

2018-2019 FLORIDA CITRUS PRODUCTION GUIDE:

Citrus Canker¹

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Citrus canker, caused by the bacterium *Xanthomonas citri* subsp. *citri*, is a leaf, fruit, and stem blemishing disease that affects most citrus. Grapefruit, Mexican lime, and some early oranges are highly susceptible to canker; Navel, Pineapple, and Hamlin oranges, as well as, lemons and limes are moderately susceptible; mid-season oranges, Valencias, tangors, tangelos, and other tangerine hybrids are less susceptible; and tangerines are tolerant.

Symptoms. Young lesions are raised on both leaf surfaces, particularly on the lower leaf surface. The pustules later become corky and crater-like with raised margins, sunken centers and surrounded by a yellow halo. Fruit lesions vary in size because the rind is susceptible for a long time and more than one infection cycle can occur on fruit. Twig and stem infections resemble those on fruit. The lesions are raised with a corky appearance and can support long-term survival of the bacterium. Older lesions may darken when they become colonized by saprophytic fungi such as *Colletotrichum* spp.

Major citrus canker outbreaks generally occur when new shoots are emerging or when fruit are in the early stages of development, especially if a major rainfall event occurs during this critical time. Frequent rainfall in warm weather, especially storms, contributes to disease development. Citrus canker is mostly a cosmetic disease, but when conditions are highly favorable for infection, it causes defoliation, shoot die-back and fruit drop. Leaf susceptibility is complicated by the Asian leafminer. The galleries caused by leafminer larvae do not heal quickly and increase leaf susceptibility. This results in leaves with highly susceptible wounds for long periods of time through which the bacterium can infect the leaf. The number of lesions and individual lesion size is greatly increased which results in many times the inoculum pressure in a grove compared to citrus can-

ker in the absence of leafminer.

Biology. The bacterium reproduces in lesions on leaves, stems, and fruit. When there is free moisture on the lesions, the bacteria ooze out and can spread to new growth and other trees. Wind-driven rain is the main dispersal agent, and wind speeds >18 mph aid in the penetration of bacteria through the stomatal pores or wounds made by thorns, insects, and blowing sand. Tissues become resistant to infection as they mature except when exposed to extreme windblown rain such as a hurricane. Almost all leaf and stem infections occur within the first 6 weeks after initiation of growth unless there is a leafminer infestation. The most critical period for fruit infection is when the fruit are between 0.5-1.5 inch in diameter for grapefruit and 0.25-1.25 inch in diameter for oranges. That is the stage when the stomates on the fruit surface are opening and fruit are particularly susceptible to bacterial penetration. After petal fall, fruit remain susceptible during the first 60 to 90 days for oranges or tangerines and 120 days for grapefruit. Infection after this time can result in the formation of small and inconspicuous pustules.

Most spread of canker bacteria by wind and rain is over short distances such as, within trees or to neighboring trees. Canker is more severe on the side of the tree exposed to wind-driven rain. Spread over longer distances, up to miles, can occur during heavy winds, severe tropical storms, hurricanes, and tornadoes. Long-distance spread occurs more commonly with the movement of diseased plant material such as budwood, rootstock seedlings, budded trees, or less commonly fruit and leaves. Workers can carry bacteria from one location to another on hands, clothes, and equipment. Grove equipment can spread the bacteria within and among plantings, especially when trees are wet.

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Management. The Citrus Health Response Plan (CHRP) does not require removal of affected trees. Thus, growers should use their best judgment in management of citrus canker. The entire state of Florida is under quarantine, and fruit movement is subject to specific regulations depending on market destination.

Canker losses can be severe under Florida conditions, and can be difficult to control on grapefruit and the most susceptible early season orange varieties. Areas that are currently canker-free should be protected to the extent possible.

Protecting Canker-Free Areas

Decontamination. Where canker is absent, decontamination protocols are still in place and should be followed. With widespread canker around the state, the likelihood of further spread is greater than ever. In moving equipment and personnel from grove to grove, every effort should be made to make sure that plant material is not moved inadvertently and that all equipment has been thoroughly decontaminated. Decontamination is especially important in harvesting operations, hedging and topping, and in any other practices involving extensive contact with foliage. Obviously, when equipment is moved from blocks where canker is endemic to other infected blocks, decontamination serves little purpose.

