HS1131

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Dooryard Citrus Production: Citrus Greening Disease [1]

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Citrus greening disease, an incurable disease also known as huanglongbing (HLB), is the most devastating disease of citrus, affecting all citrus cultivars and, in time, rendering infected plants completely unproductive. This disease has severely limited citrus production in many citrus-growing areas of the world. The disease is caused by the bacterium *Candidatus* Liberibacter spp. and is spread by a tiny insect called the Asian citrus psyllid (*Diaphorina citri* Kuwayama). This insect is not native to Florida and was first found in Florida in 1998, at which time it was considered to be a pest of moderate significance. However, the discovery of citrus greening in Florida in 2005 changed the status of this insect to a pest of great importance.

Why Be Concerned about Greening?

Greening is a very serious disease of citrus that affects all citrus cultivars and causes tree decline. Through the movement of plants and insects around the globe, greening and its insect vector have been accidentally spread throughout much of the world's citrus-producing areas. Greening has seriously affected citrus production in a number of countries in Asia (the native home of citrus), Africa, the Indian subcontinent, the Arabian peninsula, and a number of islands in the Indian Ocean. In 2004, greening was discovered in Brazil, followed by Florida in 2005. More recently, greening has been found in dooryard citrus trees in Louisiana (2008) and Georgia and South Carolina (2009).

Greening is transmitted (vectored) by insects known as psyllids. When psyllids are abundant and environmental conditions are favorable, greening can rapidly spread to existing trees, both commercial and residential, and reduce the productivity of oranges and other citrus cultivars. Mature trees, if infected, decline in health and become unproductive. Young trees that become infected may never come into fruit production. In a survey conducted on Réunion Island (an island nation in the Indian Ocean), it was found that over an eight-year period, 65% of trees were rendered unproductive within seven years of planting. Similarly, in Thailand, trees generally decline within five to eight years of planting. Infected trees become stunted and are sparsely foliated, making them aesthetically displeasing for the home landscape.

Greening is difficult to manage, and continued commercial production of citrus has proven difficult and expensive in areas where it is widespread.

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Nowhere in the world where greening exists has it been eradicated. Since greening is transmitted by the psyllid vector, which is well established in Florida, the natural spread of greening has occurred very quickly since its introduction into Florida in 2005 (Fig. 1).

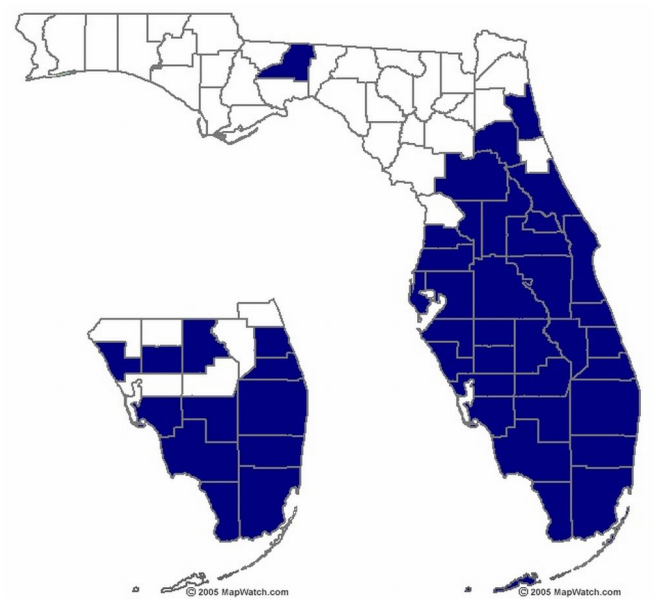

Figure 1. Maps showing the distribution of citrus greening disease in October 2006 (small inset map) and July 2009 (large map). In less than three years, greening spread to every citrus-producing county in Florida. (Map Illustration: J. D. Yates, University of Florida)

The Causal Agent of Greening

Greening disease is caused by a bacterium known as *Candidatus* Liberibacter spp. In the plant, this bacterium is limited to the phloem, the living tissue that carries carbohydrates produced by photosynthesis to all parts of the plant. Because the bacterium infects the phloem, the bacterium can move throughout the plant once it has become infected. That is, the infection is systemic, and thus cannot be removed by simply pruning away the part of the tree that is expressing symptoms. To date, researchers have not been able to culture the bacterium in the laboratory, which severely limits the progress of research into understanding and finding a cure for this disease.

