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Effectiveness of Selective Insecticides to Control Asian Citrus Psyllid and Citrus Leafminer during Leaf Flushing

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The Asian citrus psyllid (ACP) *Diaphorina citri* and citrus leafminer (CLM) *Phyllocnistis citrella* Stainton are associated with the spread of "huanglongbing" (HLB), also known as citrus greening and citrus canker diseases, respectively. Both pests and diseases are present throughout the citrus growing region of Florida, necessitating integrated management strategies. Both pests require young citrus shoots for oviposition and development of immatures. Preemptive sprays of broad-spectrum insecticides against over-wintering ACP adults have been the most effective strategy to reduce populations through spring flush and beyond while taking a minimum toll on natural enemies. However, further suppression of both ACP and CLM, preferably without undue cost to beneficial fauna, is often necessary during the growing season. To this end, sprays of relatively selective insecticides were evaluated in 15-year-old *Citrus sinensis* (L.) Osbeck 'Valencia' orange trees infested with both pests. In general, treatment effects were stronger and longer lasting against ACP than CLM. In the first experiment conducted in May, 435 Oil (horticultural spray oil) alone, spirotetramat (Movento 240 SC), tolfenpyrad, abamectin + thiamethoxam (Agriflex), and diflubenzuron (Micromite 80 WGS) all applied with 435 Oil, flubendiamide (Belt 4SC) + Induce (non-ionic surfactant), M-Pede (soap) + Addit (vegetable oil), and fenpyroximate (Portal 0.4EC) all provided significant reduction of psyllid populations compared to the control for up to 17 days after treatment (DAT). Significant reduction in CLM populations compared to the control was observed with all treatments through 10 DAT except 435 Oil at 3 DAT, Portal and tolfenpyrad at 10 DAT, and M-Pede + Addit at both observations. In the second experiment, conducted in July–August, treatments of 435 Oil and Sivanto (10.26 oz/ac) applied alone, Sivanto (6.84, 10.26 or 13.69 oz/ac rate), spinetoram (Delegate 25 WG), Movento 240 SC all with 435 Oil, and imidacloprid (Provado 1.6 F) and Sivanto (10.26 oz/ac) with Induce all suppressed psyllid populations for more than 5 weeks. Both 435 Oil and Induce were effective adjuvants for Sivanto. Significantly fewer CLM larvae compared to the control were observed at 17 DAT with Delegate 25WG and three rates of Sivanto all applied with 435 Oil. Adult ACP were suppressed more compared to nymphs, in part because of new flush growth that provided protection to immatures against contact insecticides. Nevertheless, selective insecticides during the growing season can provide needed suppression of ACP and CLM populations with less collateral damage to beneficial insects and mites than would otherwise be suffered from broad-spectrum insecticides if used at that time.

The Asian citrus psyllid (ACP), *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae), is a key pest of citrus in many citrus growing regions of the world. Young shoots are required for oviposition and nymph development, but adults can survive and overwinter on hardened leaves. Feeding by ACP nymphs and adults on young citrus shoots causes reduced and distorted leaf development. Of much greater concern is the ability of this pest to transmit the bacterium *Candidatus* Liberibacter asiaticus, causal organism of "huanglongbing" (HLB) or citrus greening disease (Bové, 2006, Halbert and Manjunath, 2004). Young shoots are also attractive to citrus leafminer (CLM) *Phyllocnistis citrella* Stainton for oviposition and larval development. Feeding by larvae facilitates the spread of citrus canker caused by *Xanthomonas axonopodis* pv. citri. Both pests and diseases are now well established throughout the citrus growing region of Florida and are increasing in incidence and severity (FDACS-DPI, 2008; Halbert and Manjunath, 2004; Qureshi et al., 2009b; Xiao et al., 2007). Therefore, effective control measures are needed to develop integrated management strategies against these pests and associated diseases.