Tree removal. If canker is detected in areas previously free of the disease, removal and burning of trees on site may slow the establishment of the disease. For tree removal to be effective, canker has to be localized and limited to a small number of trees. Tree removal is not likely to be effective if canker is already present within a mile of the grove as it can spread with the wind and rain. Before tree removal is attempted as a control measure, blocks should be thoroughly inspected to be sure that canker is not more widespread than initially thought. All infected trees as well as some apparently healthy trees surrounding the infested area should be removed. More trees should be removed if the focus is large, but if the affected area is very large, tree removal may need to be reconsidered. This measure is unlikely to eradicate the disease, but can potentially slow disease development. Tree removal must be followed by monthly inspections and removal of any further trees found positive for the disease. At some point, tree removal will no longer be economically sustainable and should be discontinued.

Defoliation and pruning. There are currently no registered defoliants, but it is possible to defoliate trees using high concentrations of legal copper or fertilizer products. However, no rates or spray volumes have been established for this practice. The results of chemical defoliation are highly variable depending on chemical rate, spray application method, tree age, water relations, and environmental conditions at time of application. The results for the same rate and application method can vary from incomplete defoliation to severe dieback of brown wood. Defoliation may be useful in areas surrounding foci of infected trees

that have been removed. These trees may appear healthy, but are likely to harbor undetectable canker lesions. Defoliation can eliminate this inoculum and save many trees. Severe pruning or buckhorning has met with some success as long as strict sanitation procedures are followed in the removal and disposal of the infected plant materials. Defoliation or pruning should only be attempted during dry times of the year and in conjunction with an intense inspection program. Removal of canker-infected trees and tissues is not likely to completely eliminate the disease. A strong flush of highly susceptible leaves will follow and is likely to become infected from residual inoculum in the tree or nearby infested groves. Following defoliation or pruning, the new growth flush should be treated with copper sprays once the growth is half expanded to protect it from new infections.

Endemic Canker. Where canker is already endemic, the primary means of control are: 1) planting of windbreaks, 2) protection of fruit and leaves with copper sprays, and 3) control of leafminer.

Windbreaks. Windbreaks are highly effective for reducing the spread of canker, but more importantly, they reduce the severity of the infection in endemic situations. When canker lesions are wetted, millions of bacteria ooze onto the leaf surface. While the bacterium can swim very short distances, it has no active means to penetrate the tissues. The vast majority of the infection occurs by wind-blown rains that push the bacteria into tissues. Winds of 18 to 20 mph are needed to force bacteria into stomates on leaves and fruit.

Windbreaks reduce wind speed for a distance five to ten times the height of the windbreak. For example, a 30-ft tall windbreak will exert an effect for about 150 to 300 ft. To be effective for canker control, windbreaks do not need to be dense. All that is required is to reduce wind speed to less than 20 mph. The need for windbreaks and the distance between rows will depend on the destination of the fruit, fresh or processed, and cultivar susceptibility. Fresh market grapefruit in Florida will likely need a windbreak that surrounds each 5- to 10-acre block. The tree species, *Corymbia torelliana*, has proved to function well in grapefruit blocks because the tree retains its leaves and branches all the way to the ground reducing wind penetration through the lower canopy. Replacement of windbreak trees that fail to thrive or have been killed by lightning is recommended to prevent breaches that allow for local wind penetration and incursions of bacterial inoculum. In many groves with less susceptible citrus cultivars, a windbreak down the row about every 300 ft may be sufficient. In situations where some protection exists and tolerant varieties are grown for processing, additional windbreaks may be unnecessary. Additionally, not topping outside rows of citrus can also serve as a viable, harvestable windbreak. Currently, the recommendation is that growers plant windbreaks along fence lines, ditches, around wetlands, or wherever they can plant without removing citrus trees. If it becomes obvious that more windbreak protection is

needed, rows of citrus or end trees can be removed to accommodate more windbreaks.

For more information on selection of plant species and design, see the CREC Web site (<http://www.crec.ifas.ufl.edu/extension/windbreaks/>).

