Tools for integrated management of citrus psyllids and leafminers

By Jawwad A. Qureshi, Philip A. Stansly and Lukasz L. Stelinski

Pest management has always been important for citrus production in Florida. It has become even more critical following invasion of the Asian citrus psyllid (ACP) and citrus leafminer (CLM), due to their association with huanglongbing (HLB or citrus greening) and canker diseases, respectively.

ACP and CLM develop and reproduce on young leaf shoots commonly known as flush. Mature citrus in Florida produces a major flush in spring with minor and more sporadic flushes in summer and fall. High temperatures or rainfall in winter and storms that cause defoliation at any time will induce or increase the intensity of new flush growth, as seen in recent winters and after Hurricane Irma.

Winds and rain from Irma caused significant fruit drop and defoliation followed by a huge flush. Post-Irma temperatures were ideal for development and reproduction of both pests. When coupled with new flush, this created ideal conditions for rapid population growth. Wind damage to leaf surfaces and driving rain also spread citrus canker. Therefore, specific consideration is warranted toward pest and disease management in the times ahead. Individually, different methods of pest control may not be enough to achieve needed pest reductions, and not all methods are applicable in all environments or at all times. So it is important to give due consideration to all available tools.

Integrated pest management (IPM) focuses on pest identification, monitoring, prevention and decision-making based on economic injury levels so that insecticide use is prescribed when it is necessary. Application thresholds for ACP in young trees are exceedingly low since very few individuals can spread HLB. On the other hand, the threshold is higher for mature trees that are already infected but still benefit from ACP control to reduce re-inoculation of the pathogen.

Yield improvements have been demonstrated by reducing ACP populations in standard mature groves with HLB as compared directly with counterparts where vector populations are not well managed. These results suggest that vector control is still important, even when nearly 100 percent of a block is already expressing symptoms of HLB. However, healthy trees will always be more productive than HLB-infected trees, so many current research projects are focused on attaining complete vector exclusion. For example, growing citrus under protective screen (CUPS) is an idea gaining momentum based on ongoing investigation.

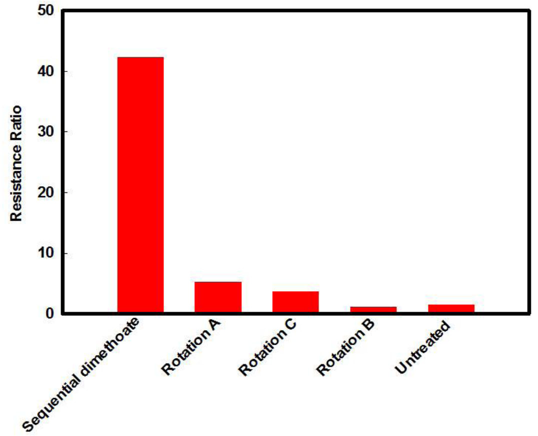

Figure 1. Significant impact of rotations of active ingredients in preventing ACP insecticide resistance. Rotation A: Organophosphate, microbial, synthetic pyrethroid, insect growth regulator and neonicotinoid. Rotation B: Neonicotinoid, synthetic pyrethroid, microbial, organophosphates and insect growth regulator. Rotation C: Microbial, insect growth regulator, organophosphate, neonicotinoid and synthetic pyrethroid. Sequential dimethoate: Five sprays with dimethoate.

Resistance ratio = LC50 of field population/LC50 of laboratory population (LC50 is the concentration of a chemical that will kill 50 percent of the tested population.)