There are three distinct isolates of the greening bacterium: *Candidatus* Liberibacter africanus from South Africa, *Candidatus* L. asiaticus from Asia, and *Candidatus* L. americanus from Brazil. The African form is believed to be more virulent in cooler climates (below 77°F) and at higher elevations (above 2250 ft). The Asian form, which is found in Florida, is more virulent at higher temperatures (above 80°F) and at lower elevations.

Insect Vectors of Greening

The different strains of greening bacterium are transmitted by two species of psyllid insects. The species *Trioza erytreae* (del Guercio) occurs in Africa, Yemen, and islands in the Indian Ocean, and is the vector of the African form of the disease. The other species, *Diaphorina citri*—the Asian citrus psyllid (Fig. 2)—is adapted to warm, humid climates and is found throughout Asia, the Indian subcontinent, Saudi Arabia, South America, Central America, and Florida. This species is the vector of the American and Asian forms of greening disease and is the species responsible for disease transmission in Florida.

Figure 2. Adult Asian citrus psyllid. (Photo: M. E. Rogers, University of Florida)

The Asian Citrus Psyllid

The Asian citrus psyllid feeds and multiplies on all species of citrus as well as a number of ornamental citrus relatives listed later in this publication. By feeding on an infected tree, the psyllids can themselves become infected with the bacterium. They can then fly to a healthy tree and infect it through feeding. Once infected, the psyllids remain capable of transmitting greening for the rest of their lives. Adult psyllids (Fig. 2) measure about 1/8 in. long and have mottled gray brown wings,

which they hold "rooflike" above their bodies. Adult psyllids can usually be found aggregated on young, tender new growth (flush), where they feed and mate (Fig. 3). The females must feed on young flush after mating to produce mature eggs. The females lay their eggs in the folds of the unexpanded young leaves or near the base of leaf buds that are just beginning to grow. If no new flush is present, the adults can be found feeding along the center vein on the undersides of leaves.

Figure 3. Adult Asian citrus psyllids aggregating on new growth. (Photo: M. E. Rogers, University of Florida)

Adult psyllids have a lifespan of about 30–50 days when temperatures are between 68°F and 86°F, but this increases as temperatures become cooler. During winter, when temperatures are typically 55°F–60°F, the adult psyllid lifespan increases to approximately 88 days. Thus during the winter, adult psyllids can live for a long time, feeding on mature leaves until new growth develops in the spring, when their populations can increase very quickly. Psyllid eggs are very small, about 0.01 in. long (Fig. 4). Once the eggs hatch, the nymphs (young psyllids) range in size from 0.01 in. just after hatching to 0.06 in. just prior to reaching the adult stage (Fig. 5). Nymphs are yellow and have red eyes. Because of their small size, they can be mistaken for aphids. However, psyllid nymphs produce a white, waxy secretion (Fig. 6) that is easily seen and makes them easily distinguishable from aphids.

Psyllids have piercing-sucking mouthparts that allow them to penetrate the phloem vessels of their host plant and feed on the carbohydrate-rich plant sap. Psyllid feeding causes new leaves to emerge twisted and curled (Fig. 7). Severe feeding damage can reduce shoot elongation and result in shoots with a bushy appearance (Fig. 8), or shoots may completely fail to develop (Fig. 9).

