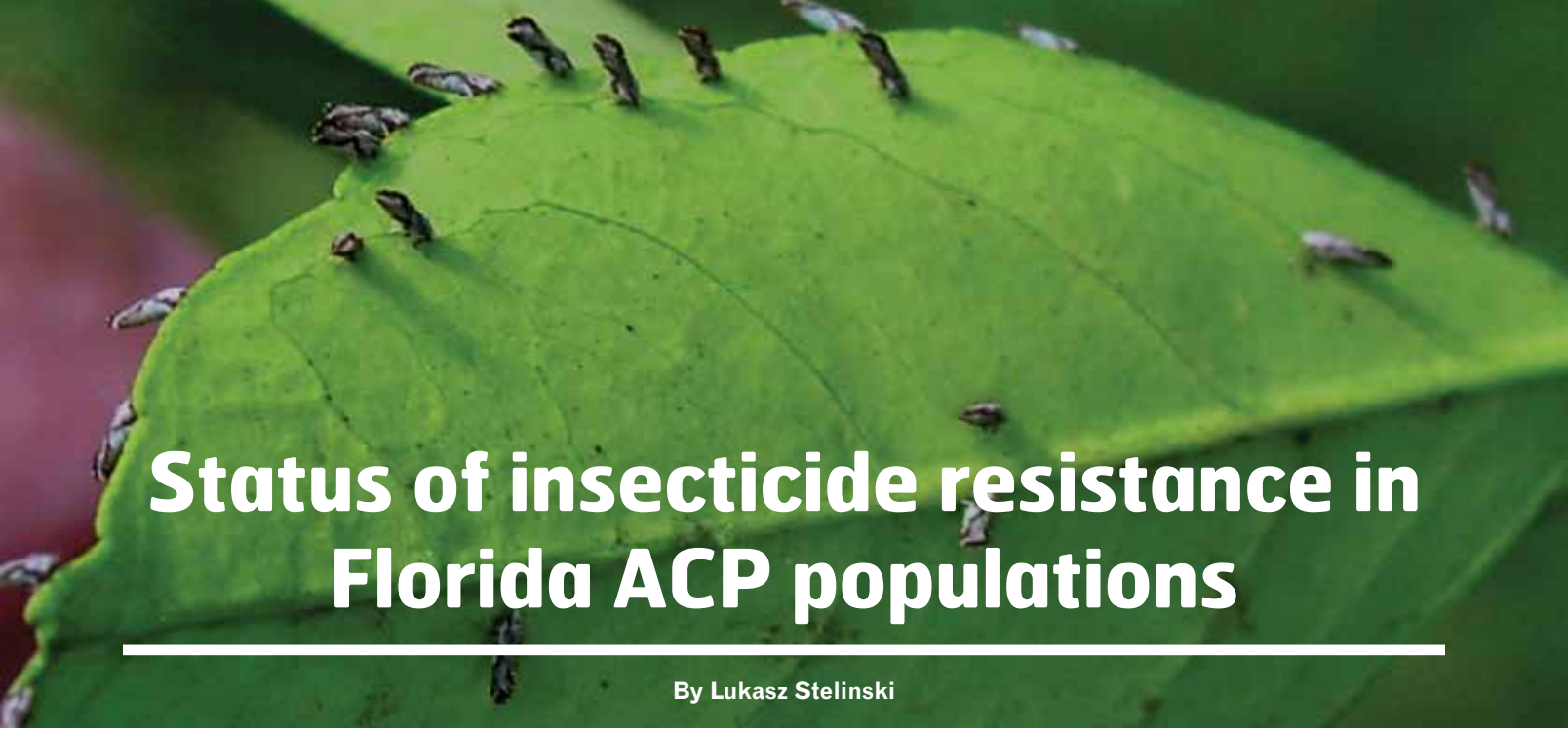

Status of insecticide resistance in Florida ACP populations

By Lukasz Stelinski

The Asian citrus pysllid (ACP) is a well-honed, pathogen-spreading machine. It is able to acquire and transmit the Liberibacter pathogen that causes greening fairly rapidly, given its relatively short lifespan. It is debatable whether ACP populations ever existed in Florida that did not harbor the pathogen causing citrus greening at some level. In Florida, the infection rate of ACP currently ranges between 38 percent and 100 percent.

As our detection methods for the pathogen have improved, it has become more difficult to find populations that are truly 100-percent uninfected. ACPs can occur in extremely large populations, if left unmanaged with insecticides. The pest can exhibit significant long-range dispersal, up to approximately a mile and a half without wind assistance. ACPs move long distances in search of new leaf flush by their own capabilities, if they need to. They even transmit the pathogen between each other at low frequencies during mating and from mother to offspring. Therefore, greening spreads rapidly within and between groves.