Copper sprays. Over the last 30 years, IFAS has evaluated dozens of products for canker control in several projects in Argentina and Brazil. Products such as antibiotics, compounds that induce resistance in plants and disinfectants provide limited canker control, but no material has proven more effective than copper products.

Copper products are quite effective for preventing fruit infection, but much less effective for reducing leaf infection. Application of copper to young leaves protects against infection, but it is soon lost due to rapid expansion of the surface area. Also, copper has limited value in reducing disease spread. Fruit grows more slowly than leaves and is easier to protect. Orange fruit are susceptible to infection after the stomates open when the fruit are 0.25 to 0.5 inch in diameter. Oranges develop resistance in mid to late July. Grapefruit are susceptible from the 0.5 to 0.75 inch size to full expansion in late September to mid-October. Infection through wounds can occur at any stage of fruit growth.

For oranges with endemic canker, most of the infection will occur from April to July. No more than five copper sprays applied at 21-day intervals are recommended for early processing oranges: one in early April (fruit at 0.25 to 0.5-inch stage); a second in late April, a third in mid-May, a fourth in early June and a fifth in late June to early July when the fruit is about a 1.5-inch diameter. Three applications at a 21-day interval should be sufficient for Valencias and midseason varieties, in mid-April (fruit at 0.25 to 0.5-inch stage), in early/mid-May, and late May/early June. Varieties of early oranges grown for higher color score (Early Gold, Westin, Ruby, Itaborai) are more susceptible than Hamlin and may require additional sprays before April and beyond July. It is advisable to consult the Citrus Copper Application Scheduler to ensure that copper residues levels are adequate for disease control. The 21-day interval is an approximate timing but growth rate and rainfall can cause copper residues to decay faster or slower than otherwise expected. More details are available in EDIS PP289 'A Web-Based Tool for Timing Copper Applications in Florida Citrus'.

Programs for fresh fruit are more complex, but many copper sprays are already used on these varieties. For fresh market grapefruit, a low rate of copper should be added to the spray of spring flush for scab. Subsequently, the copper spray program used for melanose control should also control canker, but additional applications will be required every 21 days when the fruit reach 0.5 to 0.75-inch size until fruit are fully grown in October. Copper may need to be added to applications of fun-

gicides or petroleum oil. Use caution when mixing copper with oil because it increases the phytotoxicity risk.

Most tangerines are fairly tolerant to canker. Copper programs used for *Alternaria* control should also protect against canker. Navel oranges are more susceptible to canker and will probably need to be sprayed every 21 days from early April to mid-July. Fallglo is less susceptible and probably three sprays in April, May and June should suffice. Newly planted trees in canker exposed settings are more susceptible because they produce leaf flushes more often and the flush tissue represents a high proportion of the canopy volume. The recommendation for the more susceptible varieties (grapefruit and early oranges) is that the trees be sprayed every 3 to 4 weeks to coincide with vegetative flush cycles from spring through the fall. Sprays should be applied with a hoop sprayer that thoroughly covers the foliage on all sides of the canopy.

Spray volumes for young and fruiting trees will have to be adjusted as more experience is gained. The rates of copper products depend on the length of protection expected and the weather. As little as 0.5 to 1.0 lb of metallic copper will protect spring flush growth or fruit during the dry spring season. However, in the rainy season, more than 1 lb of metallic copper may be required to protect fruit for 3-week periods.

To the extent possible, copper usage should be minimized since this metal accumulates in soil and may cause phytotoxicity to the fruit peel, or create environmental concerns.

Leafminer control. Leafminers do not spread canker, but extensive invasion of leafminer galleries by the bacterium greatly increases inoculum levels making the disease difficult to control. Leafminers are not usually a problem on the spring flush and no control is needed at that time. Leafminer control on the first summer flush can reduce disease pressure considerably. If properly timed, applications of petroleum oil, Agri-mek, Micromite, Spintor, or Assail will reduce damage by leafminer. Late summer flushes tend to be erratic and effective control at that time will probably be more difficult. (See ENY-734 section of this Guide on Asian Citrus Psyllid and Citrus Leafminer.)

