Educational Workshops Increase Florida Residents Knowledge of Asian Citrus Psyllid and Citrus Greening Management

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ABSTRACT. Since the arrival of the Asian citrus psyllid (ACP), *Diaphorina citri*, in the United States, citrus crops have faced the ongoing threat of citrus greening disease (HLB). This disease affects all settings across Florida, especially backyard citrus production. To address this, educational outreach efforts are being tailored for Florida residents to reduce the spread of ACP and HLB in urban areas. In 2023 to 2024, workshops were held in six North Florida counties (Gadsden, Jefferson, Leon, Bay, Columbia, and Santa Rosa) to help residents learn to identify, monitor, and control ACP and HLB. The outreach also introduced individual protective trees and reflective mulch as strategies to manage psyllid populations. A total of 71 homeowners participated in the post-training assessment, with 93% reporting increased knowledge of ACP identification. We found that many homeowners were not able to recognize ACP in situ, whereas they were able to identify it in a picture. From the survey, 86% of the responders expressed willingness to manage ACP and 89% agreed to remove infected trees. However, only 20% and 35% were willing to adopt individual protective tree covers and reflective mulch, respectively. Feedback suggests that public awareness and education on best management practices should be prioritized.

The Asian citrus psyllid, *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae), is an invasive pest that threatens citrus crops in the United States. This pest serves as a vector for the phloem-limited bacteria *Candidatus Liberibacter asiaticus*, which causes citrus greening, also known as Huanglongbing (HLB), an incurable disease affecting citrus worldwide (Bové 2006). *Diaphorina citri* was introduced in Florida in 1998 (Halbert and Manjunath 2004) and has caused significant damage to both commercial citrus settings and backyard citrus production. Citrus greening remains a significant concern for Florida's citrus growers and residents (Alvarez et al. 2016; Exilien et al. 2024; Khan et al. 2020; Li et al. 2020), with infection rates remaining high in both commercial and backyard trees (Alvarez et al. 2016). Unmanaged citrus trees in residential areas, along with psyllid refugia such as orange jasmine, *Murraya paniculata* (L.) Jack, a common host for psyllid oviposition, contribute to the spread of the disease (Patt et al. 2023). This underscores the importance of community engagement in ACP and HLB management.

Backyard citrus growing is popular in Florida due to favorable climate and soil conditions. Despite the pest being present for more than a quarter of a century, a recent study highlighted a significant gap in residents' ability to recognize ACP, which is crucial for effective pest management (Exilien et al. 2024). The study also found that fewer residents were willing to test individual protective covers and reflective mulch as new strategies. Educational training could increase residents' knowledge of identifying ACP and HLB, thereby enhancing their willingness to engage in pest and disease management and adopt individual protective measures, such as reflective mulch. We also hypothesized that these workshops could encourage residents to remove HLB trees once diagnosed.

To address this knowledge gap, workshops were conducted to tailor educational outreach for Florida residents. In 2023 to 2024, six workshops were organized in North Florida counties including Gadsden (Quincy), Jefferson (Monticello), Leon (Tallahassee), Bay (Panama City), Columbia (Lake City), and Santa Rosa (Milton). These workshops aimed to increase residents' ability to identify, monitor, and manage ACP and HLB in their backyards. In addition, the outreach sought to encourage the adoption of individual protective cover (tree bagging) and reflective mulch as low-labor, biorational strategies to reduce psyllid populations, making them suitable for urban environments.

Educational workshop method

Workshops organization

The workshops were organized in collaboration with county University of Florida/Institute of Food and Agricultural Sciences (UF/IFAS) extension agents and the Fruit Physiology Laboratory of the North Florida Research and Education Center (NFREC). The training content was developed based on identified needs, including horticultural practices, and the identification and management of citrus pests. The integrated pest management training primarily focused on the identification, detection, and management of *D. citri* and other citrus pests. Other aspects of citrus care, such as rootstock, fertilization, and pruning, were covered during the workshops. County extension agents invited residents to participate in the workshops via emails and phone calls through their client networks, with a reminder sent closer to the event date. To maximize participation, flyers were made available online on the UF/IFAS Extension and NFREC websites, as

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well as posted at Extension and NFREC offices until the event date. In addition, the workshops were promoted on social media platforms.

Materials and delivery

The training materials were designed to emphasize two-way communication, encouraging feedback, questions, and interaction from participants during the live, face-to-face workshops. Participants received printed materials on topics covered during the workshops: 1) citrus pest identification and management, 2) detection and management of psyllid and citrus greening, and 3) using individual protective cover and reflective mulch. For insect identification, we provided preserved insect specimens in collection boxes or in glass jars filled with alcohol, to help participants familiarize with insect's morphology (color and size) and increase their identification skills.

