Controlling ACP and other pests as critical as ever

By Jawwad A. Qureshi and Philip A. Stansly

More than a decade has passed since 2006, when huanglongbing (HLB) or citrus greening disease was identified in Florida. By then, the disease had already spread widely and went unrecognized due to high psyllid populations and a disease incubation period of months or years between infection and symptom expression. Nevertheless, management of the Asian citrus psyllid (ACP) vector is still critical to reduce disease severity in infected trees and spread into new plantings.

Research-based tactics for individual and area-wide ACP control have greatly reduced psyllid populations, helping mature citrus to maintain production and new plantings to survive and produce in spite of HLB. Tolerant or resistant plants and bactericides may reduce, but probably never eliminate, the need for ACP control. Nevertheless, challenges remain due to the rapidity of vector reproduction, dispersal and disease transmission. Therefore, management of ACP in all habitats including organic and conventional citrus, urban areas and abandoned citrus is critical for area-wide reduction of this vector-disease complex and for sustainable citrus production.

YOUNG CITRUS

ACP requires newly developing buds and young shoots of citrus to develop and reproduce. Young trees flush more frequently compared with mature trees and therefore face a greater risk of infestation by ACP and HLB infection. Consistent and longer-lasting protection from ACP provided by soil-applied, systemic insecticides interspersed with sprays of different chemistry is necessary. The systemic neonicotinoid insecticides, imidacloprid, thiamethoxam and clothianidin, may provide up to six to eight weeks of protection, but even this is not sufficient because of label restrictions that limit the amount of these products that can be used.

Furthermore, these insecticides all have the same 4A mode of action (MoA), so rotation is needed to delay resistance. Cyantraniliprole (Verimark®), a new insecticide with a different MoA (28), would be another systemic option if it were not so expensive. Foliar sprays of different MoAs are needed.

Planting on reflective mulch provides additional protection to young trees by further reducing ACP colonization and therefore HLB pressure. It is an effective tool to augment current control measures for young trees based primarily on insecticides.

MATURE CITRUS

Dormant/Winter Sprays: ACP reproduction is rapid. Up to 700 to 800 eggs per female are possible under favorable conditions in spring and summer when temperatures are optimal and flush is abundant. Emigration of infected ACP at the end of spring flush is the main event in the annual movement of HLB. Much of this movement can be preempted by controlling ACP in winter, when populations are down due to lower temperatures and lack of flush needed for reproduction. This weak link in the ACP life cycle is best exploited with sprays of organophosphate and/or pyrethroid insecticides prior to spring flush.

In the interest of resistance management and conservation of beneficials, these insecticides are not recommended during the rest of the year (except for border sprays). Area-wide dormant sprays with these products reduced ACP populations 15-fold in spring compared with an untreated grove. Natural enemies such as ladybeetles and lacewings, which contribute to control of ACP and other pests such as citrus leafminers, aphids and mites, are relatively unaffected by these dormant sprays.

We are testing conventional and organic programs for ACP management to expand options for all growers. Three separate organic programs

Figure 1. Durand Wayland AF100-32 air blast speed sprayer

Figure 2. Proptec rotary atomizer sprayer for low-volume application

Photos by J. Qureshi

— rotations of organic insecticides applied alone, with horticultural mineral oil or with insecticidal soap — are being compared with a standard conventional program for ACP control and conservation of beneficials in a block of Valencia and Hamlin oranges. Dormant sprays of the natural pyrethrum PyGanic EC 5.0 alone (17 oz./acre) or with 435 oil (2% v/v) or M-Pede (2% v/v) applied in November, December and January, and Danitol 2.4 EC applied at 16 oz./acre in January all significantly reduced ACP through March. By then, adults started to escalate above a provisional growing season threshold of 0.1 per tap sample. Danitol provided more ACP reduction than PyGanic, especially when applied both in November and in January.

Thus, two dormant sprays were better than one. PyGanic with M-Pede or 435 oil performed better than PyGanic alone. There is no threshold for dormant sprays, which are critical for year-round ACP control.

The last two winters were warm with some rain events, which resulted in unexpected flush and greater than normal populations of ACP. It may be necessary to add another dormant spray under such conditions.