Chemical pesticides are an important component of citrus pest management. HLB has greatly intensified insecticide use in Florida citrus (Rogers, 2008; Rogers et al., 2008). The systemic neonicotinoid insecticides, thiamethoxam, imidacloprid, and clothianidin, are registered for use on Florida citrus but their use as a soil application is limited to young trees (Qureshi et al., 2009a). Aldicarb was effective in large trees but lost registration in Florida in 2011 (Qureshi and Stansly, 2008). Therefore, insecticide sprays applied to the foliage are the primary control method for *D. citri* in Florida citrus and these materials are continually being tested in the field (Qureshi and Stansly, 2009a; Qureshi et al., 2009a, 2010). Field tests under different conditions are warranted to evaluate effectiveness against ACP and CLM and provide growers with multiple modes of action for resistance management.

Most mature citrus trees in Florida produce the majority of new shoots in spring followed by sporadic growth in summer and fall (Hall and Albrigo, 2007; Qureshi et al., 2009b). These

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shoots are attractive to both ACP and CLM for oviposition and immature development, and also to several natural enemies of these and other pests. Targeting overwintering ACP adults with so-called dormant sprays of broad-spectrum insecticides prior to spring growth flushes has proven to be the most effective way to protect these young shoots with minimal impact on many natural enemies (Qureshi and Stansly, 2010). Nevertheless, it may still be necessary to control both ACP and CLM during the growing season when all stages of both species are present. This would be better to do with selective products that have less impact on natural enemies than the broad-spectrum insecticides used in winter. The objective of our experiments was to evaluate the efficacy of foliar sprays of some more selective insecticides with or without adjuvants against ACP and CLM in mature citrus trees during spring and summer.

Materials and Methods

Two separate experiments, one each in spring and summer, designed as randomized complete blocks were conducted during 2010 in the citrus orchard of Southwest Florida Research and Education Center (SWFREC) in Immokalee, FL. The experimental block consisted of 15-year-old *Citrus sinensis* (L.) Osbeck 'Valencia' trees approximately 9–10 ft in height planted on double-row raised beds at a density of 326 trees/ha (132 trees/acre). Trees had been recently hedged so new shoots were plentiful to encourage ACP and CLM infestation. Trees were irrigated by micro-sprinklers and subjected to conventional cultural practices (Jackson, 1999). Treatments were applied using a Durand Wayland 3P-10C-32 air blast speed sprayer operating at 1500 RPM with an array of two stainless steel T-Jet # 5 nozzles per side delivering 608 L/ha (65 gal/acre) in the spring experiment and four nozzles per side delivering 1216 L/ha (130 gal/acre) in the summer experiment.

For the spring experiment, nine treatments and an untreated control were randomly distributed across four replicates in 19 rows that included an unhedged buffer row next to every treated row. Each replicate contained 10, five-tree treatment plots. Treatments were applied on 14 May and evaluations made at 3, 10, and 17 days after treatment (DAT). Ten randomly selected shoots per plot were collected and examined under a stereomicroscope in the laboratory to count ACP nymphs. Three fully expanded leaves on each shoot were examined to count CLM larvae and mines and average per leaf was analyzed. ACP density was estimated from three central trees in each five-tree plot by counting adults falling on a clipboard covered with a 22 × 28 cm (8½ × 11 inch) laminated white sheet held horizontally under randomly chosen branches, which were then struck three times with a PVC pipe to make a count for one "tap" sample (Qureshi and Stansly, 2007; Qureshi et al., 2009b). Four tap samples were conducted per tree and average per tap sample was analyzed. Evaluations were stopped at 17 DAT because trees had to be treated for CLM infestation.

For the summer experiment, nine treatments and an untreated control were randomly distributed across four replicates in two rows separated by a buffer row. Each replicate contained 10, four-tree plots. Treatments were applied on 12 July and post-treatment evaluations were made at 3, 10, 17, 24, 31, 38, 45, and 52 DAT. Three of the four trees in each plot were sampled as above.

