the exception of the 1986 and 1997 Manatee County outbreaks, all of these new outbreaks were caused by the strain of the pathogen detected in 1995 near the Miami airport.

Although eradication efforts continued, legal battles over the forced removal of infected trees hampered the effort. The paths of hurricanes during the very active hurricane season of 2004 (Fig. 1), followed by more hurricanes in 2005, helped to spread the disease from the original infection areas in southeast Florida throughout most of the citrus-growing areas of the state. In January 2006, it was determined that eradication of citrus canker from Florida was no longer feasible and eradication efforts ceased. Containment became paramount.

As of January 11, 2008, Florida was placed under a statewide citrus quarantine by the United States Department of Agriculture (USDA) and *no* citrus (trees, fruit, rootstocks, leaves, potted citrus plants, etc.), whether commercial or dooryard, may leave the state unless the USDA has issued a limited permit. No Florida-grown citrus may legally enter any other citrus producing U.S. state or territory (Table 1). These regulatory efforts are in place to limit the spread of citrus canker beyond those areas already infected, and to control the severity of infections within affected areas.



**Figure 1.** Map showing the path of Hurricanes Charlie, Frances, and Jeanne in 2004. The red outlined areas indicate Citrus Canker Eradication Program (CCEP) quarantine areas prior to the hurricanes. The hurricanes followed paths that were very effective at spreading canker bacteria from infected areas to uninfected areas. Map compiled by the Florida Department of Agriculture Citrus Canker Eradication Program Geographic Information Office.

## Citrus Canker Symptoms

All above-ground tissues of citrus trees are susceptible to infection by citrus canker when young. Canker symptoms can appear on fruit, leaves and stems, and vary in their appearance depending on the age and severity of the infection (Fig. 2). Severe infections can cause defoliation, stem dieback, fruit drop, general tree decline and result in very unappealing fruit. Trees with persistent, severe infections can become weak and unproductive.

### Leaf Symptoms

Citrus canker bacteria enter plant tissues through natural openings (e.g. stomates – pores in leaf surfaces) and through wounds. The earliest leaf symptoms appear as tiny, slightly raised blister-like lesions (Fig. 3). The time from infection to symptom appearance will depend on environmental conditions. Under ideal conditions, that is, the presence of moisture and temperatures between 68-86°F, lesion



**Figure 2.** Canker symptoms on a citrus leaf (upper left), stem (right), and fruit (lower left).

development will occur in 4-7 days after inoculation. Under very limiting conditions, symptoms may take as long as 60 days to appear. As these young blister-like lesions age, they turn tan to brown and the area immediately surrounding the lesion takes on a water-soaked appearance with a yellow halo (Fig. 4). The centers of the lesions become raised and corky (Fig. 5). Lesions are visible on both sides of the leaf. The centers of large, old lesions may fall out, leaving holes in the leaf (Fig. 6).



**Figure 3.** Young canker lesions on leaves have a blister-like appearance.

The citrus leafminer (*Phyllocnistis citrella*) helps to increase the susceptibility of citrus trees to citrus canker infection. Leaves damaged by citrus leafminer become more sensitive to canker infection because leafminer wounds allow easy penetration of the canker bacteria into the leaf tissue (Fig. 7). Citrus canker lesions caused by the infection of leafminer feeding galleries are much larger and more numerous than when infections occur through natural openings. These large lesions result in the production of very high levels of inoculum for more infections as the



**Figure 4.** Young canker lesions on leaves have a blister-like appearance.



**Figure 5.** Older canker lesions on a leaf develop a corky appearance. Note the water-soaking around the perimeter of each lesion



**Figure 6.** Older citrus canker lesions beginning to show how the center can fall out (arrow) of old lesions.

bacteria reproduce. Additional information about citrus leafminer can be found in the EDIS publication, "Citrus Leafminer, *Phyllocnistis citrella* Stainton (Insecta: Lepidoptera: Phyllocnistinae)" available online at <http://edis.ifas.ufl.edu/IN165> .



