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Extension Model to Improve Asian Citrus Psyllid Control in Citrus Health Management Areas (CHMAs)

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Citrus health management areas (CHMAs) have been implemented throughout Florida to provide regional coordination to manage Asian citrus psyllid (ACP) and spread of Huanglongbing disease (HLB). During the fourth season (2011–12), we provided Gulf CHMA updates and interactive maps with ACP density and "hot spots" on our website (www.imok.ufl.edu) using data from Citrus Health Research Program (CHRP) (www.flchma.com). Ring color of the proportional circle map designated the cycle, and ring size represented psyllid density. The map was readable by anyone with Adobe Reader and provides information for Cycle #, Cycle Date, County Name, and ACP density. The .pdf format allowed a grower to click on and off different cycle layers for comparison between two or more sets of data simultaneously and spatially. This project included development and testing of a spray app that will suggest the best insecticide for use by growers and consultants. Data would be converted to a map layer and used to determine which growers may need help and what chemicals appear to be failing—a precursor to predicting ACP resistance. Funding is currently being sought to continue this effort. We expect to build better working relationships with growers by offering individual support to their economic efforts, ACP management, and HLB control.

The Asian citrus psyllid, *Diaphorina citri* Kuwayama, is a pest of citrus wherever it occurs due to its role as vector of the devastating citrus "greening" disease or Huanglongbing (HLB) (Bové, 2006). The psyllid transfers the bacterium *Candidatus* Liberibacter asiaticus (Las) while feeding (Pelz-Stelinski et al., 2010; Xu et al., 1988). HLB is currently the most serious disease affecting citrus in our region; it can drastically affect yield, and is incurable (Anon., 2010). Vector control is the principal means of slowing disease progress and insecticide use has greatly increased in Florida citrus with anecdotal evidence indicating that it is not uncommon for 12 sprays a year to be directed at this pest. Therefore, continued efficacy of available insecticides is of paramount importance and reliable strategies for resistance management are urgently needed.

Resistance management strategies along with efficacy, selectivity, and control of secondary pests are primary motivators in determining which insecticides are selected for ACP control in individual groves as well as in citrus health management areas (CHMAs). However, the effect of these choices on continued susceptibility to the most frequently used insecticides requires constant monitoring.

Citrus health management areas (CHMAs) have been implemented throughout Florida (www.flchma.org) initially to provide regional coordination for insecticide sprays to control ACP in concert with a study by National Research Council (2010) which made this a recommendation of highest priority. The objective is to remove sources of re-infestation as well as subsequent refuge for insecticide tolerant individuals. The statewide program was initiated in 2010 and presently includes 38 CHMAs covering more than 500,000 acres of which the Gulf CHMA is the largest comprising some 25% of total acreage.

The Gulf CHMA undertook its first cooperative spray during the winter of 2008-09, increasing to two sprays during the 2009–10 season (Stansly et al., 2009, 2010). The "dormant spray" approach was adapted based on replicated experiments in southwest Florida demonstrating the efficacy of this strategy (Qureshi and Stansly, 2010). In spite of the evident success of this program, we were reluctant to extend it to the growing season due to the diversity of pest management needs, programs and budgets which seemed to require a more individually tailored, information driven approach.

The Citrus Health Management Program (CHRP) is a joint effort of USDA–APHIS–PPQ and the Florida Department of Agriculture and Consumer Services, Division of Plant Industries (FDACS–DPI) initiated in 2006 in response to the challenges of citrus canker and HLB. CHRP began meeting the need for real time data on psyllid populations in Aug. 2011 with an ambitious program aimed at monitoring some 6,000 citrus blocks throughout the state using the "tap sampling" method (Hall and Hentz, 2010; Qureshi and Stansly, 2007). Over 80 scouts and support personnel were hired between the two agencies to accomplish the task that to date has conducted 22 monitoring cycles. Within days, the data are made available in Excel format on the CHMA website where a grower can view by "multi-block" number. In addition, there is a link to a map showing increases or decreases in ACP tap sampling using up and down arrows or a range of colored polygons (i.e., chloropleth map) to show ACP density.

We sought to provide additional information to Gulf CHMA growers by placing updates and an interactive map on our website (http://www.imok.ufl.edu/entomology/extension/chma/). The update included a summary text for the recent cycle and a county by county graphic of mean tap counts. The interactive map was

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created in ArcGIS but made available in .pdf format, which could be viewed with Adobe Reader. The map allowed users to not only view the data spatially and temporally, but also any number of cycles by turning on and off virtual layers. Cycle date, cycle number, TRS (Township, Range, Section) multi-block ID, and ACP tap sample count appeared by clicking on a proportional circle provided for a particular grove.

