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Effects of Insecticides on Asian Citrus Psyllid (Hemiptera: Psyllidae) Populations in a Florida Citrus Grove

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Abstract

Asian citrus psyllid, *Diaphorina citri* Kuwayama, populations were monitored in a 'Valencia' sweet orange on sour orange rootstock plot planted in 1997. The plot was scouted weekly and the number of psyllids, percent trees infested, and the percentage of flush infested per tree were recorded over a 3-year period. The plot was treated with 7 insect control treatments: Admire (imidacloprid) applied at 12-, 6-, 3-, or 2-month intervals; Temik applied annually; Meta-Systox R applied annually; or no insecticide control using a randomized complete block design. Psyllid infestations persisted throughout the year. The lowest populations occurred during the winter (November-January) with peaks in the spring and fall. Annual applications of Temik, Meta-Systox R, or Admire did not reduce psyllid populations. Biannual or more frequent applications of Admire significantly reduced psyllid numbers, percentage of trees with psyllid infestations, and the percentage of flushes infested with psyllids.

Introduction

The Asian citrus psyllid, *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae), is a pest of citrus in many regions of the world where citrus is grown, including Southeast and Southern Asia, South and Central America, and the Caribbean. The psyllid was first found in the United States in Palm Beach Co., FL in 1998 (7). Since then, the insect has become established throughout the citrus growing regions of Florida.

The Asian citrus psyllid damages citrus by direct feeding and, most importantly, by vectoring the bacterium (*Candidatus Liberibacter asiaticus*) (5) which causes the citrus huanglongbing (citrus greening) disease. This disease has been observed in China for more than 100 years (13), and has moved into most of Southeast and Southern Asia and Africa. Citrus greening was reported in Brazil in 2004 (3) and Florida in 2005 (6). Citrus greening is one of the more serious citrus diseases in the world. Where it is endemic, citrus trees have a life expectancy of fewer than 10 years and do not produce marketable fruit. The citrus greening bacterium infects all citrus species, irrespective of rootstock (1,4). The initial symptom of the disease is the appearance of yellow shoots, and the yellowing progresses throughout the canopy. Symptoms can vary in severity from one location to another. At late stages there may be leaf and fruit drop, out of season flushing and blossoming, stunting, and dieback (4). Symptoms are most severe on sweet orange, mandarins, and their hybrids; moderate on grapefruit, lemon, and sour orange, and not severe on pummelo or trifoliate orange.

Efforts to manage the Asian citrus psyllid/citrus greening complex include preventing the spread of the bacterium through certification of the budwood that has been maintained in an insect-free environment and, in infected groves, roguing infected trees in combination with an intensive psyllid management program. Attempts to reduce the disease through psyllid control have focused on

introductions of parasitoids *Tamarixia radiata* (Waterson) and *Diaphorencyrtus aligarhensis* (Shafee, Alam, and Agarwal) (9). A biopesticide, azadirachtin has also been shown to reduce psyllid populations (11). Up to 81.4% reduction of red gum lerp psyllid, *Glycaspis brimblecombei* Moore, with imidacloprid has been reported (12). The use of antibiotics can provide temporary symptom remission (2,8,10). Breeding or engineering trees resistant to citrus greening is in the early stages. In spite of the efforts, greening remains the limiting factor to citrus production where the disease is endemic.

One part of an integrated strategy that has not been thoroughly investigated is the use of systemic insecticides to reduce psyllid populations and potentially reduce the risk of greening. We studied psyllid infestations in a replicated citrus plot over a 3-year period, with and without the application of systemic insecticides. This report details monthly psyllid population dynamics and their response to systemic insecticides.

Studying Asian Citrus Psyllid in 'Valencia' Sweet Orange

The experimental area consisted of 294 'Valencia' sweet orange [*Citrus sinensis* (L.) Osbeck] trees grafted onto sour orange rootstock (*C. aurantium* L.) planted in Fort Pierce, FL in 1997 in an Oldsmar fine sand. The trees were in single beds (rows) with 9.15 m between rows. The between-tree spacing was 4.5 m. The experiment was a randomized complete block with each of 6 rows serving as a replication. There were 7 treatments in each of the 6 replications, with 7 trees per experimental unit (plot). Each of the 7-tree experimental units was separated from an adjacent 7-tree experimental unit by a buffer tree. A buffer tree was also placed at the end of each row. The treatments were an annual application of Temik (Rhone-Poulenc, Research Triangle Park, NC) (8.5 g a.i. per tree, incorporated into the soil); an annual application of Meta-Systox-R (Mobay Corp., Kansas City, MO) (trunk drenched, 0.62 ml per liter); soil drenches with imidacloprid (1-[6-chloro-3-pyridinyl] methyl]-N-nitro-2-imidazolidinimine) (Admire) (Bayer, Vero Beach, FL) at 1920 mg a.i./plant applied at 12-, 6-, 3-, or 2-month intervals; and no insecticide application. Each year Temik was applied the last week of April, and the trunk drenches were applied in the spring between 19 April and 22 May, according to manufacturer's recommendation. Application rates were based on manufacturer's recommendations.

Every week, for 3 years, the experimental area was scouted for Asian citrus psyllids. Each tree was carefully examined and the number of psyllids detected on each tree was recorded. The sampling was conducted by two people examining the opposite sides of each tree. The focus area was the lower surface and petioles of young leaves. Psyllids were rarely detected elsewhere. Sampling was always conducted on wind-free days. All psyllids on each tree were counted. Each tree was also recorded as infested (any psyllids detected) or uninfested. Trees were recorded as infested if psyllids were found at any time during the month. The insect life stages were recorded as adults and/or juveniles. The percentage of young flushes infested was also recorded for infested trees. Weekly data were combined into monthly totals recorded within each replication for each treatment.