ACP females lay eggs only on new flush, and hatched nymphs feed on new flush and go through five immature life stages before becoming adults. This results in very high buildup of ACP populations during flushing periods that are capable of acquiring and transmitting HLB-causing bacteria. Management of all of these ACP life stages is currently necessary year-round.

MANAGEMENT TOOLS

In perennially growing citrus in sub-tropical climates, multigenerational and season-long occurrence of ACP is common. Therefore it is important to manage newly planted trees with soil-applied neonicotinoids and to rotate those applications with foliar sprays of a different mode of action (MOA) in order to bring young trees into production. Soil- and foliar-applied insecticides play a vital role in suppressing ACP populations that are infected or capable of acquiring and transmitting HLB bacteria.

Initially in Florida, the systemic insecticide aldicarb was utilized for ACP management; however, this product is no longer registered for use in Florida citrus. Therefore, there are currently only two modes of action, neonicotinoids (group 4) and cyantraniliprole (group 28), available as soil-applied, systemic

Adult Asian citrus psyllids congregating on the underside of a mature leaf.

treatments for management of ACP. The neonicotinoids have been a particularly critical tool for young tree protection and are the most important insecticides for protecting newly planted groves or young tree resets. Sivanto (Group 4D, Bayer CropScience) and Closer (Group 4C, Dow AgroSciences) are additional new products with chemistries that differ from the neonicotinoids, but have similar target-site activity. These may be additional useful tools for ACP management. As of yet, there is no published evidence of cross resistance of these two new products with the conventional neonicotinoids.

As new tools become registered, they must be managed wisely. In some cases, it can take decades to get new molecules identified and registered for pest management within crops. We are fortunate that new chemistries are being delivered by the agro-chemical industry. The purpose of our work, in part, is to ensure that these new tools remain effective for the long term. Our research has also allowed us to develop baseline toxicity values for existing and new insecticides, so that we can monitor their effectiveness over time.

Asian citrus psyllid nymphs feed on new flush and go through five immature life stages before becoming adults.

APPLICATION METHODS

After trees come into production, foliar applications of insecticides are implemented. Conventional spray application methods of high-volume airblast sprays of >100 gallons per acre are often insufficient to manage the need for six to eight applications that target ACP alone. Control of ACP to suppress HLB incidence may cost growers approximately $1,000 or more additionally per acre annually as compared with times prior to citrus greening in Florida.

Given the extra expense, both in money and time, other spray-delivery methods for these additional ACP applications have been tried, including low-volume "misting" based on cold fogging technology. In cases where rows are not skipped and coverage is adequate, misting technologies can knock down ACP during their application; however, the residual activity is typically no more than a day. These low-volume sprays should be considered supplemental applications and do not replace standard high-volume airblast applications.

Supplemental border row spraying (to complement, but not replace, standard full-grove management) has also been implemented by some growers, and can serve as an additional tool for managing ACP since these insects tend to accumulate on borders. However, ACP remains established in Florida, and there is a continued need to suppress populations of these vectors to maintain economical citrus production.

This may become even more important as new tolerant rootstocks or trees are being developed. Despite possible tolerance to HLB, vector control will likely remain important for these trees to enter full production. Unless a 100-percent resistant tree is developed, vector control will probably be necessary at some level in the future. Therefore, maintaining the effectiveness of insecticides by preventing resistance development is essential.

RESISTANCE EVALUATION

We have evaluated insecticide resistance in field populations of ACP for approximately the past seven years. This has allowed us to determine the fluctuation of resistance in Florida ACP populations, develop and recommend appropriate rotation schedules, and determine the specific mechanisms mediating resistance in ACP populations. We have already documented reduced susceptibility in regional Florida ACP populations, where prescribed MOAs sometimes are applied up to 12 times per year to suppress reinfection of trees.

By 2011, there was a measurable reduction of insecticide susceptibility among all ACP populations that we examined across the state of Florida. Also, there was a trend for increased resistance from 2009 to 2012. The highest levels of decreased susceptibility found in the field and laboratory in Florida ACP varied between 35 to 100 fold. However, at no point was this reduction of susceptibility sufficiently high so as to result in product failure in commercial groves. We estimate that approximately a 100-fold reduction in susceptibility may be associated with product failure based on our research in non-commercial citrus and the laboratory.

RAPID REACTION

We react to grower concerns about a product failure as quickly as we can. In the event that a grower contacts us to report a possible control failure, we do our best to react rapidly to test that population of ACP for possible resistance. This allows us to understand whether a product failure is due to resistance or other possible factors. Thus far, we have not observed a case where a product failure in a commercial grove has been unequivocally correlated with a case of resistance. However, this does not rule out the possibility that pockets of significantly resistant ACP populations do exist in Florida.