Data were subjected to the Univariate procedure to test for the assumptions of parametric analysis (SAS Institute, 2004). Data with normal distributions were subjected to ANOVA using the GLM procedure to evaluate treatment effects on ACP, and treatment means were separated using LSD, contingent on a significant treatment effect ($P < 0.05$) (SAS Institute, 2004). Non-normal data were log transformed to reduce heterogeneity of variances. Data that could not be thus normalized were analyzed by using the non-parametric Kruskal–Wallis test.

Results

Spring experiment

All treatments significantly reduced the total number of ACP nymphs of all instars compared to the control through 17 DAT, except for: 1) 435 Oil alone at 3 and 17 DAT, 2) the low and high rates of Belt + Induce at 3 and 17 DAT, respectively, and 3) M-Pede + Addit at all three observations (Table 1). The number of 3rd to 5th instar nymphs was significantly reduced compared to the control by all treatments except M-Pede + Addit and 435 Oil alone on all three observations, both rates of Belt + Induce at 3 DAT and the low rate of Belt + Induce at 10 DAT (Table 1). Movento 240SC, tolfenpyrad, Agriflex and Micromite 80 WGS all applied with 435 Oil and Portal 0.4EC applied alone provided most reduction in nymphal density. The same five treatments provided most reduction in numbers of ACP adults, although no statistically significant difference was observed between Movento 240 SC + 435 Oil and the control at 3 and 10 DAT (Table 1). Significant reduction in number of CLM larvae compared to the control was observed with all treatments through 10 DAT except 435 Oil alone and M-Pede + Addit at 3 DAT, and Portal 0.4EC, tolfenpyrad + 435 Oil and M-Pede + Addit at 10 DAT (Table 2). Similar effects were observed on CLM mines.

Summer experiment

Significantly more dead nymphs were observed in all treatments at 3 DAT except Sivanto applied alone (Table 3). Most dead nymphs were observed with Delegate 25 WG + 435 Oil followed by the low and high rates of Sivanto + 435 Oil with no significant difference among the three treatments. Compared to the control, all treatments were equally effective in reducing the number of live nymphs through 17 DAT except 435 Oil alone, which did not differ from the control at 17 DAT and also provided less nymph reduction compared to all other treatments at 3 and 10 DAT (Table 3). No statistical difference in number of ACP adults was observed among treatments at 24, 45, and 52 DAT. On other dates, all treatments compared to the control provided significant reduction of ACP adults through 38 DAT except 435 Oil alone at 3 and 31 DAT, and both Sivanto (6.84 oz/ac) and Movento 240 SC at 3 DAT (Table 3). There were no significant differences among rates of Sivanto against nymphs and adults of ACP, although control at the 10.3 oz and 13.7 oz rates tended to be better when applied with 435 Oil or Induce. Efficacy of these treatments was similar to Delegate 25 WG and Movento 240 SC applied with 435 Oil and Provado 1.6 F applied with Induce.

Significantly fewer CLM larvae compared to the control were observed in all treatments at 3 DAT but only with Delegate 25 WG + 435 Oil at 10 DAT (Table 4). However, significantly fewer CLM larvae compared to the control were seen at 17 DAT with all three rates of Sivanto and Delegate 25 WG all applied with 435 Oil, but not with the oil alone treatment or with Sivanto alone or plus Induce (Table 4). There was no significant treatment effect on number of empty mines at 3 DAT but at 10 DAT, fewest mines were seen in leaves of trees treated with Delegate 25 WG + 435 Oil, the low and medium rates of Sivanto with 435 Oil, the medium rate of Sivanto with Induce, and 435 Oil alone. At 17 DAT, all treatments provided significant reduction in CLM

Table 1. Mean number of Asian citrus psyllid (ACP) nymphs per shoot and adults per tap sample in 15-year-old 'Valencia' orange trees that were untreated or treated with foliar sprays of insecticides on 14 May 2010 at Southwest Florida Research and Education Center, Immokalee, FL.