In response to grower requests, the map also showed the locations of "hot spots" (i.e., those groves with >21 psyllids per tap sample for three consecutive cycles). The objective was to improve area-wide management of ACP by identifying problem areas that may be due to suboptimal control programs or nascent insecticide resistance. Hot spots indicate weak zones in front against ACP that require attention. We present a two-pronged strategy as a proactive approach for dealing with hot spots: 1) prevention through better guidance to all growers on best use of insecticides, and 2) remedy through focused outreach to hot spot managers. We bolstered our extension effort through intensified scouting, instruction and grower contact in hot spot areas.

We provide a model to improve CHMA-level ACP control by streamlining transfer of information to users on pest populations and best management practices. To accomplish this we 1) created Gulf CHMA maps every 3 weeks and monitored for hot spots (i.e., tap samples >21 psyllids for three consecutive cycles) within the Gulf CHMA for its five counties (Charlotte, Hendry, Lee, Glades, and Collier); and 2) provided assistance to growers by increased monitoring of the hot spot or other difficult to manage, blocks, offering spray suggestions and data analysis.

Materials and Methods

Interactive maps. ArcMap (ESRI, ArcGIS Ver. 10, 2010) is a geographical information systems (GIS) program used to integrate data by geocoding and developing maps to plot data spatially. Adobe Acrobat has options (i.e., object data tool) built into its software that enable it to read ArcMap maps exported as .pdf files with map layers intact and functional. CHMAs have been implemented throughout Florida (www.flchma.org) to provide regional coordination for insecticide sprays for control Asian citrus psyllid (ACP) and the spread of HLB. We obtained and used these data to create an interactive map for the Gulf CHMA (http://www.imok.ufl.edu/entomology/extension/chma/) that allows a grower to not only view the data spatially and temporally, but also compare any number of cycles by turning on and off virtual layers.

Gulf CHMA tap sampling data are geocoded (or matched) to a spatial shape file using the multi-block ID field. Multi-blocks with no data are excluded from analyses. The ring color of the proportional circle map designates the cycle, and the ring size represents the number of ACP adults per 50 taps. The largest ring represents psyllid numbers of 21 or greater. The map is readable by anyone with Adobe Reader, and it permits the user to click on and off different cycle layers and view data for Cycle #, Cycle Date, TRS (Township, Range, Section), County Name, and ACP count, thus allowing comparison between two or more sets of data simultaneously and spatially.

Determination of "Hot Spots." We published Gulf CHMA maps and monitored for "hot spots" (i.e., tap samples >21 psyllids for three consecutive cycles) within the Gulf CHMA for its five counties (Charlotte, Hendry, Lee, Glades, and Collier). Attribute tables for each cycle are analyzed for "hot spots" (i.e., highlighted, Fig. 1) by selecting data by the ACP field that fit the criteria of >= 21 psyllids. Those selected records are then exported to a new shape file labeled Cycle#hotspots. Then, using the spatial analysis tool and intersection, the three hot spot files for individual cycles (i.e., Cycle#hotspots) are selected and inputted into the program, and the hot spots for three consecutive cycles are determined. With grower permission, DACS–DPI provides grower names and addresses. The list of names is then distributed to the Gulf Coast Florida Growers Association, where (with grower permission) we then contact and offer help to growers by increased monitoring of the hot spots block, offer spray suggestions and data analyses.

Extension efforts. Interactive maps, graphs, and newsletters were created using the CRDF data on the CHMA website, www.flchma.com.

Results

Interactive maps. The design of interactive maps using the CHRP/DPI data started Nov. 2011 in an attempt to present psyllid data to growers in an easy to use format (Fig. 1).

Determination of "hot spots." For 2012, we determined the number of "hot spots" for each cycle (Table 1), and will use this information as a baseline to compare the next 3 years of data to see where we have improved our monitoring and where we need to focus our efforts.

Extension monitoring. Last year, where we noticed growers that had difficulties controlling psyllids, we sent out a technician that trained the scout of the particular grove how to do tap sampling. Data were collected by the grove's scout, scanned for email submission to our Center, and uploaded by us for analysis as to when and what to spray. The grower received personal suggestions according to his/her needs, and the psyllid populations were then reduced as a result of the provided recommendations. During the most recent CHMA meeting held at the Citrus Research and Education Center in October (2012), CHMA captains made the suggestion that they needed to have the ACP data delivered to them sooner so that they could handle any spikes in population. Our Gulf CHMA already has started this approach. Physical outreach should only be necessary once a year for individual hot spot growers, but we would continue to monitor their progress through our analyses of CHRP data.