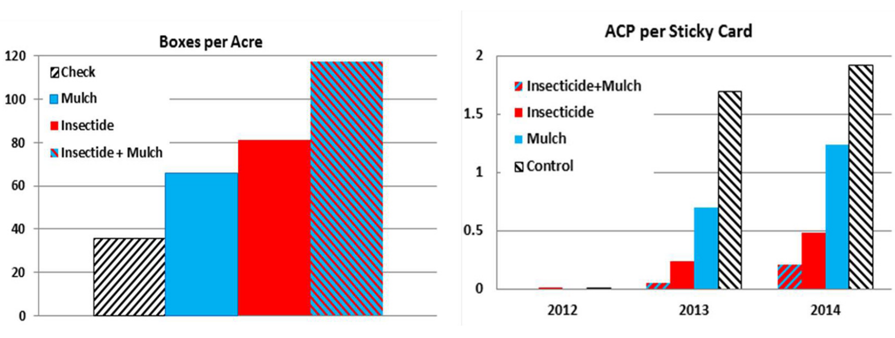

Figure 2. Use of UV-reflective mulch during 2012–2014 reduced ACP populations and improved yields. Psyllid numbers are adult counts on sticky traps. Insecticide alone and insecticide combined with mulch provided significantly more reduction in ACP populations than mulch alone. Use of mulch also resulted in a significant increase in boxes of fruit per acre, which doubled when combined with insecticide treatment.

PEST MONITORING

Regular scouting for pests is important for making need-based decisions regarding applications of insecticides. This is the best way to evaluate the effectiveness of the spray program and to minimize unnecessary investment in control measures as well as collateral damage to beneficial insects and mites. ACP has become the principal target of most spray applications, although management of other pests is still important.

Sticky traps, sweep nets, suction devices and stem-tap sampling are all monitoring options for adult ACP. Stem-tap sampling is easy to conduct compared to other methods and provides instant data for making management decisions. A tap sample is made by holding a white clipboard (8½ x 11 inches) or laminated white sheet of paper horizontally under a randomly chosen branch that is struck three times with a length of PVC pipe. ACP adults are counted as they fall onto the clipboard (see https://edis.ifas.ufl.edu/pdffiles/IN/IN111600.pdf). Pests such as CLM adults, weevils and even spider mites as well as beneficials such as ladybeetles, spiders and lacewings can also be monitored with stem-tap sampling.

Eggs and nymphs of ACP and larvae of CLM must be monitored visually, and are noted as present or absent per flush shoot. A visual count is most useful when accompanied by an estimate of the approximate number of flush shoots per tree.

A good estimate of ACP in large blocks may require at least 100 tap samples, especially if populations are low. Tap samples are taken in groups of 10 — half in the perimeter of the block where psyllids tend to congregate, and half toward the center. Investigations in Florida have shown that spraying mature HLB-infected trees can be justified economically if the average throughout the block reaches one to two adults per 10 tap samples.

CHEMICAL CONTROL

Pesticides are critical components of management programs for ACP and CLM. However, it is important to understand the class of product being used and proper timing of application. Most mature trees are not producing flush required by ACP and CLM for reproduction between November and February. Consequently, these populations are mainly comprised of declining numbers of adults during this period.

Broad-spectrum insecticides like organophosphates (chlorpyrifos, Imidan, dimethoate) and pyrethroids (Mustang, Danitol, Baythroid) are good candidates for use during this time for their effectiveness and low cost. Effective control of ACP adults during this time will suppress their re-establishment until sufficient flush is present in the spring. One application during November–December and a second one before the spring flush in January or early February can be sufficient to significantly reduce populations of ACP and stop them from recolonizing for four to six weeks (or more). A third spray may be needed if temperatures are high and if trees flush during November–December. It is recommended to restrict the use of organophosphates and pyrethroids from November to February to reduce damage to beneficial insects and mites, which are common starting in spring, and also to slow development of insecticide resistance.

Selective products such as horticultural crop oils, soaps and conventional insecticides such as spirotetramat, diflubenzuron, methoxyfenozide (for CLM) and others are less hazardous to beneficial insects and mites and therefore better choices for use during the growing season when natural enemies are normally abundant and contributing to control of multiple pests. Selection of products should be made according to the labels and University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) guidelines, which provide details on product use rates, timing and expected efficacy against multiple pests in order to minimize unnecessary applications (see www.crec.ifas.ufl.edu/extension/pest/PDF/2017/ACP%20and%20Leafminer.pdf).