Figure 4. Asian citrus psyllid eggs massed at the tip of a young expanding shoot. (Photo: M. E. Rogers, University of Florida)

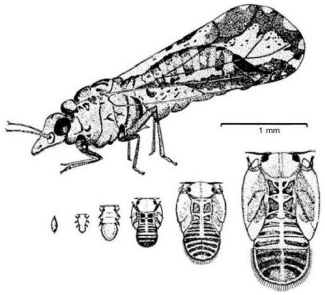

Figure 5. Diagram showing the developmental stages and relative size of Asian citrus psyllids from egg (bottom left) to mature nymph (bottom right) to adult (top). (Drawing: D. L. Caldwell, University of Florida)

Figure 6. Asian citrus psyllid nymphs showing white secretions. Note the red eyes. (Photo: M. E. Rogers, University of Florida)

Figure 7. Newly expanding leaves displaying twisted and curled distortions caused by Asian citrus psyllid feeding. (Photo: M. E. Rogers, University of Florida)

Figure 8. Bushy, abnormal shoot development caused by Asian citrus psyllid feeding during shoot development. (Photo: M. E. Rogers, University of Florida)

Figure 9. Shoot tip death caused by Asian citrus psyllid feeding. (Photo: M. E. Rogers, University of Florida)

Long-distance movement of greening can occur through the movement of infected plant material, including cuttings as well as potted trees. Epidemics of the disease have been documented when infected plant material is brought into an area where the psyllid vector is present to spread the disease. The movement of all citrus plant material into and out of Florida, whether by commercial companies or individuals, is restricted by state regulations and should not be done under any circumstances. It is also recommended that citrus plant material not be moved within the state because this will facilitate the spread of greening as well as other diseases and disorders.

What Plants Are Affected?

The greening bacterium can infect virtually all citrus species, cultivars, and hybrids, as well as several citrus relatives. Sweet oranges, mandarins (tangerines), and mandarin hybrids (tangelos) are highly susceptible to greening. Lemons, grapefruit, pummelos, and sour orange are also affected and are rendered unproductive when infected. Mexican lime, trifoliate orange, and some trifoliate orange hybrids are more tolerant and may show only some leaf symptoms.

In addition to cultivated citrus and its relatives, greening can infect a number of citrus-related (family Rutaceae) ornamental plant species. The greening bacterium can infect and multiply in orange boxwood (*Severinia buxifolia*, Fig. 10) and orange jasmine (*Murraya paniculata*, Fig. 11). These plants are also excellent host plants of the Asian citrus psyllid. Thus, having these ornamentals in the landscape can allow psyllid populations to build up and increase the risk of spreading the disease to other ornamental and citrus plants. Movement of these ornamentals is restricted under Florida regulations, and they should not be moved out of areas where greening is present (see Fig. 1).

Greening Symptoms

As research continues, we are learning that the symptoms of greening are not constant over time, within a tree, or between locations; thus it is important to be familiar with all of the manifestations of this disease. Citrus greening symptoms are most easily detected on leaves but can also be found on fruit from severely infected trees.

Figure 10. Orange boxwood (*Severinia buxifolia*). (Photo: http://www.hktree.com)

Figure 11. Orange jasmine (*Murraya paniculata*). (Photo: Forest & Kim Starr, http://www.hear.org/starr/)

Leaf symptoms. The leaf-yellowing symptom on a single branch or shoot (from which the Chinese name "yellow shoot" [huanglongbing] comes) is seldom seen in Florida (Fig. 12). The more typical symptom in Florida, particularly early in the development of the disease, is what is known as blotchy mottle (Fig. 13). This is a variegated chlorosis or yellowing of the leaf that is not symmetrical about the center vein of the leaf. That is, the symptoms on the two halves of the leaf are not mirror images of one another, but rather are random across the leaf. An easy test to help determine if the symptoms are symmetrical or not is to draw two circles on the leaf surface on either side of the center vein as shown in Figure 14. If the areas within the two circles have a similar appearance, the symptoms are symmetrical and do not indicate greening. However, if the areas within the two circles are not similar, the symptoms are not symmetrical and may indicate greening.