Demonstrations of sticky traps as a monitoring tool for ACP and control method for citrus leafminer (Arevalo et al. 2010; Martini 2021; Vanaclocha et al. 2016) were conducted, along with other methods taught during the workshops (Fig. 1B). Materials such as tree bagging, and reflective mulch as novel tactics to control ACP (Chuang et al. 2024), were displayed during each session (Fig. 1C). All the sessions were nearly identical, each lasting 2 hours with a midway 10-minute break. A lecture followed by a hands-on activity, which included a table with insect specimens and materials. Trainings were delivered using PowerPoint (Microsoft, Redmond, WA, USA) presentations and printed brochures, with the content tailored for an audience with little to no background in entomology and horticulture. Pictures were included in the presentations to help the audience better understand the content (Fig. 1A).

At the beginning of the session, participants were asked to fill the "Before this workshop" section of a 2-page survey (Supplemental Material). After the 2-hour training session, participants completed the full survey to provide feedback. The survey focused on subjective gains in knowledge from before and after the training, and participants intended behavioral change regarding the topics discussed during the workshops, especially ACP monitoring.

Educational workshop results

Demographic. We provided training for 125 residents from six counties. Seventy-one total residents responded to the survey, with the highest participation from Bay County (35%). Female participants were predominant (61.97%, n = 44). Most participants were Caucasian (80.28%, n = 57) and African Americans represented only 4.23% (n = 3). Other ethnic groups, including Asian, Hispanic/Latino, American Indian/Alaskan, and Native Hawaiian, collectively accounted for 15.49% (n = 11). This ethnic imbalance as compared with Florida's demographics (US Census 2023) was also observed in our previous survey (Exilien et al. 2024), with minorities being underrepresented in extension activities.

Impact of the training in building participants' knowledge. We assessed participants' knowledge before and after workshop sessions to measure the level of knowledge gained during the period. Our evaluation focused on three topics covered throughout the training (Table 1). Feedback from participants revealed a significant change ($P < 0.05$, Table 1) in knowledge across all topics discussed. For the first topic, citrus pest identification and management, most participants initially rated their knowledge as low (33.8%, n = 24) or very low (46.47%, n = 33). However, by the end of the training, 60.56% of participants reported having a high (39.43%, n = 28) to very high (21.13%, n = 15) level of knowledge. Regarding the second topic, detection and management of psyllid and citrus greening, 60.56% of participants rated their post-training knowledge as high (39.43%, n = 28) to very high (21.13%, n = 15). This marked improvement from the 84.51% who initially rated their knowledge as low (21.13%, n = 15) or very low (63.38%, n = 45). For the third topic, use of individual protective cover and reflective mulch, 59.14% (n = 42) of trainees reported a high to very high level of knowledge after the training, compared with only 2.53% (n = 16) before and 66.2% (n = 47) who rated their knowledge level as low or very low. On average, 31.45% of participants perceived their knowledge level of *D. citri* management as moderate after the workshop.

Overall, 93% (n = 66) of participants reported an increase in their knowledge of monitoring and managing *D. citri* and citrus greening in their backyards. In addition, 94% (n = 67) indicated that their understanding of alternative *D. citri* control methods, including individual protective cover and reflective mulch, had improved. Furthermore, 87% (n = 62) felt better equipped to identify and

Fig. 1. Training session (A), and demonstration materials: leaf symptom sample and sticky trap for Asian citrus psyllid and citrus leafminer monitoring (B), and reflective mulch and tree bagging (C). (Credit photos A: Shahid Iqbal; B and C: Hellenah Khunga, UF/IFAS).

Table 1. Participants rating their pre- and post-training knowledge level after a 2-h workshop on citrus pest management. χ^2 tests compare the proportions of response before and after the training.

	Topic 1. Citrus pest identification and management					
Assessment	**No response (%)**	**Very low (%)**	**Low (%)**	**Moderate (%)**	**High (%)**	**Very high (%)**
Pre-training	2.81	46.47	33.8	12.67	2.81	1.41
Post-training	0	1.41	5.63	32.39	39.43	21.13
χ^2	—	37.163	16.06	6.817	26.414	11.904
P value	—	0.001*	0.001*	0.009*	0.001*	0.001*
	Topic 2. Detection and management of Asian citrus psyllid and citrus greening					
Assessment	**No response**	**Very low**	**Low**	**Moderate**	**High**	**Very high**
Pre-training	1.4	63.38	21.13	9.85	2.81	1.41
Post-training	1.4	0	5.63	32.39	39.43	21.13
χ^2	—	62.981	6.076	9.508	26.414	11.904
P value	—	0.001*	0.013*	0.002*	0.001*	0.001*
	Topic 3. Using individual protective cover and reflective mulch					
Assessment	**No response**	**Very low**	**Low**	**Moderate**	**High**	**Very high**
Pre-training	2.81	66.2	22.53	5.63	1.41	1.41
Post-training	4.22	0	7.04	29.57	39.43	19.71
χ^2	—	67.295	5.588	12.428	29.293	10.734
P value	—	0.001*	0.018*	0.001*	0.001*	0.001*

An asterisk (*) indicates a significant difference ($P < 0.05$).