Pest populations can evolve resistance to insecticides following repeated exposure to the same mode of action (MOA). Resistance has been documented in Florida to several products that are widely used either as sprays or as soil drenches, such as soil-applied systemic neonicotinoids (MOA 4A). Diversifying and strictly rotating MOAs can allow populations of resistant pests to revert back to susceptibility and is very useful for ACP (Figure 1, see page 16). Programs are being expanded for additional area-wide monitoring of ACP resistance to help growers maintain efficacy of available tools.

For CLM, insecticides that kill the larvae are currently the most important tools for control. The early larval stage soon after emergence from the egg is the most susceptible and best target to avoid injury to tender flush. Young trees flush often and are most susceptible to CLM damage. Soil applications of neonicotinoid insecticides can provide multi-week control of CLM in non-bearing trees and should be applied up to two weeks prior to a leaf flush in order to allow lethal concentrations of insecticide to accumulate in the foliage. Again, it is important to remember that all neonicotinoid insecticides share the same MOA, so back-to-back applications of these insecticides may hasten development of insecticide resistance in both pests, which must be avoided.

Insecticides recommended for

CLM control can be found in the UF/IFAS Florida Citrus Pest Management Guide. Applications of foliar insecticides should be made during a window when CLM larvae hatch and begin feeding to maximize larval kill. In general, the earliest applications should occur between 13 and 30 days after budbreak. The goal is to kill larvae as soon as they begin mining.

There are opportunities for combining control of CLM with that of other pests. Many recommended products for CLM control are also effective against ACP, which also develops in young flush. Well-timed summer applications of Agri-Mek or Micromite can also be useful to manage citrus rust mite. Products with the active ingredient cyantraniliprole (Cyazypyr) are highly effective against CLM as well as ACP in soil and foliar applications.

However, any consecutive application of an insecticide employing the same mode of action, whether it is a single or dual mode of action, should be avoided because it increases the probability of insecticide resistance developing in the pests. Intrepid 2F (methoxyfenozide) + 2 percent volume/volume horticultural spray oil (435) is effective against CLM larvae by interfering with the molting hormone. Intrepid can be used alone or tank mixed with another insecticide without selecting for resistance to ACP, upon which it has no effect.

CULTURAL CONTROL

Preventing ACP from colonizing citrus, particularly in non-bearing trees, is paramount to minimize HLB and maximize the chances of trees becoming productive. CUPS offers a possibility of complete protection from ACP and HLB. However, there may be some risk from other pests such as thrips, mites and CLM, which are manageable. Growers have already begun establishing CUPS.

Significant progress has also been made toward reducing psyllid access to young citrus by planting seedlings on beds covered with metalized polyethylene mulch. The mulch should be at least 3 mils thick, with a clear, UV-stabilized coating to protect the reflective surface. It comes in 1,000 x 6-foot rolls that cost a little more than $300 each (Figure 2, see page 16). Drip irrigation is needed to provide water, fertilizer and soil-applied pesticides. The mulch can last for three years or longer if care is taken to avoid spraying products such as oil that attack polyethylene. The resulting decrease in ACP and HLB incidence plus the beneficial effects of the mulch/drip irrigation system have been shown to increase yields from 40 to 90 percent at first (3-year) harvest. Depending on crop value, this yield increase could be sufficient to cover the cost of the mulch.

BIOLOGICAL CONTROL

Biological control contributes to population management of all citrus pests in Florida. Significant investments were made to import and establish species of predators and parasitoids, which not only attack ACP and CLM, but also several other pests of citrus. Effective predators of ACP include lady beetles, lacewings and spiders. Predators and parasitoids (parasitic wasps) are able to access ACP and other pests hidden in citrus flush where access by insecticides is difficult.