Figure 12. Yellow shoots (arrows) caused by citrus greening disease on a sweet orange tree. (Photo: J. D. Yates, University of Florida)

Figure 13. Citrus leaf expressing the typical blotchy mottle symptom of citrus greening. (Photo: M. E. Rogers, University of Florida)

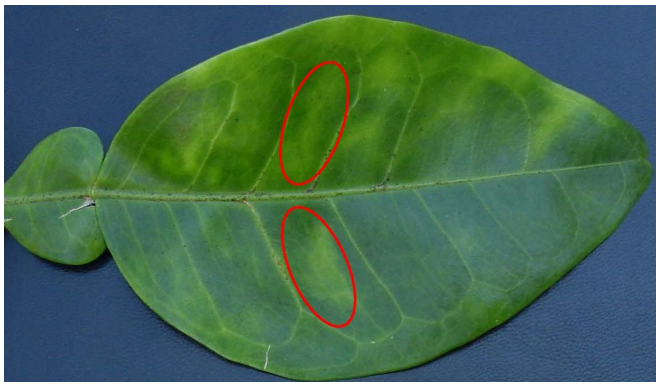

Figure 14. A leaf expressing the blotchy mottle symptom of citrus greening. Note that the symptoms are not the same in the circles drawn on opposite sides of the leaf mid-vein (asymmetrical). (Photo: M. Zekri, University of Florida)

It is very important to distinguish greening symptoms from mineral nutrient deficiencies, which also cause leaf yellowing. Mineral nutrient

deficiencies, such as those caused by zinc, iron, manganese, and magnesium, can resemble greening (Fig. 15). However, mineral nutrient deficiency symptoms are symmetrical about the center vein of the leaf.

Figure 15. Leaves showing mineral nutrient deficiency symptoms and greening disease symptoms. Nutrient deficiencies are manganese (top left), iron (top right), zinc (bottom left), and magnesium (bottom center). Note the uniformity (symmetry) of the mineral deficiencies; the left and right halves of the leaves are mirror images of one another. The greening leaf (bottom right) does not show this symmetry. (Nutrient deficiency photos courtesy of T. A. Obreza, University of Florida. Greening photo by T. M. Spann, University of Florida.)

With time, the yellowing usually spreads throughout the tree. Affected trees may show twig dieback, and productivity will decline. Additionally, leaves may develop what is known as vein corking (Fig. 16). This symptom is typified by bright yellow leaf veins that are raised and have a corky appearance.

Fruit symptoms. As an infected tree declines, the fruit may begin to display disease symptoms as well. Symptomatic fruit is commonly misshapen and appears lopsided (Fig. 17). Other symptoms include a yellow stain in the peel just below the point of stem attachment, dark-colored aborted seeds, uneven peel coloring, and an unbalanced, unripe taste (Fig. 18).

How to Detect Greening

Detecting greening in dooryard citrus can be difficult, particularly if the trees are in poor health from other causes. The blotchy mottle symptom (see Fig. 13) is the most diagnostic symptom of the disease and is usually the best symptom for

Figure 16. Leaves exhibiting the yellow corky vein symptom of greening disease. Note how the center and lateral veins appear raised above the surrounding leaf tissue and have a corklike appearance. (Photo: J. D. Yates, University of Florida)

Figure 17. A greening-affected (left) and healthy (right) 'Valencia' orange fruit at the same stage of development. Note the much smaller size of the greening-affected fruit and its lopsided development. (Photo: J. D. Yates, University of Florida)