Activator of Systemic Acquired Resistance. SAR is a natural or chemical induction of resistance to disease, in this case canker, throughout the plant. The disease may occur or continue to develop before SAR can be naturally induced or take full effect. The SAR activator, Actigard triggers the natural defense mechanism before the onset of disease but has no direct effect on the pathogen. High inoculum levels can overcome defense activation, so it is important to apply Actigard before weather and host flush conditions are favorable for infection at the beginning of each season. There are two methods of application – drench or chemigation but drench was found to be more effective.

Use scenarios for Actigard vary with age and size of trees:

New Plantings (0-3 year-old trees)

- Goal is to limit establishment of citrus canker during the non-bearing stage.
- Initiate treatments after planting when trees have overcome transplant shock and begun active growth. Continue through the entire non-bearing cycle.
- Use in conjunction with soil applied neonicotinoid insecticides, which also can induce SAR. Actigard cannot replace a soil-applied neonicotinoid scheduled for Asian citrus psyllid management.
- Use in conjunction with other canker management tactics like windbreaks in highly susceptible grapefruit.
- Continue applications throughout the spring, summer, and fall at 60-day intervals.

Young Bearing Plantings (4-5 year-old trees)

- Limits development of lesions on foliage thereby reducing potential for fruit infection.
- Initiate post-bloom, but prior to conditions favorable for citrus canker.
- Use in conjunction with other canker management tactics.
- Continue throughout spring, summer and fall at 30 to 60 day intervals depending on tree size and planting density (Table 2).

Mature Bearing Plantings (6+ year-old trees)

- Limits development of lesions on foliage thereby reducing potential for fruit infection.
- Initiate post-bloom, but prior to conditions favorable for citrus canker.
- Use in conjunction with other canker management tactics.
- Continue throughout summer season at 30 to 60 day intervals depending on tree size and planting density (Table 2).

The rules and regulations regarding canker are changeable. For current information on disease status and regulations, see the website of the Florida Department of Agriculture and Consumer Services:

<http://www.freshfromflorida.com/Divisions-Offices/Plant-Industry/Agriculture-Industry/Citrus-Health-Response-Program/Citrus-Diseases/Citrus-Canker>

or the CREC Web site:

<http://canker.ifas.ufl.edu>

Contact your county agent for additional information, training materials, and programs.

RECOMMENDED CHEMICAL CONTROLS

READ THE LABEL.

See Table 1.

Rates for pesticides are given as the maximum amount required to treat mature citrus trees unless otherwise noted. To treat smaller trees with commercial application equipment including handguns, mix the per acre rate for mature trees in 125 gallons of water. Calibrate and arrange nozzles to deliver thorough distribution and treat as many acres as this volume of spray allows.

For applications of Actigard (drench or chemigation) use rates are expressed as the amount of Actigard per tree. Recommended drench water volume is 8 to 16 fl.oz./tree.

TABLE 1. Recommended Chemical Controls for Citrus Canker

Pesticide	FRAC MOA ¹	Mature Trees Rate/Acre ²
Actigard 50WG	P01	See Table 2
copper fungicide	M01	Use label rate

¹ Mode of action class for citrus pesticides from the Fungicide Resistance Action Committee (FRAC) 2018. Refer to ENY624, Pesticide Resistance Management, in the 2018-2019 Florida Citrus Production Guide for more details.

² Lower rates can be used on smaller trees. Do not use less than the minimum label rate.

TABLE 2. Recommended Rates and Use Patterns for Actigard 50WG/100 Trees

Number of Applications/Year ¹	Tree Age and Rate ^{2,4} (oz./Application)			
	< 1 year ³	1-2 years	2-3 years	>3 years
4 or less	0.125 - 0.25	0.25 - 0.50	0.50 - 0.75	0.75 - 1.5
5 or more	0.125	0.25	0.50	0.75 - 1

¹ Minimum interval between applications is 30 days. If tree stunting, yellowing or other symptoms of possible phytotoxicity are observed reduce the use rates in subsequent applications to the low end of the recommended rate range and increase the application interval to 60 days.

² Do not use more than 12.8 oz./A/year and no more than 3.2 oz./A/application.

³ For newly planted trees delay applications until trees become established & overcome transplant shock and initiate treatment at 0.125 oz./100 trees.

⁴ As tree size increases during the season dosages should be adjusted towards the upper end of the recommended rate range.