Psyllid numbers (square-root transformed) and infestation percentages (square-root, arcsin transformed) (to smooth out the variance) were subjected to an analysis of variance (ANOVA) by the SAS software program (SAS Institute Inc., Cary, NC) using a model that tested for month $\times$ treatment interaction (which accounted for less than 6% of the variation). Main treatment effect means that had a significant F test were separated by Fisher's protected least significant difference (LSD) test, 5% level.

Psyllid Population and Response to Systemic Insecticides

The monthly population densities of Asian citrus psyllids during the 3-year test period in non-Admire treated trees is shown in Table 1. The data are presented for adults only. Juvenile counts were similar to those for adults in all cases. The data for the Temik-treated, Meta-Systox-R treated, and control (no insecticide) were combined because there was no significant difference among

these treatments. Asian citrus psyllids were detected throughout the year. The percentage of trees infested varied from month to month and year to year which makes seasonal prediction of psyllid outbreaks difficult. Psyllid infestations were rare during the winter months (November-December). The highest psyllid infestation was in September of 2002 (182 per tree).

The effect of the 7 insect control treatments on psyllids is shown in Table 2.

Table 1. Seasonal variation of asian citrus psyllids in a Florida citrus grove.

Month	Year			Average
	2002	2003	2004	
January	2 ± 1.5 a*	3 ± 2.6 a	4 ± 2.8 a	3 ± 2.3 a
February	1 ± 1.2 a	129 ± 25.5 c	15 ± 13.5 a	48 ± 20.1 b
March	14 ± 12.5 a	2 ± 1.6 a	15 ± 14.3 a	10 ± 9.5 a
April	50 ± 8.8 b	59 ± 10.1 b	11 ± 9.1 a	40 ± 9.3 b
May	1 ± 1.7 a	119 ± 22.0 c	53 ± 11.8 b	58 ± 17.8 bc
June	2 ± 1.4 a	7 ± 5.7 a	18 ± 15.6 a	9 ± 7.9 a
July	3 ± 1.2 a	17 ± 16.4 a	76 ± 10.9 c	32 ± 9.5 b
August	144 ± 22.1 c	73 ± 16.9 b	1 ± 1.6 a	73 ± 14.5 cd
September	182 ± 23.8 c	101 ± 15.7 bc	4 ± 2.6 a	96 ± 14.0 d
October	51 ± 21.9 b	22 ± 21.2 a	2 ± 1.2 a	25 ± 14.8 b
November	2 ± 1.5 a	2 ± 1.5 a	11 ± 9.0 a	5 ± 3.8 a
December	1 ± 1.3 a	0 ± 0.0 a	3 ± 1.3 a	1 ± 1.1 a

* Numbers are the means ± standard error of adult psyllids per tree (averaged from 21 trees) of six replications. Data are from non-Admire treated trees. Numbers in a column followed by different letters are significantly different (5% level) by Fishers protected LSD.

Table 2. Effects of seven insect control treatments on asian citrus psyllids in a Florida citrus grove.*

Treatment**	Tree infestation (%)	Flush infestation per tree (%)	Mean no. of adult psyllids per tree
Admire 1X	53.0 ± 15.6 b	15.5 ± 7.8 b	45 ± 7.5 b
Admire 2X	5.5 ± 2.3 a	0.3 ± 0.8 a	3 ± 1.7 a
Admire 4X	2.8 ± 1.8 a	0.0 ± 0.0 a	2 ± 1.4 a
Admire 6X	5.1 ± 2.6 a	0.7 ± 0.7 a	6 ± 3.2 a
Temik	78.7 ± 11.9 b	6.3 ± 5.3 ab	66 ± 15.3 b
Meta-Systox-R	54.6 ± 14.9 b	13.3 ± 8.4 b	76 ± 25.6 b
Control	60.2 ± 7.1 b	17.5 ± 9.4 b	58 ± 11.9 b

* These data were collected during the peak of psyllid activity (August-September and April-May), averaged over 3 years. A tree or flush was considered infested if at least one adult was detected. The means were determined from 6 replications. Numbers in a column followed by different letters are significantly different (5% level) by Fishers protected LSD.

** Admire 1X – Imidacloprid applied annually
 Admire 2X – Imidacloprid applied every 6 months
 Admire 4X – Imidacloprid applied every 3 months
 Admire 6X – Imidacloprid applied every 2 months
 Temik – applied annually
 Meta-Systox-R – applied annually
 Control – no insecticide applied

Data were combined for the 3-year observation period since the results were the same for each year. Neither Temik nor Meta-Systox-R reduced Asian citrus psyllid infestations, compared to untreated trees, as evaluated by population densities, percent trees infested, or percent flush infested. A significant reduction in psyllid numbers, and tree and shoot infestation was achieved with Admire when applied every 6, 3, or 2 months. With these treatments, when psyllids did occur, they were on only a few flushes. A single annual application of Admire was not sufficient to reduce psyllid populations.

Asian citrus psyllid populations varied consistently from month to month and year to year. The populations followed observed flushing of trees, so the presence of new flushes rather than time of year was probably the most important factor.

We can conclude from the study that a soil drench with Admire every 6 months significantly reduced psyllid infestation, and this was observed all 3 years. Additional Admire applications did not further reduce infestation. It is not known whether the observed psyllid control is sufficient to reduce transmission of the bacteria that cause citrus greening. Answering this question will require further experimentation where citrus greening is endemic.

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