Figure 18. Fruit showing symptoms of greening disease. The fruit on the left shows lopsided development, yellow staining below the point of stem attachment (yellow arrow), and dark aborted seeds (black arrow). The fruit on the right shows abnormal peel color development and is also misshapen. (Photos: J. D. Yates [left] and W. C. Oswalt [right], University of Florida)

identification. Symptoms become difficult to detect during the summer months when the trees are actively growing; therefore, carefully examining trees during the fall and winter offers the best chances for detecting the disease. When examining trees for disease symptoms, have a guide with which to compare suspect leaves. The University of Florida publication "Nutritional Deficiencies and HLB/Citrus Greening" has color photos of leaves with greening symptoms and nutrient deficiencies. It is available at all county Cooperative Extension offices free of charge. Leaf symptoms may appear anywhere on the tree, so it may be necessary to move branches out of the way and look inside the tree. Fruit symptoms may manifest if the disease is more advanced in the tree.

If you suspect that your tree is infected with greening, you can call your local county Extension office or send them a digital photo of the symptoms. If your county Extension office asks you to bring a sample to the office for a closer look, seal the sample in a plastic bag to prevent unknowingly spreading pests and/or diseases. You should only bring the sample to the office if asked to do so. You can find the contact information for your local county Extension office at http://solutionsforyourlife.ufl.edu.

Managing Greening and Psyllids

Psyllid control. In order for psyllid control measures to be 100% effective at eliminating the chance of disease spread, the psyllid population would need to be reduced to zero. Such a scenario is simply not possible. The best we can hope to achieve is suppression of psyllid populations through careful management; however, options are limited.

There are many beneficial insects that prey upon psyllids and will reduce their populations. However, in commercial citrus production, this strategy has not adequately suppressed psyllids to prevent the spread of greening. Psyllid nymphs are preyed upon by lady beetles (Fig. 19) and the parasitic wasp *Tamarixia radiata* (Fig. 20) that has been released in Florida. Together, these predators can consume over 90% of psyllids that hatch, but it only takes one psyllid to potentially infect a tree. For homeowners choosing to use pesticides on their dooryard citrus trees, the options are limited. Horticultural spray oils malathion and carbaryl (Sevin), which are used to control a broad spectrum of insect pests, are efficacious against psyllids. Some psyllid control will be achieved when these products are applied for other pests, but they do not have any systemic activity (movement into and throughout) in the plant. That is, they will only be effective against what is present at the time of spraying, and they will not prevent new psyllids from moving onto the tree after spraying.

Figure 19. Beneficial lady beetles that prey upon psyllid nymphs and other insect pests. (Photo: M. E. Rogers, University of Florida)

Figure 20. A psyllid nymph body (light brown area) that was parasitized by the predatory wasp *Tamarixia radiata* (dark brown in center). (Photo: M. E. Rogers, University of Florida)

Greening bacterium control. At the present time, there is no method for controlling the greening bacterium itself. Once a tree becomes infected with greening, there is no way to prevent it from spreading throughout the tree, causing the tree to decline and become unproductive. Furthermore, an infected tree that is allowed to remain standing potentially does little more than serve as a source of inoculum to spread the disease to healthy trees. Because the disease is systemic, pruning away symptomatic branches is not effective since other parts of the tree may already be infected but not yet expressing symptoms.

Eliminating the ornamental plants orange jasmine and orange boxwood from the landscape will also help since both of these species are hosts for the psyllid and the greening bacterium. Reducing the number of potential host plants will directly help to reduce psyllid populations and the amount of bacterial inoculum available.

Greening is one of a few citrus diseases that can truly limit citrus production. Now that the disease and its vector are present in Florida, it is important to limit its spread as much as possible so that we all may continue to enjoy Florida citrus. There is no cure for greening once a tree has become infected, and an infected tree serves as a source of inoculum to infect other trees. It is recommended not to plant ornamentals that are alternate hosts of the greening bacterium and psyllid. Homeowners are strongly encouraged not to move citrus or citrus-related plant material within the state. Doing so can spread the bacterium and psyllid even more quickly. Additionally, homeowners should not bring any citrus-related plant material into Florida from other states or countries because these materials may contain pests and diseases not yet present in Florida.

Additional Information

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