HUANGLONGBING (CITRUS GREENING) IN FLORIDA, 2008

Susan Halbert¹, Keremane Manjunath², Fritz Roka³, and Matthew Brodie⁴

¹Florida Department of Agriculture and Consumer Services, Division of Plant Industry, P.O. Box 147100, Gainesville, Florida 32614-7100, USA
²National Clonal Germplasm Repository for Citrus and Dates, USDA/ARS, Riverside, California, USA
³Southwest Florida Research and Education Center, University of Florida, IFAS, Immokalee, Florida, USA
⁴Plant Inspection Supervisor for Southwest Florida, Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Naples, Florida, USA

ABSTRACT

Citrus is a high-valued fruit crop in Florida. Citrus fruit and juice production has been reported to have generated US$9.29 billion total economic impact. However, huanglongbing (HLB) has threatened the long-term viability of the Florida citrus industry. The history of origin and spread of HLB has been traced. The disease has become widespread in the Florida peninsula. The University of Florida and the Division of Plant Industry have advocated standard management practices for the control of HLB. These practices consist of propagating and planting disease-free nursery plants, inspecting every tree at least four times a year, eliminating symptomatic plants, and preventing build-up of psyllid populations. The growers have responded appropriately to the recommended practices. They have invested time and money to secure their operations. Scientists have observed good results with timely application of pesticide recommendations for psyllid control. Despite these efforts, Florida growers are not bound by state or federal law to control HLB. Florida has neither mandatory regulations nor financial incentive to remove HLB-infected trees. As such, compliance with recommended practices varies among commercial and smallhold citrus growers. As in other countries worldwide, finding a holistic viable solution to HLB problems in Florida citrus remains uncertain.

Key words: Huanglongbing, citrus production, Florida

History of Diaphorina citri Kuwayama and Huanglongbing (HLB) in Florida

Diaphorina citri Kuwayama was discovered in Florida in June 1998. Delimiting surveys for D. citri after it was discovered indicated that it had spread coastally about 25 miles north and south of an apparent point of introduction in east central Palm Beach County (Fig. 1). Based on the rate of spread indicated by subsequent survey data, D. citri was discovered within six months to one year of its original introduction.

After the initial discovery of D. citri, the Florida Department of Agriculture and Consumer Services, Division of Plant Industry (DPI) personnel surveyed for HLB in Palm Beach County where D. citri was first found. A more thorough survey occurred in 1999 after an erroneous report that HLB was found in Florida. Other surveys occurred in Homestead (Miami-Dade County), West Palm Beach (Palm Beach County), Ft. Pierce (St. Lucie County) and other locations, but no trace of the disease was found by the end of 2000. These initial surveys for HLB, which continued into 2000, indicated that the initial D. citri population probably was not contaminated with HLB.

Intensive surveys by Cooperative Agricultural Pest Survey (CAPS) teams in Orlando and Tampa Bay in 2003 through spring 2005 detected no HLB. The Orlando CAPS survey in 2004 after the hurricanes
was of interest because of the unusually high populations of *D. citri* that responded to the damage and subsequent re-growth of the plants. The CAPS surveys focused on neighborhoods with predominant demographics linked to the regions where HLB was endemic. A CAPS survey of Asian farms in south Miami-Dade County found HLB for the first time in North America in August 2005.

After HLB was discovered in Florida, two large-scale delimiting surveys were done according to Incident Command System (ICS) protocol. One was on the east coast of the Florida peninsula (Fall 2005), and the other was in southwest Florida (January-February 2006). These surveys were jointly initiated by USDA and DPI personnel. The ICS surveys indicated that by the time that HLB was discovered in Florida, it had spread extensively and could not be eradicated (Fig. 2).

The Southeast Florida delimiting survey was done in transects five miles apart. Infected plants were found in nearly every surveyed square mile. Thus, if there had been time and manpower to survey the additional intervening square miles, essentially all southeastern coastal square miles would have been positive for HLB.

**Spread of *D. citri* and HLB in Florida**

*Diaphorina citri* spread from the initial point of introduction on its own for approximately 18 months until it reached the southern tip of the peninsula, where *Murraya paniculata* (orange jasmine) was produced in large quantities. From there, *D. citri* spread by plant movement primarily through large discount retail chains (Fig. 3) (Halbert et al. 2003). So far, there has not been any record of *D. citri* in the landscape in Northwest Florida, but several counties have records in discount stores. It is not known whether *D. citri* can survive the winter in Northwest Florida.