Growing Season Management of ACP: Factors to consider for control of ACP during the growing season include abundance of nymphs or adults, other pests which also need to be controlled, cost, and effects on beneficials. Just seeing one or two adults per 50 taps or single infested flush may not be sufficient to justify spraying an entire block. Thresholds based on annual accumulation of ACP in mature blocks with high HLB incidence have been developed (see Citrus Industry magazine, February 2015). Flush protection is critical because when an infected female has access to a new bud or shoot, it not only lays eggs, but injects the pathogen into those soft tissues, thus spreading the infection to the tree, its progeny and other colonizing adults.

We have been using a provisional 0.1 adults per tap sample threshold

CRDF Planning Directions and Processes

By Harold Browning

As we move through the current production and harvest season, the Citrus Research and Development Foundation (CRDF) has been initiating plans and activities to continue delivering HLB solutions in 2017. This article summarizes some of the directions that CRDF is taking.

- CRDF is implementing results of strategic planning concluded in 2016. Initiative 1 is short-term solutions (less than 3 years to grower delivery). Initiative 2 is medium/long-term solutions requiring more than 3 years. Subcommittees of the Executive Committee are evaluating these two initiatives, and discussions will occur at 2017 committee and board meetings to make these the highest priorities for CRDF investment.
- CRDF initiated in-house review of all active and recently ending projects to determine progress and value to continue. Each year, CRDF conducts this portfolio review, beginning with project managers and the Scientific Advisory Board. Reviews and recommendations from these first steps are provided to the Research Management Committee and the Commercial Product Delivery Committee (CPDC). The board ultimately determines the final recommendations to invite new or revised proposals for CRDF review. An additional outcome of the portfolio review is to identify research results to advance to the field through the CPDC.
- At its December board meeting, CRDF approved a project for an independent, comprehensive review of HLB research conducted over the recent decade in Florida, but also to include research sponsored by other institutions and funding programs. This 1-year evaluation will provide further direction for the topics that most likely will lead to HLB solutions, and recommend specific priorities to accomplish delivery of solutions to growers. Publication of the full report of this comprehensive review is slated for early 2018.
- CRDF has intensified oversight of research and delivery topics, reducing the breadth of individual projects being funded and encouraging more team efforts toward field evaluation. A significant component of current CRDF activity is the conduct of field trials and grower evaluations to advance early results. Project managers will report regularly in 2017 on progress in these priority areas.
- Finally, CRDF continues to coordinate with the California Citrus Research Board, the U.S. Department of Agriculture's (USDA) National Institute of Food and Agriculture Specialty Crop Research Initiative, Citrus Disease Research and Extension Program and the USDA's Animal and Plant Health Inspection Service HLB Multi-Agency Coordination Group. Where different groups are working independently, teams can be encouraged to rapidly bring forth best options for management of citrus in the presence of HLB.

Please visit citrusrdf.org to follow CRDF activities and programs.

Harold Browning is Chief Operations Officer of CRDF. The foundation is charged with funding citrus research and getting the results of that research to use in the grove.

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for the three organic programs and one conventional program described above. Organic insecticides rotated with M-Pede or 435 oil used 50 percent less insecticide while providing better control than organic insecticides alone. Reduction of ACP was still greater with the conventional program, but not always significantly so, compared with programs using organic insecticides with M-Pede or 435 oil.

We have been testing these spray applications mostly at 100 gallons per acre using a Durand Wayland AF100-32 air blast speed sprayer, and sometimes at 10 gallons per acre using a Proptec rotary atomizer sprayer, and have seen good results with both (see figures 1 and 2, page 16). Best yields were obtained using organic insecticides with 435 oil or conventional insecticides and did not differ between the two programs (see Figure 3, page 19). Yield did not improve with organic

Table 1: Time of the year and potential choices of insecticides for sprays using rotation of single MoA to control Asian citrus psyllid (ACP) and other pests of citrus.

