Management of Asian citrus psyllid and citrus leafminer

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

The Asian citrus psyllid (ACP) (Figure 1) and citrus leafminer (CLM) (Figure 2) are key insect pests of citrus. Control of ACP is currently of greatest concern in Florida, given its role as a vector of huanglongbing (HLB) or citrus greening, a devastating disease of citrus. However, CLM facilitates spread of citrus canker and causes sufficient leaf damage itself to warrant control in young trees.

Knowledge of the biology and ecology of these and other pests and their interaction with citrus flushing cycles is important for good management. Monitoring of ACP and CLM, biological control, judicious use of insecticides, optimized plant nutrition and removal of infected trees may all contribute to the reduction of these pests and associated diseases. Integrated use of these tactics is important for sustainable pest and disease management. Additional pest and disease problems can result from overuse of insecticides through development of resistance and collateral damage to beneficial insects and mites that help maintain pests below economic injury levels.

CITRUS FLUSH, ACP AND CLM

Citrus flush is the common term used for new foliar growth between budbreak and shoot expansion which remains suitable to ACP and CLM reproduction for about two weeks. Female ACP and CLM need new flush for egg laying and development of immatures. The almond-shaped orange-colored eggs of ACP (Figure 1A) are deposited in the folded leaves of opening buds or shoots. The CLM female lays individual eggs, which resemble tiny dew drops, usually next to the midvein on the underside of an unexpanded leaf. The ACP female may lay up to 800 eggs and the CLM female about 75. Eggs hatch in four to six days for ACP and two to 10 days for CLM, depending upon temperature.

Figure 1. Eggs (A), nymphs with white wax tubes filled with honeydew (B) and adult (C) of Asian citrus psyllid.

ACP nymphs can destroy the terminals on which their colonies develop, but more serious risk is associated with their ability to acquire the HLB bacteria that could later be spread by adults from tree to tree and grove to grove. CLM larvae create mines under the leaf cuticle while feeding, which opens wounds that are susceptible to infection by the citrus canker bacteria. Spread of these diseases in endemic areas is a risk even with 5 percent to 10 percent survival of these pests, which is not uncommon despite various measures of control.

MONITORING ACP AND CLM

Adult ACP and CLM can be monitored as an aid to timing insecticide applications and evaluating effectiveness.

The stem tap is a common method to monitor ACP due to its ease and rapidity. However, yellow sticky traps and sweep nets are also used. For research purposes, devices that serve as large-scale modified vacuums have also been employed in Florida citrus.

All that is necessary to conduct a tap sample is a laminated sheet of letter-size paper or a smooth white surface such as a clipboard, and a stick or length of PVC pipe (Figure 3, page 13). The sheet or board is placed about 1 foot below a leafy branch, which is then struck three times. The number of psyllids falling onto the sheet are counted and recorded. The slippery sheet surface impedes the psyllids from taking flight, but some

