Monitoring Florida citrus groves for insecticide resistance in Asian citrus psyllid populations

By Dhana Raj Boina, Michael E. Rogers and Lukasz L. Stelinski

Imagine it's Monday morning and the spray rigs are making their way through the grove applying the product of choice for controlling the Asian citrus psyllid. The previous week's scouting report indicated that psyllid populations were increasing throughout the grove operation, so now thousands of dollars are being spent to knock back the psyllid population.

Now fast forward to the following Monday. Seven days have passed since the psyllid spray was made and the scouts are making the first post-spray psyllid assessment. Not long after the scouts head out into the grove, a call comes in over the radio, "Are you sure Block 1 got sprayed? We're finding psyllids everywhere!"

As the morning progresses, the same results are reported in numerous blocks throughout the grove operation. With solid scouting data in hand to show that there was little difference between the pre-spray and post-spray psyllid counts, it appears that the time, effort and money spent on psyllid control has been of little use … why did this happen?

When an insecticide application appears to not be effective, it's difficult to go back in time and determine exactly what caused the failure, particularly if the appropriate application records have not been kept and adequate scouting reports to confirm the pest level before and after application are not available. While there are a number of "correctable" factors that could be responsible for pesticide failures that occur on a grove-by-grove basis, development of insecticide resistance in psyllid populations due to repeated insecticide use could become a reality.

To date, there are no documented cases of psyllid resistance to pesticides in Florida. However, cases of pesticide resistance in psyllids have occurred in other citrus producing countries. In a visit to India made by researchers from the Citrus Research and Education Center in October 2008, Indian researchers and growers described how repeated use of dimethoate and monocrotophos, both organophosphate (OP) insecticides, has lead to development of resistance in psyllid populations to this class of chemistry. Currently, the only product they have which provides some control of these OP resistant psyllids is imidacloprid. Other researchers working in China have also reported psyllid resistance to insecticides. Thus, as we continue to use more and more insecticides for psyllid control, the development of insecticide resistance in Florida psyllid populations is a potentially serious problem.

The main approach to preventing the development of insecticide resistance is to not apply pesticides with the same mode of action "back-to-back." In the 2009 Florida Citrus Pest Management Guide, the chapter titled "Asian citrus psyllid and citrus leafminer (ENY-734)" lists 10 different insecticide active ingredients, of which there are numerous additional brand name products. Among those 10 different active ingredients however, there are only five different modes of action (MOAs) available. Of those five MOAs, the organophosphates/carbamates, pyrethroids and neonicotinoids are used more frequently due to their broad-spectrum activity and typically cheaper cost for the grower.

RESISTANCE MONITORING PROGRAM

Given the repeated use of the few insecticide MOAs currently available, a psyllid insecticide resistance monitoring program has been initiated to monitor the susceptibility levels of psyllids to currently used insecticides. This resistance monitoring program was initiated in 2008 through grant funding from the Florida Citrus Production Research Advisory Council (FCPRAC). Based on the findings of this program, if changes in susceptibility (development of resistance) to insecticides are found to be occurring, pro-active measures can then be taken to prevent the loss of these important psyllid management tools.

During the first year of work on this project, the baseline toxicity of insecticides used for psyllid control was determined using a laboratory colony of psyllids not previously exposed to insecticides. To determine toxicity, droplets of acetone containing various concentrations of insecticide were applied to many replicated adult psyllids. The psyllids were then checked after 24 hours to determine the number of dead psyllids at each of the different insecticide concentrations tested. These data were then used to develop an LD50 for each insecticide. LD50 refers to the lethal dose of insecticide required to kill 50 percent of the insect (psyllid) population. The LD50 developed using the laboratory colony not exposed to insecticides is then compared to the LD50 of psyllids collected from the field which have been exposed to insecticides to develop a resistance ratio. This resistance ratio can then be tracked over time to determine if insecticide resistance development is occurring. In other words, is it taking more insecticide to control the pest?