Treatment/ formulation	Active ingredient	Rate (amt product/acre or % v/v)	ACP nymphs (all instars)/shoot[z]			ACP nymphs (3–5 instar)/shoot[z]			ACP adults/tap sample[y]		
			3 DAT	10 DAT	17 DAT	3 DAT	10 DAT	17 DAT	3 DAT	10 DAT	17 DAT
Control	Untreated		17.28 ab[x]	10.83 b	33.23 b	10.78 b	5.52 b	21.30 b	0.92 ab	0.58 ab	1.40 a
Movento 240 SC + 435 Oil	Spirotetramat + oil	5 oz + 3%	2.10 e	0.18 f	2.60 e	0.88 c	0.10 e	0.03 f	0.31 bc	0.15 bcd	0.19 cde
435 Oil	Oil	3%	10.23 bc	7.93 c	22.63 b	5.78 b	4.50 b	13.35 bc	0.65 b	0.85 a	0.52 bc
Portal 0.4 EC	Fenpyroximate	64 fl oz	5.88 d	0.20 f	1.40 ef	1.00 c	0.20 e	0.20 f	0.02 c	0.00 d	0.10 cde
Tolfenpyrad + 435 Oil	Tolfenpyrad + oil	24 fl oz + 3%	1.18 e	0.20 f	0.08 f	0.65 c	0.20 e	0.05 f	0.00 c	0.00 d	0.04 de
Agriflex + 435 Oil	Abamectin + thiamethoxam + oil	8.5 oz + 3%	0.30 e	0.00 f	0.55 ef	0.05 c	0.00 e	0.08 f	0.00 c	0.00 d	0.00 e
Belt 4 SC + Induce	Flubendiamide + adjuvant	5 oz + 0.25%	10.75 bc	6.88 cd	11.70 cd	6.07 b	5.80 bc	5.28 de	0.52 b	0.33 abc	0.44 bcd
Belt 4 SC + Induce	Flubendiamide + adjuvant	7.5 oz + 0.25%	7.48 cd	2.50 de	20.60 bc	4.52 b	2.38 cd	10.92 cd	0.92 b	0.35 abc	0.42 bcd
Micromite 80 WGS + 435 Oil	Diflubenzuron + oil	6.25 oz + 3%	1.65 e	0.78 ef	16.23 d	0.33 c	0.68 de	8.00 e	0.02 c	0.06 cd	0.06 cde
M-Pede + Addit	Soap + vegetable oil	2% + 1.5%	22.90 a	21.60 a	64.08 a	15.30 a	11.95 a	41.28 a	2.29 a	0.65 a	0.65 b

[z]n = 10 shoots from 5 trees.
[y]4 tap samples conducted per tree on 3 central trees in each five-tree plot and average per tap sample analyzed.
[x]Means in a column followed by the same letter are not significantly different ($P > 0.05$).

Table 2. Mean number of citrus leafminer (CLM) larvae and mines per leaf in 15-year-old 'Valencia' orange trees that were untreated or treated with foliar sprays of insecticides on 14 May 2010 at Southwest Florida Research and Education Center, Immokalee, FL.