Ageniaspis citricola and *Tamarixia radiata* are parasitoids highly specific to CLM and ACP, respectively. Historically, high levels of parasitism (60 to 80 percent) by these species were observed before increased use of insecticides for ACP management over the past several years. Following consistent releases, *T. radiata* has established in greater abundance in organic citrus production systems with parasitism, averaging up to 31 percent. Populations of this parasitoid and associated higher attack rates of ACP occur when fewer conventional insecticide sprays are applied.

Also, fungi such as *Hirsutella*, *Beauveria* and *Paecilomyces* contribute to pest control. These beneficial organisms can be conserved by limiting use of broad-spectrum insecticides to the dormant season. Historically, mortality rates of 90 percent or better for ACP and 70 percent or better for CLM were typical prior to the present-day intensive use of insecticides.

Use of selective insecticides, oils, soaps and releases of parasitoids during the growing season will contribute to development of functioning citrus IPM.

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Studying Soil Microbes and Microbial Amendments

This article addresses the idea that beneficial, naturally occurring soil- and root-based bacteria might aid in the management of HLB. The background for field trials described below is work by Nian Wang of the University of Florida Institute of Food and Agricultural Sciences, funded in part by the Citrus Research and Development Foundation (CRDF).

Wang hypothesizes that bacteria in commercially available microbial soil amendments could act as antimicrobials to control HLB bacteria. In his work, some surviving citrus trees appear relatively healthy, even in heavily HLB-diseased groves. There were only minor differences, however, between soil properties and associated bacteria of surviving and declining trees. Several bacterial isolates increased grapefruit seedling emergence and growth of root systems in pots in the greenhouse. By comparing healthy and HLB-infected root/soil samples, several bacteria types were enriched in the healthy roots.

Effects of application of potentially beneficial bacterial isolates on plant defenses and attractiveness to psyllids have also been tested with little success. Application of a few beneficial bacteria seems to suggest that manipulation of soil microbes had no effect on HLB disease control once the infected trees become severely symptomatic. The beneficial microbes seem to delay, but do not prevent infection when applied on healthy, asymptomatic trees or symptomatic trees at the early stage of infection. This is consistent with the nature of delayed HLB symptom development of HLB escape trees.

After several growers observed tree improvements following soil applications of microbial amendments, CRDF designed field trials at three locations to test the idea that commercially available, soil-applied microbial amendments can mitigate the effects of HLB on citrus tree health and yield. There were five replicated soil-amendment treatments, plus an untreated control applied to Valencia/Swingle trees in a Ridge site with 19-year-old trees, an East Coast site with 6-year-old trees and a Southwest Florida site with 11-year-old trees. Along with good psyllid control and good water/nutrient management, the soil treatments were repeated over three years (2014–2016) at recommended label rates, and a subset of trees within each treatment were also mulched annually with mature cow manure.

Overall, results were disappointing. At the Ridge and East Coast sites after three years of treatments, all treated trees were HLB positive. There were no treatment effects on canopy volume, fruit yield, fruit size or juice quality. Some treated trees even had more visible disease symptoms than the untreated trees. At the Southwest Florida site, most of the treated trees were HLB negative. Here, two of the soil treatments produced larger trees than the untreated trees, but there were no treatment effects on visible symptoms or fruit yield. The mulched treatment increased yield, but there were no significant effects of mulch anywhere else. Overall, there were no persistent treatment effects on root density or on leaf mineral nutrition as all nutrient values were within optimal ranges. Thus, there were no positive effects of these soil microbial amendments on tree health and yield of HLB-affected trees in these trials.

It is likely that these bacterial products did not survive well in the soil and had little effect on the rhizosphere soil bacterial community of citrus. Detailed results from the 3-year study can be found in "Soil Microbial Product Interactions with HLB in Valencia/Swingle Trees over Three Seasons at Three Contrasting Sites in Florida," to be published in the upcoming 2017 Proceedings of the Florida State Horticultural Society.

Prepared by the CRDF project management team

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