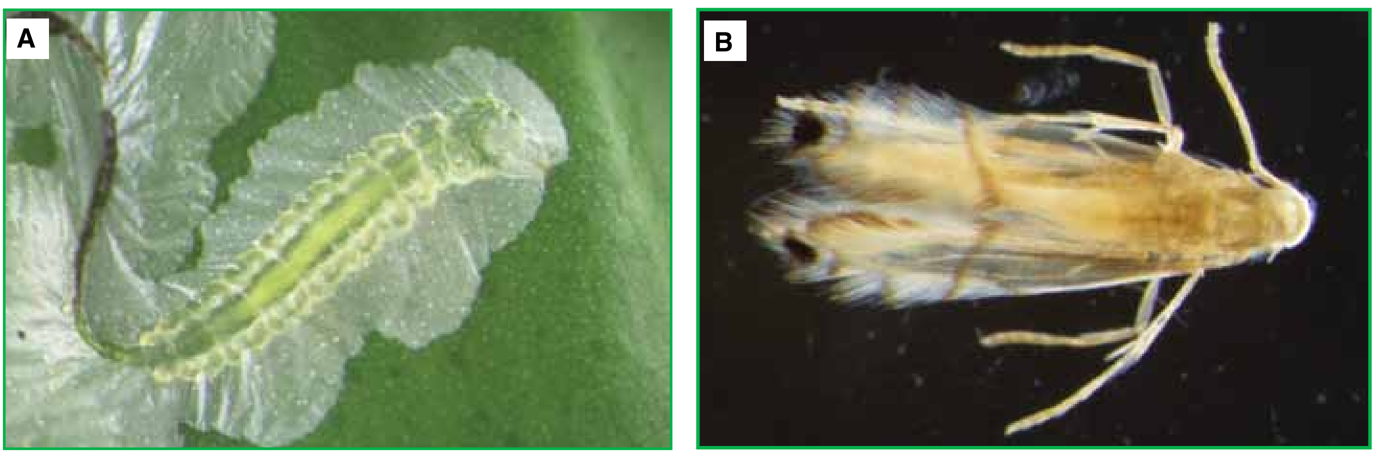

Figure 2. Larva with mine (A) and adult (B) of citrus leafminer.

Figure 3. Demonstration of stem tap method and resulting adults of Asian citrus psyllid.

may fly off before they can be counted if numbers are sufficiently high. Such situations would warrant treatment. Ten tap samples conducted at each of the 10 locations in a block — five around the borders where psyllids tend to congregate and five in the interior — can generate enough information to decide whether to treat or not. Unfortunately, there is no set threshold for ACP, given its role as a vector of a pathogen that can wreak havoc on fruit production and tree health. A single infected psyllid could initiate an infection, the gravity of which increases in the tree as it continues to be inoculated by more ACP. Therefore, detection of 10 adults in 100 tap samples (average of 0.1 adults per tap sample) warrants treatment where HLB incidence is already high.

Beneficial insects such as ladybeetles, spiders and lacewings can also be counted using the stem tap, as can other pests such as weevils and leafminer adults. However, CLM adults are very active, small silvery white moths (Figure 2B) that may be difficult to spot against a white background. They are most active at night and best monitored using traps baited with commercially available lures which contain a female sex pheromone that specifically attracts males. These traps may not only provide information regarding the population of CLM within groves, but they are also a possible method for evaluating the effectiveness of a treatment.

A simple method for monitoring CLM is to hang traps in the outside canopy at "truck window" height and monitor weekly. Most, if not all, insects captured will be male CLM, so identification is easy. There is currently no set "standard" for trap density, although one per 5 grove acres has proven adequate for monitoring CLM. Even a few traps can provide valuable information on effectiveness of insecticides and especially suppression by mating disruption pheromone treatments (described below). Placing pheromone traps for CLM on block borders will likely yield the most catches because these insects occur on border rows, as do most pests of tree fruit crops; however, interior traps would also help

evaluate a management program.

Examination of new growth or flush is very important to monitor the immature stages of both species for management decisions. Psyllid nymphs are orange in color and secrete a white wax tube filled with honeydew from the anus (Figure 1B), whereas CLM larvae are translucent light to yellow-green in color (Figure 2A) and can also be identified by the mines they create while feeding within leaf tissue. A hand lens is useful to identify eggs and young instars of both species. Older instars, as well as wax from ACP or leaf mines from CLM, are easily visible without magnification and indicate that some damage has already occurred.

It is also important to note that this new growth is also colonized by beneficial insects and mites which attack several pests and therefore warrant protection. Also, honeybees and other pollinators are attracted to bloom that accompanies much of the spring flush during which time most insecticides cannot be sprayed. Therefore, always follow the product label.

BIOLOGICAL CONTROL

ACP and CLM populations can be reduced by 90 percent or more by predation from naturally occurring biological control agents in Florida. This is in large part the action of predators, such as ladybeetles, spiders and lacewings that feed on ACP, and ants, lacewings and spiders that feed on CLM. Species specific parasitoids have also been released against both pests to enhance mortality.

Tamarixia radiata is a parasitoid of ACP nymphs that was originally imported from Taiwan and Vietnam and established in Florida. Populations in Florida are currently being augmented by mass release of wasps originating from Pakistan, China and Vietnam. More than 2 million have been released in Florida citrus through the University of Florida-Southwest Florida Research and Education Center and the Florida Division of Plant Industry. Future mass releases are planned with the new production facility of this beneficial insect in Dundee. Parasitism rates have increased from 20 percent to 60 percent to 80 percent in some locations in response to these releases.

Unfortunately, the current increased use of insecticides has somewhat curtailed the effectiveness of biological control. Such negative effects can be reduced by limiting broad-spectrum insecticides to the dormant season and using more selective chemistries at other times as detailed below.