**Figure 7.** Canker lesions develop along the tunnels of citrus leafminers.

### ***Stem and Twig Symptoms***

Because stems and twigs are somewhat more resistant to infection than leaves, the presence of citrus canker lesions on stems and twigs generally indicates that an infection has been present for some time. Stem lesions can serve as a reservoir of inoculum that can continue to re-infect new tissues as they are produced. Symptoms on stems and twigs are generally dark brown, raised, corky lesions which when young, may have an oily or water-soaked appearance around the edges (Fig. 8, top). Stem lesions *do not* usually have the yellow halo typical of leaf lesions. As the lesions on stems age they begin to appear more dried out and take on a scabby appearance (Fig. 8 bottom).



**Figure 8.** Canker lesions on stems are generally dark brown and raised. Young lesions may have a water-soaked or oily appearance around the edges (top). Older lesions appear dry and have a scab-like appearance (bottom).

### ***Fruit Symptoms***

Lesions on fruit tend to be dark brown and raised, similar to those on stems, and are frequently surrounded by a yellow halo (Fig. 9). Fruit symptom

appearances may differ slightly depending on the citrus variety (Fig. 10). Canker lesions on fruit may cause premature fruit drop, thus reducing fruit yield, and give the fruit an unappealing appearance. However, canker lesions on fruit are only "skin deep" and the fruit is still edible.



**Figure 9.** Canker lesions on fruit with a yellow halo, similar to leaf lesions.



**Figure 10.** Comparison of the appearance of citrus canker lesions on grapefruit (left) and sweet orange (right).

### ***Other Diseases***

A few other diseases of citrus, such as citrus scab, melanose and *Alternaria* brown spot, have symptoms that may at first be mistaken for citrus canker (Fig. 11). However, upon closer inspection these diseases can be distinguished quite easily from citrus canker.

Scab infections begin as small, pale orange, somewhat circular, elevated spots on leaves and fruit. As the infection develops, the spots become wart-like. The crests of the wart-like growths usually become covered with a corky pale tissue and become somewhat flattened as the fruit matures, especially on grapefruit.

Melanose lesions are small, raised dots, pustules, and irregularly shaped spots ranging from brick red to black that feel like sandpaper when touched.

*Alternaria* brown spot infections on fruit, appear as small, slightly depressed black spots which can cause the young fruit to fall from the tree. *Alternaria* lesions may also be surrounded by a yellow halo, similar to canker; however, the depressed lesions distinguish it from canker.



**Figure 11.** Citrus fruit displaying citrus scab (top), melanose (middle), and *Alternaria* brown spot (bottom) symptoms.

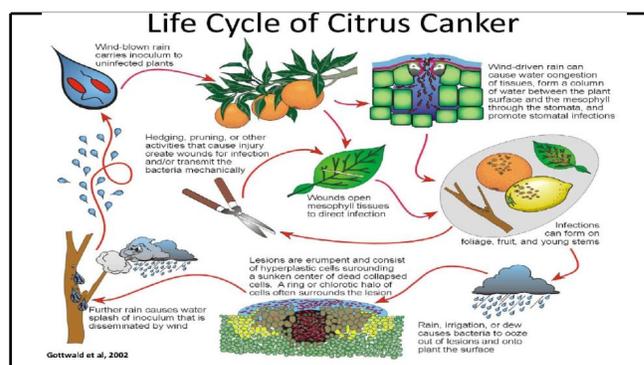
## Citrus Canker Infection and Spread

In order for canker bacteria to cause an infection they must be able to enter plant tissues. For this reason, young leaves, stems and fruit (Fig. 12) are highly susceptible to natural infections because they have not yet fully developed their natural protective layer, called the cuticle. Once these tissues have matured and "hardened-off," infection is unlikely. However, wounding any of these tissues, young or old, can provide a point of entry for the bacterium and lead to an infection. Wounds can be caused by physical means, such as pruning, or by plant pests, such as citrus leafminer.