Psyllid LD50 values for 13 insecticides were determined in the laboratory during 2008. Then in 2009, after the LD50 values from the laboratory colony had been determined, we began monitoring for insecticide resistance in psyllid populations at six different grove locations across Florida. To date (July 2009), LD50 values have been determined for three of the six study sites. The psyllid LD50 values from these field sites have been compared to the laboratory colony to develop a resistance ratio for each pesticide evaluated. The three sites completed thus far in 2009 are groves located in Lake, St. Lucie and Polk counties. Development of resistance ratios is underway for three additional groves in the more southern growing region of the state.

The resistance ratios determined for nine of the 13 insecticides at three of our study sites is shown in Table 1. The results showed that psyllids collected from three Florida counties showed various levels of decreased susceptibility to the insecticides listed in Table 1. The lower level of susceptibility found is not unexpected since our laboratory colony has not been exposed to insecticides whereas the field populations of psyllids have been exposed to insecticides. Overall, the resistance ratios for most products can be considered low at this time. Resistance ratios below 10 are usually not cause

Insecticide class	Insecticide	Resistance Ratio (LD_{50} of field psyllids/LD_{50} of laboratory psyllids)		
		Lake County	St. Lucie County	Polk County
Organophosphates and Carbamates	Chlorpyrifos	1.20	13.50	11.98
	Dimethoate	3.13	2.97	3.02
	Malathion	1.16	1.68	1.56
	Aldicarb	2.16	2.31	4.25
	Carbaryl	2.92	1.71	1.43
Pyrethroids	Cypermethrin	1.22	1.33	1.65
	Fenpropathrin	2.13	4.35	1.07
Neonicotinoids	Imidacloprid	14.20	8.87	6.49
	Thiamethoxam	11.77	1.24	0.91

Table 1. *Insecticide resistance/tolerance levels observed in psyllids collected from Lake, Polk and St. Lucie counties 2009.*

for concern. However, in St. Lucie and Polk counties, the resistance ratio for chlorpyrifos exceeded 10. In Lake county, both neonicotinoid products imidacloprid and thiamethoxam also exceeded 10. Thiamethoxam is a new product, with the same MOA and similar pest activity to imidacloprid, which was recently labeled for use in Florida citrus in July 2009. Because imidacloprid and thiamethoxam have the same MOA, it is possible that any resistance development to imidacloprid could also be transferred to thiamethoxam.

Based on the limited amount of work conducted to date, it is premature to infer that resistance to any of the insecticides tested is developing in psyllid populations in the field. Although results showed various levels of decrease in susceptibility to insecticides in field psyllids with some resistance ratios exceeding a value of 10, there could be subtle naturally occurring genetic differences between the psyllid populations that are responsible for the differences in insecticide susceptibility found.

In the coming year, resistance monitoring will be continued at these same study sites to see if the resistance ratios increase or stay the same. An increase in the resistance ratios would indicate that pesticide resistance is indeed developing and additional strategies would then need to be developed to minimize the chance of failures of these products in the future.

KEEP ROTATING PRODUCTS

In the meantime, growers should make every effort to continue rotating between psyllid control products with different modes of action. Because psyllids are mobile and move between groves that are likely on different pesticide product rotations, efforts might be made to synchronize MOA rotation among neighboring groves as one approach to manage potential resistance problems. In doing so, this could ensure that as psyllids move between groves, they are not being exposed repeatedly to the same pesticide MOA and thus help to decrease the likelihood of resistance development.

Dhana Raj Boina is a post-doctoral researcher in entomology at the University of Florida-IFAS Citrus Research and Education Center (CREC), Lake Alfred. Michael E. Rogers and Lukasz L. Stelinski are assistant professors of entomology at the CREC.

Figure 1. *Post-doctoral researcher Raj Boina applies insecticide to an adult Asian citrus psyllid.*