Treatment/ formulation	Active ingredient	Rate (amt product acre or % v/v	CLM larvae/leaf/shoot[z]			CLM mines/leaf/shoot[z]		
			3 DAT	10 DAT	17 DAT	3 DAT	10 DAT	17 DAT
Control	Untreated		0.78 a	2.81 b	2.68 d	1.27 a	3.46 b	3.35 d
Movento 240 SC + 435 Oil	Spirotetramat	5 oz + 3%	0.15 bcd	1.22 d	4.13 a	0.83 b	2.12 cde	5.23 a
435 Oil	Oil	3%	0.59 a	1.98 c	3.04 cd	0.96 ab	2.38 cd	3.71 cd
Portal 0.4 EC	Fenpyroximate	64 fl oz	0.03 d	4.34 a	3.54 abcd	0.43 c	4.86 a	4.23 bcd
Tolfenpyrad + 435 Oil	Tolfenpyrad + oil	24 fl oz + 3%	0.18 bc	3.53 ab	3.39 bcd	0.75 b	4.12 ab	4.03 bcd
Agriflex + 435 Oil	Abamectin + thiamethoxam + oil	8.5 oz + 3%	0.05 cd	0.18 e	3.3 abcd	0.27 c	0.23 f	3.97 bcd
Belt 4 SC + Induce	Flubendiamide + adjuvant	5 oz + 0.25%	0.18 bc	1.31 d	2.83 cd	0.47 c	1.96 de	3.73 bcd
Belt 4 SC + Induce	Flubendiamide + adjuvant	7.5 oz + 0.25%	0.28 b	1.93 c	2.92 cd	0.77 b	3.27 c	3.69 cd
Micromite 80 WGS + 435 Oil	Diflubenzuron + oil	6.25 oz + 3%	0.07 cd	1.28 d	3.93 ab	0.43 c	1.54 e	4.68 ab
M-Pede + Addit	Soap + vegetable	2% + 1.5%	0.66 a	2.96 b	3.38 abc	0.97 ab	5.61 b	4.13 bc

[z]n = 10 shoots from 5 trees, 3 fully expanded leaves examined on each shoot and average per leaf analyzed.
[y]Means in a column followed by the same letter are not significantly different ($P > 0.05$).

mines compared to the control except the medium rate of Sivanto applied alone or with 435 Oil, Movento 240 SC with 435 Oil, and Provado 1.6 F with Induce.

Discussion

Foliar sprays of most insecticides targeted at flushing citrus in spring or summer reduced populations of both ACP and CLM. Treatment effects were stronger and longer lasting against ACP adults than against immature ACP or CLM. Psyllid adults were suppressed for 3 weeks in the spring study and more than 5 weeks in the summer study with the most effective treatments. In contrast, effects against ACP nymphs or CLM larvae lasted from 2 to 3 weeks. The difference is likely due to protection afforded to eggs and immatures by their cryptic location inside unexpanded leaves, where they were largely inaccessible to insecticide sprays. In addition, new shoots growing after the application were not protected. The effectiveness of the experimental product tolfenpyrad against ACP was similar to other commonly used insecticides tested in spring. However, tolfenpyrad provided only 3 days control of CLM. M-Pede + Addit, a combination of soap and vegetable oil, was not effective against either pest although

Table 3. Mean number of Asian citrus psyllid (ACP) nymphs per shoot and adults per tap sample in 15-year-old 'Valencia' orange trees that were untreated or treated with foliar sprays of insecticides on 12 July 2010 at Southwest Florida Research and Education Center, Immokalee, FL.