**Figure 12.** Canker lesions developing on young fruit (left) and leaves (right) showing the susceptibility of these immature tissues.

The life cycle of citrus canker infection and spread is shown in Figure 13. Wind-driven rain is the primary mechanism for movement over short to medium distances. A rain drop can carry millions of bacteria. These rain drops can then flow into leaf pores, introducing the bacteria to the internal leaf tissues where it causes infection.



**Figure 13.** Graphic demonstrating the citrus canker life cycle and the contribution of wind-blown rain to spreading the infection.

Long-distance spread of citrus canker occurs primarily through human activity, via the movement of infected plant material, equipment or even

clothing. However, some natural events, such as hurricanes, can transport bacteria long distances.

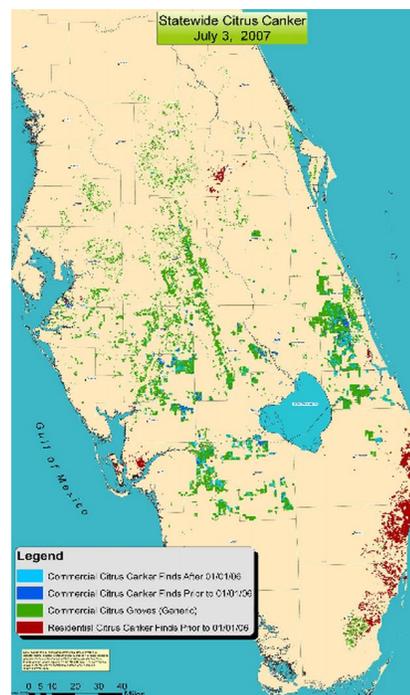
## Citrus Canker Management

As of January 2006, citrus canker eradication efforts have been suspended. This means that the removal of infected trees and those trees within 1900 ft of infected trees is no longer required. However, under the USDA statewide quarantine, no citrus may leave the state of Florida without a USDA-issued limited permit. These restrictions apply to commercially grown as well as residential citrus, and apply to all plant material, not just fruit. These rules may change in the future and the Florida Department of Agriculture and Consumer Services, Division of Plant Industry (FDACS, DPI) Citrus Canker website (<http://www.doacs.state.fl.us/pi/canker>) should be consulted for the most up-to-date quarantine information.

Florida's warm and humid climate is very favorable for citrus canker, thus it will likely be difficult to control. It should be the goal of all Florida residents to protect areas that are currently canker free. Although it is legal to move citrus within Florida, it is recommended that homeowners *not* move citrus material around under any circumstances. This includes fruit, potted plants and even tree trimmings. This is especially important for those living in an area where canker has become endemic, as they are the most likely to be moving infected material.

### Preventing Infection

When working in your yard, you should take precautions to avoid infecting your trees or spreading the disease from one tree to another within your yard. Gardening tools and your hands can be disinfected while working in your yard to help prevent the spread of the disease if one of your trees is infected. If you borrow gardening tools from a friend, disinfect them prior to using them on your citrus trees and before you return them. Your hands and garden tools can be easily disinfected using a variety of products, including hydrogen peroxide, household chlorine bleach, rubbing alcohol, sanitizing sprays (e.g. Lysol®) or hot water and antibacterial soap. Proper



**Figure 14.** Map showing the distribution of citrus canker in Florida counties as of July 3, 2007.

caution should be exercised when using any of these household chemicals.

At this time, homeowners may replant citrus trees anywhere in Florida, regardless of past citrus canker quarantine areas. However, in an effort to control citrus canker and other diseases, the FDACS has implemented strict regulations for propagating and selling citrus trees in Florida. New citrus trees must be purchased from certified nurseries that are registered with the state. Every citrus tree sold in Florida *must* have a tag on it which identifies the nursery that produced the tree by name and state registration number. *Do not* buy a citrus tree without this tag.