Month	Season/ Tree Stage	Active Ingredient	IRAC MOA[a]	Product Trade Name[b]	Pest Targets and Product Efficacy (+++ high, ++ medium, + low)
Nov-Dec	Dormant	Organophosphates	1B		
		Phosmet		Imidan	ACP^{+++}, root weevils^{+}, rustmites^{+}
		Dimethoate		Dimethoate	ACP^{+++}, scales^{+}, mealybugs^{+}
		Chlorpyrifos		Lorsban	ACP^{+++}, scales^{+}, mealybugs^{+++} root weevils^{+}, rustmites^{+}, leafminers^{+}
Jan	Dormant	Pyrethroids	3		
		Fenpropathrin		Danitol	ACP^{+++}, root weevils^{+}, rustmites^{+}, spidermites^{+}, mealybugs^{+}
		Zeta-cypermethrin		Mustang	ACP^{++}, root weevils^{+}
		Beta-cyfluthrin		Baythroid	ACP^{+++}
Feb-Mar	Growing: Bloom	Fenpyroximate	21A	Portal[c]	ACP^{++}, rustmites^{++}, spidermites^{++}
		Diflubenzuron	15	Micromite[c]	ACP^{++}, leafminers^{++}, rustmites^{+++}, root weevils^{++}
		Flupyradifurone	4D	Sivanto[c]	ACP^{+++}, aphids^{+++}, mealybugs^{++}, leafminers^{+}
		Spirotetramat	23	Movento[c]	Leafminers^{+++}, orange dog^{+++}
		Methoxyfenozide	18	Intrepid	
	Post-Bloom	Cyantraniliprole	28	Exirel	ACP^{+++}, leafminers^{+++}, root weevils^{+}
Apr		Mineral oil	Unknown	435 Oil	ACP^{+}, rustmites^{+}, spidermites^{+}, leafminers^{+}, scales^{+}, mealybugs^{+}
		Fenpyroximate	21A	Portal[c]	ACP^{++}, rustmites^{++}, spidermites^{++}
		Diflubenzuron	15	Micromite[c]	ACP^{++}, leafminers^{++}, rustmites^{+++}, root weevils^{++}
		Cyantraniliprole	28	Exirel	ACP^{+++}, leafminers^{+++}, root weevils^{+}
		Tolfenpyrad	21A	Apta	ACP^{+++}, rustmites^{++}, spidermites^{++}, mealybugs^{+}, scales^{+}, root weevils^{+}
		Flupyradifurone	4D	Sivanto[c]	ACP^{+++}, aphids^{+++}, mealybugs^{++}, leafminers^{+}
May-June		Spirotetramat	23	Movento[c]	ACP^{+++}, rustmites^{++}, scales^{+++}
		Abamectin	6	Agri-Mek	ACP^{++}, leafminers^{+++}, rustmites^{+++}, spidermites^{+}
		Cyantraniliprole	28	Exirel	ACP^{+++}, leafminers^{+++}, root weevils^{+}
		Tolfenpyrad	21A	Apta	ACP^{+++}, rustmites^{++}, spidermites^{++}, mealybugs^{+}, scales^{+}, root weevils^{+}
		Flupyradifurone	4D	Sivanto[c]	ACP^{+++}, aphids^{+++}, mealybugs^{++}, leafminers^{+}
		Spinetoram	5	Delegate	ACP^{+++}, leafminers^{+++}
		Pyriproxyfen	7C	Knack	Scales^{+++}
July-Aug		Mineral oil	Unknown	435 Oil	ACP^{++}, rustmites^{+}, spidermites^{+}, leafminers^{+}, scales^{+}, mealybugs^{+}
		Tolfenpyrad	21A	Apta	ACP^{+++}, rustmites^{++}, spidermites^{++}, mealybugs^{+}, scales^{+}, root weevils^{+}
		Flupyradifurone	4D	Sivanto[c]	ACP^{+++}, aphids^{+++}, mealybugs^{++}, leafminers^{+}
		Organophosphates	1B	Multiple brands	ACP^{+++}, rustmites^{+}, spidermites^{+}, mealybugs^{+}, scales^{+}, root weevils^{+}
Sept-Oct		Spinetoram	5	Delegate	ACP^{+++}, leafminers^{+++}
		Spirotetramat	23	Movento[c]	ACP^{+++}, rustmites^{++}, scales^{+++}
		Tolfenpyrad	21A	Apta	ACP^{+++}, rustmites^{++}, spidermites^{++}, mealybugs^{+}, scales^{+}, root weevils^{+}
		Flupyradifurone	4D	Sivanto[c]	ACP^{+++}, aphids^{+++}, mealybugs^{++}, leafminers^{+}