The original delimiting survey in Southeast Florida indicated that HLB had spread as far north as St. Lucie County (Fig. 2). There was an apparent gradient of numbers of infected plants and severity of symptoms suggesting that south Miami-Dade County was the source of the problem. Someone had probably introduced infected plants into the area either before the vectors arrived or shortly thereafter.

Fairly robust data exist for the flight of *Trioza erytreae* (del Guercio), the African citrus psyllid (van den Berg and Deacon...
Mark and recapture studies indicate that *T. erytreae* can fly at least 1.5 km in the absence of host plants. At first, we assumed this published outer limit on psyllid flight and thought that Florida residents who move potted citrus plants from place to place had accounted for the remainder of the spread of HLB in Florida. However, the first delimiting survey in the fall of 2005 found HLB-infected plants as far north as St. Lucie County (Fig. 2). Thus, the disease had spread approximately 240 km in a little over five years. Given the lengthy incubation period of the disease, this rate of spread could not be explained by a 1.5 km flight range and movement of homeowner potted citrus plants.
We suspect that *D. citri* can fly more than 1.5 km. In surveys in fall 2005 of a large citrus grove to the west of the Florida Everglades (a swamp largely devoid of citrus), inspectors easily found infected plants on the eastern borders of the grove (Fig. 4 and Fig. 5). During the Southwest Florida ICS program, inspectors revisited this grove. It was difficult to find infected plants even one mile inland from the Everglades, but neighboring groves to the north had epidemics on their eastern borders. Distribution evidence strongly suggested that infected insects had crossed the Everglades from heavily infected urban areas along the coast, infecting plants near the eastern borders of the groves. This is
a distance of at least 67 km. No data for *D. citri* show that the insects can fly that far; however, it is known that *Bactericera cockerelli* (Šulc), the potato psyllid, migrates trans-continentally every year (Liu et al. 2006), suggesting that flight distances of 67 km are not out of the question.

Another pathway for disease movement was distribution of plants in wholesale and retail channels prior to the establishment of scientifically sound specific phytosanitary regulations to mitigate these risks. *M. paniculata* is a host of HLB pathogens as well as of *D. citri* (Zhou et al. 2007). Zhou et al. (2007) transmitted *Ca. Liberibacter asiaticus* from Florida *M. paniculata* to citrus using dodder. The *M. paniculata* plants for the experiment were obtained from among those for sale to the public at a nursery in southern Miami-Dade County. Much of the *M. paniculata* produced for landscaping and for sale to the public was produced in southern Miami-Dade County, the epicenter of our HLB epidemic. Distribution of this plant could have played an important role in the spread of the disease.

DPI plant inspectors send hundreds of regulatory samples of *D. citri* collected from retail stores to our laboratory in Gainesville for confirmation. Many of these samples were tested by Dr. Manjunath Keremane, USDA ARS, Riverside, California, for the presence of citrus greening pathogens. In samples tested in 2005 and 2006, 7.9% of the psyllid samples collected from discount garden centers were positive for HLB (Manjunath et al. 2008). Similarly, 7.6% of the samples from other retail establishments were positive for HLB. 15.2% of these positive samples were collected from *M. paniculata* (Manjunath et al. 2008). In several cases, psyllid nymphs collected from *M. paniculata* tested positive, strongly suggesting that the plants were infected, even though it proved difficult to obtain a positive result by testing the plants directly by PCR methods. A sample of *D. citri* (E2005-5111) collected on *M. paniculata* from a discount store in Nassau County in extreme northeast Florida was strongly positive for *Ca. Liberibacter asiaticus*. The plants were traced to a nursery in Miami-Dade County. This sample provided additional confirmation that the pathogens, as well as the vectors, were moving with plants for sale, and with *M. paniculata* in particular.

The bulk of distribution of HLB on *M. paniculata* may have occurred quite recently. Evidence for that can be found in Orlando,
which is located just north of the center of the Florida peninsula. In the fall of 2004, Orlando experienced three hurricanes. These storms damaged citrus trees such that they all produced lots of new growth, resulting in extremely high populations of *Diaphorina citri* in October 2004. If there had been significant HLB inoculum at that time, most of the home yard citrus in the city would have shown HLB symptoms within four years. In fact, that was not the case. HLB was difficult to find in Orlando in autumn, 2008.