Discussion

A recent study found that Florida's economy has lost $3.6 billion dollars in revenue and more than 6,000 jobs since 2006 due to the reduction in citrus production caused by damage associated with HLB (Hodges and Rahmani, 2009). Five counties in southwest Florida (Charlotte, Hendry, Lee, Glades, and Collier) contain about 25% of the state's citrus acreage, much of which consists of large-scale commercial groves. The region quickly became front line in the fight against HLB because of the early appearance of the disease and the strong grower response to a call for action. Many of the current management practices were developed and implemented in this region, and keen grower support for research and extension can be expected. Southwest Florida citrus is a process juice industry which has seen tremendous increase in insecticide use over the past 5 years in response to HLB, made possible in part by strong market prices for juice. However, these prices and practices may not be sustainable in the future. Furthermore, most citrus managers in the area were brought up with a strong commitment to IPM, and there is great

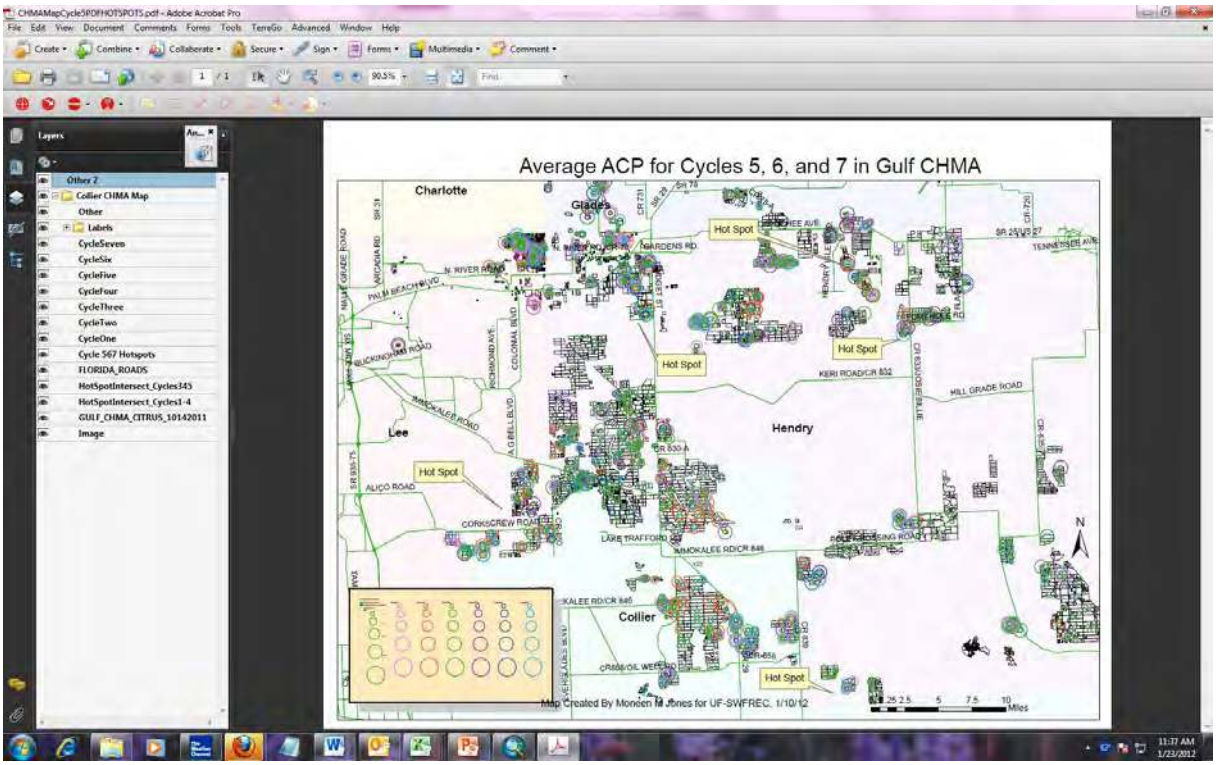

Fig. 1. A screen shot of an interactive map located on our Gulf CHMA website. The layers selected for viewing are turned on and off by clicking the "eye ball" icons visible to the left on the figure.

Table 1. Sample table listing the number of "hot spots" or multi-blocks that had >21 psyllids per tap sample for 2011–12.

Date	Hot spots (no.)	Date	Hot spots (no.)
9 Aug.–12 Oct. Cycles 1–4	4	8 Mar.–18 Apr. Cycles 11–13	3
19 Sept.–2 Nov. Cycles 3–5	5	28 Mar.–9 May Cycles 12–14	7
12 Oct.–23 Nov. Cycles 4–6	10	18 Apr. –31 May Cycles 13–15	9
2 Nov.–14 Dec. Cycles 5–7	11	9 May–20 June Cycles 14–16	21

concern over the possible consequences of present insecticide use practices, including the likelihood of control failure due to insecticide resistance. Therefore, there is strong interest in, and support for, this research that will benefit the entire Florida citrus community.