[a] Mode of action (MoA) class of the active ingredient according to the Insecticide Resistance Action Committee (IRAC)

[b] Check product label for rates, restrictions and recommended use in citrus. Some products appear multiple times in the table due to their role in controlling different pests but not to repeat a particular MoA. Neonicotinoids and premixes not included due to resistance concerns. Neonicotinoid use is best reserved for soil drenches on young trees. Premixes expose pests to more than one MoA.

[c] Allowed for use on blooming citrus

insecticides alone compared to the untreated check, and was significantly less than the check with organic insecticides plus M-Pede, possibly due to a spray on bloom.

The relative effectiveness of conventional insecticides for control of ACP and other pests is listed in Table 1 (page 18). Smart choices which target multiple pests that may be present in significant numbers with one spray of single MoA will reduce unnecessary sprays and attendant costs.

More research and funding is still warranted to investigate the sustainability of these organic programs, their role in managing other pests and integrated use of organic and conventional insecticides.

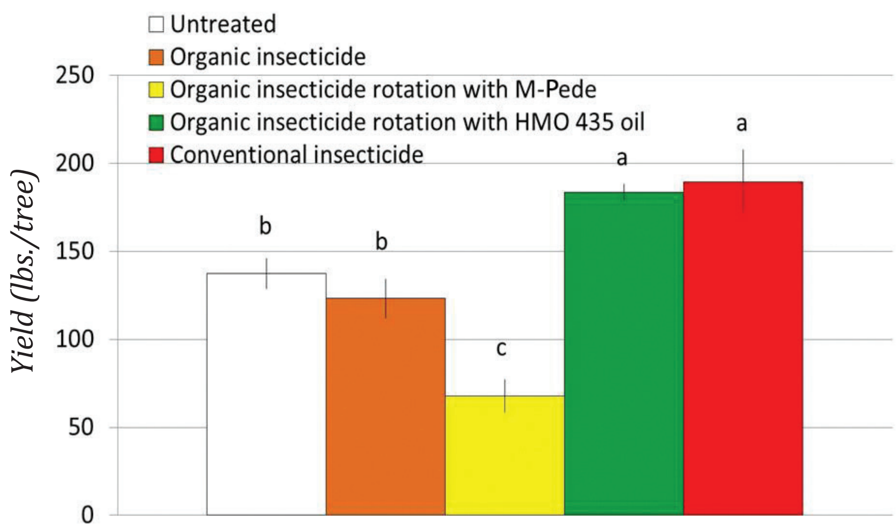

Figure 3. Valencia yield (lbs./tree) in organic and conventional programs, 2016.

BIOLOGICAL CONTROL

Natural enemies including predators, parasitoids, certain fungi and even nematodes play an important role in controlling pests of citrus. Many beneficial insects are rare in citrus groves during winter due to the lack of prey, but increase in spring coincident with new growth and may persist during the growing season.

ACP, citrus leafminers, aphids, weevils and mites colonize flush, as do their natural enemies such as ladybeetles, lacewings, spiders, minute pirate bug, predaceous mites and parasitic wasps, with the potential of keeping these pests under control. Sprays targeted at flush negatively impact beneficial insects, reducing natural control for many pests and often leading to secondary pest outbreaks. Citrus leafminers, aphids and root weevils are associated with canker, tristeza and root rot, respectively. So these diseases increase with increased pest pressure.

We saw that lacewings, spiders and ladybeetles all increased where organic insecticides were used, which may have contributed to ACP reduction. Green lacewings were the most abundant predator and are mobile enough to move in quickly from the surrounding habitats. Ladybeetles, which were formally abundant in our groves, are now rarely seen, presumably due to frequent use of broad-spectrum insecticides. Likewise, the parasitoid *Tamarixia radiata* was released in all plots in the above experiments, but mostly recovered from ACP nymphs in plots sprayed with organic insecticides. Thus, the best time to release Tamarixia would be in the spring flush after dormant sprays.

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