In Brazil, it has been estimated that the geographic range of HLB expanded by approximately 20 km per year (Gottwald et al. 2007). In Florida, probably assisted by movement of plants with retail trade, its range expanded 50-60 km/year. Much of the long-range distribution could have occurred fairly recently as a result of disease spread in large commercial nurseries that produced *M. paniculata* in southern Miami-Dade County.

**Current Situation**

**Status.** Citrus is Florida’s signature agricultural crop. Our vehicle license plates feature oranges and orange blossoms, which have been designated the Florida state flower. In 2003-2004, Florida citrus growers collectively produced nearly 292 million boxes for a total value of US$1.778 billion. When all indirect economic impacts are considered from citrus fruit and juice production, the Florida citrus industry is credited with a US$9.29 billion total economic impact (Spreen, et al. 2006). HLB is the most significant threat the Florida citrus industry has ever faced and threatens the long-term viability of the industry.

HLB is widespread in the Florida peninsula (Fig. 6). Every citrus-producing county has infected plants. Pressures from HLB, citrus canker, and urban development have all but eliminated commercial citrus in Miami-Dade County, including our once-lucrative lime industry. Further up the east coast and in Southwest Florida, many grove blocks are badly damaged and becoming unproductive. In 2008, a few growers are seeing significant reduction in yield due to HLB in some blocks. Florida officials do not have a good handle on the number of symptomatic trees. Based on county surveys and various training sessions for inspectors done by the senior author, HLB is scarce in the northern half of the Florida peninsula, but further south the disease is much more evident even with casual examination of groves.

Research indicates that sometimes psyllids that are positive for HLB can be found months to years prior to being able to see symptoms on plants (Manjunath et al. 2008). HLB-positive psyllids have been found in several counties north of the line indicating the presence of positive plants (Fig. 6). In quite a few cases, the first positive psyllids in the county were found in retail stores, as was the case for county records of the insects themselves (Manjunath et al. 2008; Halbert et al. 2003).

The State of Florida has regulations in place since January 2008 to curtail the sale of infected *M. paniculata*. As of January 1, 2008, all *M. paniculata* must be produced under screen from clean sources. Plants have to be treated with a systemic pesticide prior to sale. So far, no nurseries that produce *M. paniculata* have built structures to comply with the new regulations.

**Management.** Both the University of Florida and DPI advocate standard management practices for the control of HLB. These practices consist of propagating and planting disease-free nursery plants, inspecting every tree at least four times a year, eliminating symptomatic plants, and preventing build-up of psyllid populations. Adoption has been mixed.

One bright spot in Florida has been the response of the commercial citrus nursery industry to very stringent new regulations. Florida statutes have enacted the recommendations from the Citrus Health Response Plan (CHRP) in regard to nursery tree production. As of January 1, 2008, all certified nursery trees have to have been grown within protected structures. The new regulations were designed to prevent both HLB and canker-infected nursery stock from being planted in commercial groves. Florida nursery growers have invested time and money to secure their operations. Currently, nursery trees are scarce and expensive, but they probably will become more plentiful in the coming years as the new facilities build capacity.
Florida growers, to a large extent, have responded to HLB with aggressive psyllid control practices. University of Florida/IFAS has produced pesticide recommendations for psyllid control that works much better than previous practices. Trap collections in commercial groves in Florida have declined approximately an order of magnitude and are now at par with similar collections in Brazil. Although the University/IFAS cannot afford to treat 24 times each year as many growers do in Brazil (nor would environmental regulations allow it), scientists observe reasonably good results with timely applications. Furthermore, neighboring growers are starting to coordinate their psyllid control efforts jointly with aerial applications.