For CLM, *Ageniaspis citricola*, introduced from Australia, is also established in Florida. This natural enemy of CLM is a parasitic wasp that attacks immature stages of CLM. A parasitism rate of 86 percent was observed in 1995, but has decreased over time with increased use of insecticides to combat ACP. Several other species of native parasitoids of CLM are also common and contribute to mortality of this pest. In addition, similar biological control reduces populations of other potential citrus pests such as aphids, scales, mealybugs and whiteflies that often occur below economic thresholds.

Considering the important role of biological control against multiple pests, judicious use of insecticides is still something to consider, even during the era of HLB in Florida citrus. Monitoring of pest populations to determine the need for insecticide use is one method of potentially reducing impact of sprays on biological control.

INSECTICIDES AND TIMING OF APPLICATION

Insecticides are an important management tool to reduce the incidence of both ACP and CLM and associated diseases.

Soil-applied systemic applications: Risk of infestation and infection is greater in young trees, which produce more frequent flush compared to mature trees. Also, mature trees typically produce major flushes during spring, followed by sporadic flushes during summer and fall, while young trees may flush more often throughout the season. Therefore, more consistent and longer lasting protection from both ACP and CLM is needed in young trees for optimal growth and disease protection. Insecticides recommended against these two pests and others are listed in Table 1. More details are available through product labels and the 2014 Florida Citrus Pest Management Guide.

Research has shown that best protection is possible with systemic insecticides applied to the soil with likely less risk to beneficial insects because of reduced potential for direct contact as compared with foliar sprays. Three neonicotinoid insecticides — imidacloprid, thiamethoxam and clothianidin — are available and recommended for such applications. They should provide at least eight weeks of significant pest reduction on young trees if applied correctly and the grove is not inundated by rain soon afterward. However, all share the same 4A mode of action (MoA) (http://www.irac-online.org/documents/moa-classification/?ext=pdf) and therefore could previously only be rotated with sprays of other chemistries to slow selection for insecticide resistance.

A new insecticide, cyantraniliprole, with MoA 28, has been shown to provide significant reduction of ACP, as well as CLM. It will soon be available for soil application to rotate with neonicotinoid insecticides. Federal registration and conditional Florida registration for the cyantraniliprole-based products called Verimark™ and Exirel™ (intended for soil and foliar applications, respectively) has been approved. Soil applications of neonicotinoids and Verimark™ should be made about two weeks prior to appearance of new flush to allow time for the toxin to be absorbed by the roots and translocated to the canopy to impact the immatures as they start to develop on new growth, as well as feeding adults. Soil applications should be made at least 24 hours prior to significant rain events to avoid leaching of the product from the root zone, so foliar sprays of other chemistries may be preferred during the rainy season.

Foliar sprays: Timing to apply insecticidal sprays is also very critical to optimize control of both ACP and CLM and to reduce insecticide use and cost of control. Both ACP and CLM may be suppressed during the growing season from the action of insecticides and biological control. Populations of these pests may diminish further during winter due to lack of flush for reproduction. Overwintering ACP adults must survive on mature leaves or non-host plants until spring flush and therefore constitute the weakest link in this pest's biology.

Broad-spectrum insecticides (organophosphates and pyrethroids) are commonly applied during winter as "dormant sprays" to target adults and reduce their impact during the growing season when they begin to reproduce on young shoots and rapidly increase in number. Results of original research and statewide coordinated sprays through the Citrus Health Management Areas program (www.flchma.org) show that two dormant sprays reduce the need for sprays during bloom when pollinators and several other beneficial insects are common and very few insecticides are permitted.

There are enough insecticides effective against ACP currently available that it is possible to rotate the MoA at least eight times per year (Table 1). Cyantraniliprole, described above, and tolfenpyrad MoA 4A (Apta 15 SC) from Nichino America Inc. already have federal registrations approved and should be available soon. Flupyradifurone (Sivanto™ 200 SL) from Bayer CropScience also is in the process of registration and has shown promising results against ACP, especially as foliar sprays.

Monitoring for the presence of ACP and CLM may be quite helpful as adults are therefore targeted prior to anticipated new flush growth. This reduces their reproductive potential and may help reduce the number of sprays needed per season. It is also difficult to achieve maximum suppression of immature stages of ACP with contact insecticides due to the protection afforded to eggs or neonates by the folded leaves where most are deposited or emerge. CLM populations also build up in spring, although they appear later within leaves as compared to ACP.