CHMAs are currently coordinating area-wide sprays of insecticides in order to manage ACP and reduce the likelihood of resistance. However, a limited number of insecticide modes of action, primarily pyrethroids and organo-phosphates, are being employed for area-wide application, raising the specter of rapid selection for resistance in populations of ACP in addition to resurgence of secondary pests. The choice of what and when to spray requires integration of multifarious factors that present a challenge to finding an optimal solution. Efficacy, pest populations, label restrictions including reentry and postharvest intervals, minimum residue limits (MRLs) for export fruit, cost, resistance management, and conservation of natural enemies all need to be considered.

Growers need real-time access to information and help integrating it according to their own priorities in order to make the optimal decision that will provide the most benefit from each intervention while minimizing cost and risk. Data provided from interactive maps on success of present programs (i.e., Gulf CHMA) are necessary to manage the spread of HLB and insecticide resistance. This information aids growers in making more informed decisions to plan ACP management programs that provide satisfactory control while minimizing selection for resistance. Results are communicated to the Florida citrus industry in a timely manner with the objective of increasing sustainability of individual and regional psyllid management programs.

Our future objectives are to fill these needs through improved analysis and presentation of ACP incidence data gathered regularly by CHRP, through a smart phone app that will integrate information on pesticide effects and restrictions and through an outreach program to struggling growers aimed at eliminating CHMA "hot spots."

Feedback on spray programs, together with ACP incidence data, will provide the means to fine tune management strategies. Geographical Information Systems (GIS) and Extension Services will provide immediate and long-term benefits to the public/industry, provide pest and disease control, and increase the sales and marketability of Florida commercially grown specialty crops.

Literature Cited

Anonymous. 2010. Strategic planning for the Florida citrus industry. Committee on the Strategic Planning for the Florida Citrus Industry: Addressing Citrus Greening Disease (Huanglongbing). Board on Agr. and Natural Resources, Div. on Earth and Life Studies, Natl. Research Council of the Natl.Academies. Natl. Academies Press, Washington, DC. <www.nap.edu>.

Bové, J.M. 2006. Huanglongbing: A destructive, newly-emerging, century-old disease of citrus. J. Plant Pathol. 88:7–37.

ESRI. 2012. ArcGIS [Computer Software] Redlands, CA. ESRI. Available from: <http://www.esri.com/software/arcgis>.

Hall, D.G. and M.G. Hentz. 2010. Sticky trap and stem–tap sampling protocols for the Asian citrus psyllid (Hemiptera: Psyllidae). J. Econ. Entomol. 103:541–549.

Hodges, A.W. and M. Rahmani. 2009. Economic impacts of the Florida citrus industry in 2007/08. Electronic Data Information Source (EDIS) FE802, University of Florida, Gainesville. <http://edis.ifas.ufl.edu/fe802>.

Pelz-Stelinski, K.S., R.H. Brlansky, T.A. Ebert, and M.E. Rogers. 2010. Transmission parameters for *Candidatus* Liberibacter asiaticus by Asian citrus psyllid (Hemiptera: Psyllidae). J. Econ. Entomol. 103:1531–1541.

Qureshi, J.A. and P.A. Stansly. 2007. Integrated approaches for managing the Asian citrus psyllid *Diaphorina citri* (Homoptera: Psyllidae) in Florida. In: Proc. Fla. State Hort. Soc., 3–4 June 2007, Palm Beach, FL, p. 110–115.

Qureshi, J.A. and P.A. Stansly. 2010. Dormant season foliar sprays of broad spectrum insecticides: an effective component of integrated management for *Diaphorina citri* (Hemiptera: Psyllidae) in citrus orchards. Crop. Prot. 29:860–66

Stansly, P.A., H.A. Arevalo, M. Zekri, and R. Hamel. 2009. Cooperative dormant spray program against Asian citrus psyllid in SW Florida. Citrus Ind. 90:14–15.

Stansly, P.A., H.A. Arevalo, and M. Zekri. 2010. Area-wide psyllid sprays in Southwest Florida: An update on the cooperative program aimed at controlling the HLB vector. Citrus Ind. 91:6–8.

Xu, C.F., Y.H. Xia, K.B. Li, and C. Ke. 1988. Further study of the transmission of citrus huanglungbing by a psyllid, *Diaphorina citri* Kuwayama, p. 243–248. In: L.W. Timmer, S.M. Garnsey, and L. Navarro (eds.). Proc. 10th Conf. of the Intl. Org. of Citrus Virologists, Riverside, CA.