Treatment/	Active	Rate (amt product acre or	Dead ACP nymphs/ shoot[z]	Live ACP nymphs/shoot[z]			ACP adults/tap sample[y]							
formulation	ingredient	% v/v)	3 DAT	3 DAT	10 DAT	17 DAT	3 DAT	10 DAT	17 DAT	24 DAT	31 DAT	38 DAT	45 DAT	52 DAT
Control	Untreated	0.08 e	0.08 e	27.15 a[x]	18.03 a	6.38 a	0.27 ab	2.75 a	1.75 a	1.21 a	0.79 a	1.10 a	0.58 a	0.65 a
435 Oil	Oil	2%	1.25 d	13.63 b	3.90 b	10.18 e	0.33 a	2.35 b	0.83 b	0.95 a	0.63 ab	0.19 bc	0.32 a	0.35 a
Sivanto	Flupyradifurone	10.26 oz	1.95 de	3.65 c	0.45 c	1.33 bc	0.00 d	0.42 bc	0.67 bc	0.58 a	0.31 bc	0.27 bc	0.21 a	0.13 a
Sivanto + 435 Oil	Flupyradifurone + oil	6.84 oz + 2%	9.13 de	2.13 cd	0.20 c	3.58 b	0.06 bcd	0.63 bc	0.36 bcd	0.35 a	0.06 bcd	0.06 c	0.19 a	0.10 a
Sivanto + 435 Oil	Flupyradifurone + oil	10.26 oz + 2%	2.63 cd	1.00 de	0.00 c	4.10 bc	0.02 d	0.33 bc	0.23 bcd	0.27 a	0.35 d	0.04 c	0.29 a	0.04 a
Sivanto + 435 Oil	Flupyradifurone + oil	13.69 oz + 2%	6.25 ab	0.05 e	0.05 c	0.18 c	0.00 d	0.04 c	0.23 bcd	0.10 a	0.08 cd	0.08 cd	0.29 a	0.08 a
Sivanto + Induce	Flupyradifurone + adjuvant	10.26 oz + 2%	3.73 bc	0.03 e	0.13 c	0.88 bc	0.02 d	0.15 c	0.02 d	0.13 a	0.21 cd	0.13 bc	0.04 a	0.10 a
Delegate 25 WG + 435 Oil	Spinetoram + oil	5.0 oz + 2%	18.25 a	1.23 de	0.85 c	0.35 bc	0.00 d	0.06 c	0.10 cd	0.13 a	0.08 cd	0.21 bc	0.04 a	0.06 a
Movento 240 SC +435 Oil	Spirotetramat + oil	10.0 oz + 2%	4.53 bc	0.43 e	0.08 c	1.33 bc	0.23 abc	0.33 bc	0.29 bcd	0.35 a	0.19 cd	0.42 b	0.19 a	0.19 a
Provado 1.6 F + Induce	Imidacloprid + adjuvant	10.0 oz + 0.25%	3.98 bc	0.15 e	0.00 c	1.18 bc	0.06 cd	0.33 bc	0.27 bcd	0.27 a	0.02 d	0.15 bc	0.06 a	0.15 a

[z]n = 10 shoots from 4 trees
[y]4 tap samples conducted per tree on 3 of the 4 trees in each plot and average per tap sample analyzed
[x]Means in a column followed by the same letter are not significantly different (*P* > 0.05).

Table 4. Mean number of citrus leafminer (CLM) larvae and mines per leaf in 15-year-old 'Valencia' orange trees that were untreated or treated with foliar sprays of insecticides on 12 July 2010 at Southwest Florida Research and Education Center, Immokalee, FL.

Treatment/	Active	Rate (amt product/	CLM larvae/leaf/shoot[z]			CLM empty mines/leaf/shoot[z]		
formulation	ingredient	acre or % v/v)	3 DAT	10 DAT	17 DAT	3 DAT	10 DAT	17 DAT
Control	Untreated		0.14 a[y]	0.08 bc	0.71 ab	0.24 a	0.20 a	0.90 a
435 Oil	Oil	2%	0.05 bc	0.07 bcd	0.55 abc	0.20 a	0.08 bcd	0.48 bc
Sivanto	Flupyradifurone	10.26 oz	0.03 bc	0.18 a	0.53 abc	0.23 a	0.13 abc	0.69 ab
Sivanto + 435 Oil	Flupyradifurone + oil	6.84 oz + 2%	0.03 bc	0.03 bcd	0.34 cd	0.18 a	0.04 cd	0.48 bc
Sivanto + 435 Oil	Flupyradifurone + oil	10.26 oz + 2%	0.03 bc	0.07 bcd	0.38 cd	0.17 a	0.09 bcd	0.60 abc
Sivanto + 435 Oil	Flupyradifurone + oil	13.69 oz + 2%	0.03 bc	0.03 cd	0.25 d	0.23 a	0.13 abc	0.48 bc
Sivanto + Induce	Flupyradifurone + adjuvant	10.26 oz + 0.25%	0.03 bc	0.02 cd	0.49 abc	0.24 a	0.09 bcd	0.60 bc
Delegate 25 WG + 435 Oil	Spinetoram +oil	5.0 oz + 2%	0.08 b	0.00 d	0.38 cd	0.15 a	0.02 d	0.45 c
Movento 240 SC + 435 Oil	Spirotetramat +oil	10.0 oz + 2%	0.03 bc	0.05 bcd	0.44 bcd	0.29 a	0.15 ab	0.61 abc
Provado 1.6 F + Induce	Imidacloprid + adjuvant	10.0 oz + 0.25%	0.01 c	0.10 b	0.68 a	0.16 a	0.14 ab	0.70 ab