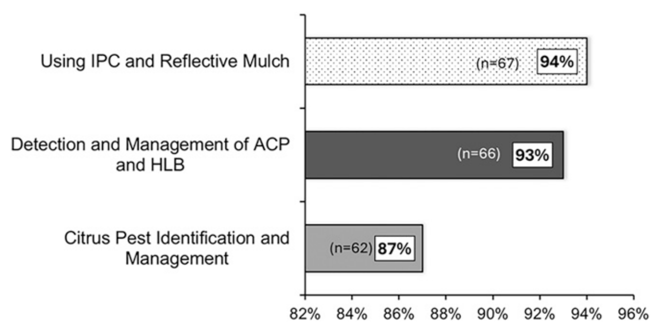

Fig. 2. Percentage of participants who improved their knowledge during the training. ACP = Asian citrus psyllid; HLB = Huanglongbing; ICP = individual protective cover.

control citrus pests on their properties (Fig. 2).

Behavioral changes post-training

We assessed participants' intended behavior in following up on the new skills and knowledge acquired during the training sessions based on six proposed actions described in Table 2. Overall, most participants agreed to implement actions related to citrus pest monitoring (84.51%, n = 60), *D. citri* management (81.69%, n = 58), removal of HLB-infected trees after they decline (83.1%, n = 59), and immediate removal of HLB-infected trees (54.93%, n = 39). However, most participants were uncertain about using individual protective cover (46.48%, n = 33) or reflective mulch (42.25%, n = 30) to control psyllid infestation on citrus trees, with only 19.72% (n = 14) and 35.21% (n = 25) expressing interest in trying these techniques, respectively.

Conclusion

D. citri remains a significant threat to citrus crops in both backyards and commercial farms. Coordinated efforts from stakeholders are essential to slow its spread and prevent introduction to new areas. Educational awareness is a cornerstone in managing the ACP population. Neglected backyard citrus can serve as reservoirs for psyllid spread (Hickey 2017). However, with specific knowledge and skills in ACP monitoring, identification, and control measures, residents can actively be involved in

Table 2. Participants declarative behavioral changes after a 2-h citrus pest management workshop.

	Participant response (%)				
Proposed actions	**No response**	**No**	**Maybe**	**Yes**	**ADT**
Monitor for citrus pests	1.41	0	4.23	84.51	9.85
Control psyllid	1.41	0	12.67	81.69	4.23
Using IPC to control psyllid	7.04	26.76	46.48	19.72	0
Using reflective mulch to control psyllid	4.23	18.31	42.25	35.21	0
Remove HLB-infected trees	4.23	2.82	5.62	83.1	4.23
Remove HLB-infected trees immediately	28.16	1.41	8.45	54.93	7.05

ADT = already doing this; HLB = Huanglongbing; ICP = individual protective cover.

psyllid management with potential impacts reaching far beyond the backyard.

Educational workshops significantly increased participants' self-reported pre- and post-knowledge regarding ACP monitoring, identification, and management. During the workshops, we confirmed previous findings that most residents cannot identify adult *D. citri* in situ (Exilien et al. 2024). When presented with preserved psyllids, participants surprisingly indicated that they had never seen this insect before, whereas they were able to identify it on a macroscopic photograph during the lecture. This highlights the importance of using collection specimens during training rather than relying solely on pictures. These workshops also demonstrated that it is possible to change participants' behavior regarding the monitoring and management of psyllid populations and citrus greening. Follow-up evaluations should assess the long-term retention of ACP knowledge and the application of monitoring and management techniques in participants' backyard citrus care. Although numerous participants expressed a willingness to try tree bagging and reflective mulching, almost half remained unsure about implementing these techniques. As a pilot outreach initiative, similar workshops should be held statewide to strengthen efforts against psyllid populations and citrus greening. This will help Florida extension agents raise awareness of ACP and HLB. Extension agents in other states affected by HLB and ACP may also use these findings to improve their outreach programs, fostering greater resident involvement in managing this pest and disease. Educational methods should include follow-up surveys, field observations, tree health monitoring, and peer networks to assess knowledge retention and the practical application of ACP management techniques.

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