An investigation from Mexico around our 2011 survey showed that ACP had become 100-fold and 4,000-fold resistant to organophosphates and neonicotinoids, respectively, in Mexican lime. Moreover, this investigation showed that ACP had developed some level of resistance to every MOA that these investigators tested. The example from Mexico should not be ignored and illustrates how resistance management is critically important for ACP. Our goal is to prevent this from happening in Florida by proactively monitoring resistance within citrus health management areas (CHMAs) and prescribing appropriate management protocols as they become necessary.

IMPROVED RESISTANCE; VIGILANCE STILL NEEDED

Over the course of our resistance surveys conducted from 2008 to 2011, a steady increase in insecticide resistance was observed in ACP populations in Florida. However, the good news is that it appears to have decreased in a relatively short period of time, starting in 2013. This suggests that susceptibility

to insecticides among populations of ACP can change in a short period of time, and that regular monitoring is useful for understanding these trends.

There has been significant improvement in ACP management in Florida since 2005, when HLB was first detected here. A proposal for coordinated insecticide sprays was introduced to the Florida citrus industry in 2008. Attempts to begin coordinating insecticide sprays began around this time. In 2010, the National Academy of Sciences proposed development of CHMAs, which are working effectively today. These cooperative teams of citrus growers located within close proximity of one another coordinate their psyllid management sprays and have significantly reduced ACP populations over the years. The coordination of treatments is meant to enhance insecticide use against ACP by preventing rapid reinfestation by psyllids from non-sprayed areas. By the end of 2010, there were 10 CHMAs established. Our 2010 survey was conducted during that inception period of CHMAs.

From 2013 to 2014, there has been a progressive drop in resistance observed among ACP populations in Florida. In fact, based on our sampling capabilities, it appears that since 2013, we have returned to pre-2009 levels of ACP insecticide susceptibility across the state. The number of active CHMAs has risen from the initial 10 to a current 52. We can hope that coordination and effective rotations of insecticides for ACP have contributed to this decline in resistance. However, given that we know up to 4,000-fold resistance to the very important neonicotinoid insecticides can occur in ACP populations, we must remain vigilant by rotating MOAs and monitoring resistance.

Lukasz Stelinski is an associate professor in the University of Florida/ Institute of Food and Agricultural Sciences Entomology and Nematology Department, based at the Citrus Research and Education Center in Lake Alfred.

Meeting Challenges, Moving Forward

By Harold Browning

We all recognize that the Florida citrus industry is facing one of the most serious challenges it has dealt with in decades. The introduction of an insect-vectored bacterial disease that can attack both rootstocks and scions of virtually all commercial cultivars, which leads to chronic decline after years of infection, is on everyone's mind all of the time. The monumental efforts of growers and the industry as a whole to respond to this challenge can be considered unprecedented.

The August Citrus Expo is one of many annual meetings where results of ongoing research and delivery of solutions can be communicated. This happens via the two-day educational seminars as well as numerous exhibitors and displays where solutions to growing citrus in the presence of HLB are presented. This year was no exception, with the theme of the Expo being **"Meeting Challenges. Moving Forward."** With a sold-out exhibit hall and robust educational program, attendees were provided with the latest updates on topics surrounding HLB management.

Also in parallel with CRDF organization and investment, the educational program focused on the targets for intervention among the insect vector, the pathogen and the tree. Sections of the program addressed above-ground treatments and issues, soils, the impact of HLB on root systems, and eventually focused on considerations for new trees. We recognize that success with HLB will require maintenance of tree health for those trees out there in the industry, and the need for their productivity to remain viable until newly planted trees can reach maturity. Thus, the objectives are split between these two goals.

Topics of importance at the Citrus Expo seminars included:

Canopy and Fruit Issues

- Economic benefits of citrus health management areas
- Rationale for removal to manage disease spread — looking to the future
- Progress with Florida Department of Agriculture and Consumer Services Multi-Agency Coordinating Group inoculum removal project
- What harvesters are seeing across the industry

Product Solutions Research for HLB and Citrus Canker

- Current progress of CRDF Commercial Product Delivery Committee field trials for managing HLB and canker
- What has been learned with root systems and HLB
- Grower perspective on treatment of root systems to manage tree health

New Plantings

- Current status of Florida citrus nurseries and inventory
- Tolerant rootstocks for pest and disease management
- IFAS sweet orange varieties: the licensing process, challenges and opportunities
- Progress using thermotherapy to rejuvenate HLB-diseased trees
- Motivations and approaches to pest and disease management used by growers who are replanting

Growers wanting to know what their research investment is achieving need only participate in meetings such as the Citrus Expo, Annual Citrus Growers Conference, Florida Citrus Growers Institute and the many University of Florida/ IFAS Extension meetings, field days and state and regional grower meetings to realize the intensity of effort, commitment and success in bringing forth new solutions. The pace is slow, but the quest continues, and the Florida industry investment is paying off.

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.

CRDF Grower Dollars at work for you

Column sponsored by the Citrus Research and Development Foundation