[z]n = 10 shoots from 4 trees, 3 fully expanded leaves examined on each shoot and average per leaf analyzed.
[y]Means in a column followed by the same letter are not significantly different (*P* > 0.05).

it might be if applied at greater volume given the strictly contact activity of these products. The effectiveness against ACP and CLM of another experimental product, Sivanto, was similar to other commonly used insecticides tested in summer. Both formulated 435 Oil and the non-ionic surfactant Induce enhanced the effectiveness of Sivanto compared to application without adjuvants. On the other hand, some insecticides applied with oil were not better than oil alone.

Frequent applications of oil during the growing season may be an option to reduce both pests and insecticide use (McCoy, 1985; Qureshi and Stansly, 2009b; Stansly and Qureshi, 2008). Oil is relatively safe to beneficial insects compared to many insecticides so this tactic could be more compatible with biological control of all citrus pests. Although published studies are limited, diflubenzuron, abamectin, fenpyroximate, spirotetramat, and 435 Oil were judged compatible with *Tamarixia radiata*, an ectoparasitoid of ACP, based on laboratory study of residual effects at 1–3 d after application (Hall and Nguyen 2010). Persistence of these chemistries against common natural enemies in citrus range from short to intermediate compared to long for broad-spectrum toxins such as carbaryl and dimethoate (http://www.ipm.ucdavis.edu/PMG/r107300811.html#REFERENCE). On a scale of 1–4 (least = most harmful), fenpyroximate, horticultural spray oil, and spiromesifen, which has the same mode of action as spirotetramat, all ranked 1–2 against *Chrysoperla carnea,* a generalist predator of ACP, and several other pests common during the growing season compared to diflubenzuron which is ranked 3–4 (http://side-effects.koppert.nl/#). On the same scale, diflubenzuron was ranked 1 for the adult and 4 for the larvae of lady beetle *Harmonia axyridis*. Abamectin is ranked 4 for the adult and 1 for the larvae of *Chrysoperla carnea*. This compared to organo-phosphates and pyrethroids, which ranked 4 against these natural enemies with upwards of 8 to 12 weeks persistence.

New shoots are not only attractive to both ACP and CLM for oviposition and immature development, but also to several predators and parasitoids that attack these and other pests of citrus (Qureshi and Stansly, 2009b; Stansly and Qureshi, 2008). Dormant season sprays when no flush is present are sparing of these natural enemies even though broad-spectrum insecticides are used. Subsequent recolonization of flushing citrus in spring time by ladybeetles and other predators after residues have weathered may explain in part why up to 6 months suppression of ACP was seen with dormant sprays (Qureshi and Stansly, 2010; Stansly et al., 2009a) compared to 3 to 5 weeks during the growing season. Nevertheless, additional control of ACP as well as CLM may be necessary during spring or summer growth cycles when immature stages of both pests are present and natural enemies are also active. Selective insecticides would be preferable choices to spare key beneficial arthropods foraging on young shoots during this period. Our results demonstrate that suppression of both ACP and CLM is possible with judicious choice of relatively selective insecticides, even when applied to citrus foliage during flush cycles.

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