Fewer products are recommended against CLM than ACP, and all target larvae in the mines (Table 1). Timing is important because flush expansion takes only about two weeks, after which many leafminers will have already emerged as mobile adults from their pupae and therefore not be susceptible to sprays. Effective products include neonicotinoids and cyantraniliprole (Verimark™) for young trees as soil drenches, and methoxyfenozide (Intrepid 2F), spinetoram (Delegate WG), abamectin, Altacor (chlorantraniliprole) and, when permitted, cyantraniliprole (Exirel™) for sprays. Premixes Agriflex and Voliam Flexi also provide good control of both ACP and CLM; however use of a dual MoA product needs to be considered when planning effective insecticide rotation.

Mating disruption is another promising technique which utilizes release of large quantities of a synthetic blend of female sex pheromone to impede males from finding females. This either renders females unmated or delays their mating, causing a significant reduction in fecundity. When successful, populations of CLM are suppressed before eggs are laid and therefore before leaves are damaged. More success has been observed with mating disruption of CLM in mature trees than in new plantings where air drainage is more rapid. This work is in progress and large-scale successful demonstrations show promise.

Jawwad A. Qureshi (jawwadq@ufl.edu) is research associate professor of entomology and Philip A. Stansly is professor of entomology, both with the University of Florida-IFAS at the Southwest Florida Research and Education Center at Immokalee. Lukasz L. Stelinski is associate professor of entomology, also with the University of Florida-IFAS, at the Citrus Research and Education Center at Lake Alfred.

Table 1. Insecticides for control of primary insects pests and other pests in citrus

Active ingredient	Product trade name	IRAC MOA*	Application method	Recommended primary pest target	Other pest targets
Abamectin	Agri-Mek 0.15SEC Agri-Mek SC	6	Spray	Citrus leafminer (CLM)	Citrus rust mite, Asian citrus psyllid (ACP)
Chlorpyrifos	Lorsban 4E	1B	Spray	ACP	Mealybug, orangedog, katydids, grasshoppers, aphids, thrips
Clothianidin	Belay 50WDG	4A	Soil drench	ACP, CLM	Aphids, some scales
Diflubenzuron	Micromite 80 WGS	15	Spray	ACP, CLM	Citrus root weevils, citrus rust mites
Dimethoate	Dimethoate 4E	1B	Spray	ACP	Aphids, some scales, flower thrips
Fenpropathrin	Danitol 2.4EC	3	Spray	ACP	Flower and orchid thrips, adult root weevils
Fenpyroximate	Portal	21A	Spray	ACP	Spider mites, rust mites
Imidacloprid	Admire Pro 4.6F Admire 2F Alias 2F Couraze 2F Nuprid 2F	4A	Soil drench	ACP, CLM	Aphids, some scales
Imidacloprid	Admire Pro 4.6F Couraze 1.6F Nuprid 1.6F Pasada 1.6F	4A	Spray	ACP	Aphids
Methoxyfenozide	Intrepid 2F	18	Spray	CLM	Orangedog
Phosmet	Imidan 70W	1B	Spray	ACP	Citrus root weevils
Spinetoram	Delegate WG	5	Spray	ACP, CLM	
Spinosad	SpinTor 2 SC	5	Spray	CLM	Orangedog, thrips
Spirotetramat	Movento 240 SC Movento MPC	23	Spray	ACP	Citrus rust mite, mealybugs, some scales
Sulfoxaflor	Closer SC	4C	Spray	ACP	Aphids, mealybugs
Thiamethoxam	Platinum 75 SG	4A	Soil drench	ACP, CLM	Aphids
Thiamethoxam	Actara 25 WG	4A	Spray	ACP	Aphids, CLM, weevils
Thiamethoxam + Abamectin	Agri-Flex	4A 6	Spray	ACP, CLM	Aphids, citrus rust mites
Thiamethoxam + Chlorantraniliprole	VoliamFlexi	4A 28	Spray	ACP, CLM	Aphids
Zeta-cypermethrin	Mustang	3	Spray	ACP	Citrus root weevils

**Insecticide Resistance Action Committee Mode of Action*