The major problem will be inoculum control. Presently, Florida growers are not bound by state or federal law to control HLB. In contrast, the state of São Paulo, Brazil, has a law in place requiring growers to: 1) inspect trees for HLB at least two times per year; 2) report all findings to the state department of agriculture; and 3) eradicate all symptomatic trees. The most conscientious Florida growers probably are scouting four times per year, but some growers do not scout at all, even if HLB has been found in their groves. In Brazil, many of the larger growers are revising their inspection schedules to scout once a month, or do at least 10 inspections per year. In contrast, Florida does not have manpower and financial resources to match the intensive scouting effort in Brazil, where labor costs are less. At the current exchange rate (1.6R/US$1), a Brazilian grower can hire a person to scout 2000 tree/day for US$745/month. Half this amount goes to the worker. The other half pays for the employment social taxes. Assuming 176 hours/month (22 days at 8 hr/day), a Brazilian employer is paying close to US$4.25 per hour of scouting labor. A Florida grower would have to pay at least double (US$8.75/hr; US$6.70/hr + 30% employment taxes) for the equivalent work.

Several Florida growers already are confronting the difficult choice of how to manage heavily infected blocks. It is not clear that growers who remove symptomatic trees aggressively are keeping up with the disease curve in heavily infected blocks. If they follow recommended protocols, the entire block would have to be removed. If they choose to leave the trees in place, infected trees become reservoirs for the bacteria and harbor infectious vectors for the neighboring groves. Short-term economic considerations are critical in a grower’s decision-making process, especially when he is faced with removing mature trees with profitable crop yields in markets with high prices. The economic incentive of not removing infected mature trees is particularly strong among smaller growers, who do not have either the acreage or financial resources to survive an aggressive eradication program. Thus, among commercial growers, aggressive control actions by one individual may be offset by the inaction of neighboring growers. This is particularly true for smaller holdings surrounded by groves with heavy infection rates.

Similarly, urban inoculum will be present for the foreseeable future. Little can be done about homeowners who keep HLB-infected citrus trees and orange jasmine plants. Part of the problem with urban inoculum is residual adverse public reaction to citrus canker eradication program. In 1997, the DPI began removing canker-infected and canker-exposed trees. The exposure (mandatory removal) radius around a single infected tree started at 125 feet (38 m) and increased to 1900 feet (576 m) in 2000. The program was slowed down by legal proceedings initiated by the residential sector until the disease had progressed to the point that it could no longer be eradicated, and the eradication effort was abandoned in 2006. Despite the force of federal law and a compensation program for tree removal, the strong negative reception by a minority of the residential public to this program has made it impossible to deal with HLB in urban areas.

Florida has neither mandatory regulations nor financial incentive to remove HLB-infected trees. Partly, the reason for this is inadequate knowledge about large-scale epidemiology of the disease. Some unanswered questions include: What is the ratio of symptomatic trees to infected ones? Will 100% of the asymptomatic trees that are PCR positive for HLB bacteria ultimately develop disease? How fast do diseased trees decline and lose productivity? Can damage be mitigated, even for a season or two, by
agronomic practices? Is it possible to get ahead of the disease curve if neighbors do not remove infected plants? Such knowledge gaps and the potential threat of legal proceedings prevent regulatory scientists from making recommendations with confidence.

Some growers, faced with high levels of HLB infection and little opportunity to replant, have turned to various treatments intended to prolong the life of infected trees. The treated trees look much better and appear to remain productive at least for a season. The long term results and economic benefits, if any, are under investigation.

**Observations from Florida’s Experience with HLB**

Several conclusions can be drawn from Florida’s experience with HLB for just less than ten years:

- Florida is one of the few places where there is a fairly firm beginning date for HLB spread. The rapid range expansion of the disease in Florida cannot be explained by movement of homeowner potted citrus and an extrapolated flight radius (from data on *T. erytreae*) of 1.5 km for *D. citri*. To account for infections in groves west of the Florida Everglades, we think psyllid vectors can move at least 70 km in the absence of host material. Additionally, both HLB and *D. citri* in Florida moved on plants in wholesale and retail commerce before specific regulations were in place.

- After HLB is established in a locality suitable for its continued spread, it becomes difficult to produce citrus within about ten years. This suggests that the association between *Ca. Liberibacter* spp. and citrus probably should be measured in decades, not centuries. Given the severe damage to citrus caused by HLB and the rapid decline of citriculture when HLB gets established, it is unlikely that the association is a lengthy one.

- *M. paniculata* played a significant role in the distribution of both HLB and psyllid vectors in Florida.

- Florida is in the same situation as the rest of the world with respect to HLB. Finding economically viable management practices that will maintain our pre-HLB level of citrus production remains uncertain.

**REFERENCES**