### Controlling Existing Infections

Once a canker lesion occurs, that lesion cannot be cured. However, the bacteria can be prevented from spreading beyond that lesion and creating a more severe infection because the bacterium is not systemic within the plant. That is, the bacteria do not move within the plant; they are restricted to the lesion unless moved by water or some other physical means.

If you find citrus canker on your trees, the best thing you can do is try to eradicate the disease if it is

limited to a relatively small area (e.g. a single branch or a few fruit). This can be easily done by pruning away the infected portion of the tree. The remaining portion of the tree should be monitored carefully for any new infections and they should be removed as soon as they are detected. Citrus canker bacteria can easily survive from one season to the next in old lesions on fruit, leaves and stems, especially in Florida's climate. Thus, removing infected material reduces inoculum sources and reduces the potential for new infections. Any material that is removed from a plant that has citrus canker should be sealed inside a double plastic bag before disposing of it in the trash. *Do not* place canker-infected plant material in compost piles or horticultural waste because this will not kill the bacteria and may allow for easy spread of the disease.

The only chemical products that are at all effective for canker control are copper-based fungicides/bactericides. However, these products act only as a chemical barrier against canker infection, not systemically. Therefore, if one of these products is applied to a young leaf or fruit, that leaf or fruit will only be protected as long as the copper coating remains intact. The copper only coats the surface, and when the surface expands the coating is no longer intact and the tissue is again susceptible to infection. Trying to prevent citrus canker infection by using a copper-based product is difficult, costly, highly inefficient, and can be environmentally hazardous. It is not recommended that homeowners try to control citrus canker chemically. However, if you choose to use chemical controls, you must follow all label directions for the product you are using.

### Diagnosing Citrus Canker

If you are unsure whether a disorder on your citrus tree is citrus canker, please contact your local county cooperative extension office (visit <http://solutionsforyourlife.ufl.edu> to find your local office) or the FDACS, DPI Citrus Canker and Citrus Greening Helpline (1-800-282-5153). They may ask you to e-mail them a digital photo of the symptomatic tissue for positive identification. If a positive identification cannot be made this way or you are unable to provide them a photo, you may be asked to bring a sample to the office. If you bring a sample to

the county extension office it should be sealed inside two clear plastic zip-top bags to prevent the possibility of spreading the disease. *Do not* transport suspect material without being specifically asked to do so and without first double-bagging the sample.

### Susceptible Varieties

Citrus canker affects all types of citrus, but there is some variation in the severity of the disease depending on the variety of citrus grown. A general ranking of variety susceptibility, from most susceptible to least susceptible is shown in Table 2.

Although it is no longer governed by the strict rules that were in place during eradication, citrus canker is still a serious disease of citrus. The disease has become endemic in many parts of the state, but it is still possible to restrict its spread beyond these areas. Citrus canker is highly contagious and can easily be spread by human activity, further threatening what is a hallmark of the Florida landscape – citrus. Homeowners should be familiar with disease symptoms and regularly inspect their dooryard trees for citrus canker infections. No citrus, including fruit, potted trees or cuttings should be moved into or out of Florida without first checking the most current quarantine regulations on the FDACS, DPI website. Through vigilance on the part of homeowners and commercial citrus growers alike, citrus canker can be controlled and Florida's citrus trees can be protected.

### Additional Information

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**Table 1.**

U.S. citrus-producing states and territories into which Florida citrus may not enter.	
States	Territories
Arizona	American Samoa
California	Guam
Hawaii	Northern Mariana Islands
Louisiana	Puerto Rico
Texas	U.S. Virgin Islands

**Table 2.**

Highly Susceptible	
Grapefruit	Key Lime
Lemon	
Susceptible	
Hamlin Orange	Persian/Tahiti Lime
Tangelos	
Navel Orange	
Less Susceptible	
Valencia Orange	Murcott
Mandarin/Tangerine hybrids	
Resistant	
Kumquat	Citron
Calamondin	Mandarins