

Assessing the Risk of Insecticide Resistance in Citrus Thrips in Arizona¹

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Abstract

Bioassay with Dimethoate, Carzol, Danitol, Baythroid and Success were conducted on citrus thrips collected from the Yuma Mesa to determine if insecticide resistance to these insecticides occurred. Low to moderate levels of resistance were detected for Dimethoate, Carzol and Danitol, and one population exhibited a high level of resistance to Baythroid. No resistance was evident for Success. Susceptibility to Success was much higher for the Yuma populations relative to populations previously reported in California.

Introduction

Currently there are only a few efficacious insecticides for controlling citrus thrips, *Scirtothrips citri* in Arizona citrus. Success (spinosad), Carzol (formetanate HCL), Dimethoate, Baythroid (cyfluthrin), and Danitol (fenpropathrin) have been some of the most commonly used insecticides for thrips control in Arizona citrus. Of these products, only Success and Carzol offer good residual activity under hot conditions, and of these two products, only Success is considered soft on beneficial arthropods and has not been implicated in flaring secondary pests such as mites, mealybugs and whiteflies. If citrus thrips were to become resistant to any of these insecticides, but most importantly Success, Arizona citrus growers would have a difficult and expensive task managing citrus thrips.

Insecticide resistance in citrus thrips is a reality. In California, citrus thrips have been reported resistant to Dimethoate, Carzol and Baythroid; and in Arizona in 1992 some data suggested that citrus thrips in the Yuma Valley were resistant to Danitol. At that time, Danitol was being used under a Section 18 registration. Shortly after resistance was reported, the Danitol Section 18 expired and it was no longer used in citrus until 2000. In 2002, it was noted that in several insecticide efficacy trials Danitol was not performing as well as it had the previous year, and by 2003, Danitol was ineffective in University of Arizona field trials. Although it is not certain, it appeared that resistance to Danitol could be a factor. If resistance is playing a role in the inefficacy of Danitol, it is possible that cross-resistance to Baythroid could follow since these are similar chemistries.

In this study, we report the bioassay results of Success, Dimethoate, Danitol, Baythroid, and Carzol to citrus thrips from the Yuma Mesa.

Materials and Methods

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Citrus thrips were collected from three separate lemon groves growing on the Yuma Mesa near Yuma, AZ. Approximately 3,000 adult female thrips were aspirated into clear plastic straws from each grove using hand-held battery-powered mini computer vacuums. Approximately 20-25 trees within each grove were used to collect the samples for each population. The samples were placed in a cooled ice chest for transport to the laboratory. Populations were collected at: The University of Arizona, Mesa Agricultural Center on 14 April 2004, at County 15th and Avenue C on 23 May 2004, and at County 16 ½ and 2E on 9 June 2004 .

The technique used to conduct the bioassays was based on previous research conducted at The University of California, Riverside in the laboratory of Dr. Joe Morse (Immaraju et al. 1989). Commercial formulations of Dimethoate 4E, Carzol 90SP, Baythroid 2E, Danitol 2.4EC and Success 2SC were used. The dilutions used for the bioassays were: Dimethoate at 0, 1, 5, 10, 50, 100, 500 and 1,000 ppm; Carzol at 0, 0.5, 1, 5, 10, 50, 100, 500, and 1,000 ppm; Baythroid at 0, 0.1, 0.5, 1, 5, 10, 50 and 100 ppm; Danitol at 0, 0.1, 0.5, 1, 5, 10, 50, 100, 500, 1,000, 5,000 and 10,000 ppm; and Success at 0, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, and 1 ppm. All dilutions contained Kinetic non-ionic surfactant at 0.1% v/v.

New, fully expanded lemon leaves were collected and dipped into each dilution. Each leaf was swirled in the insecticide solution for 5 seconds to ensure adequate coverage. The leaves were then placed on paper towels ventral side up and allowed to dry in a fume hood for approximately 30 minutes. The leaves were then placed ventral side up in Munger cells and approximately 20 citrus thrips with dislodged from the collection straws onto the leaves and sealed. Each dosage for each insecticide was replicated four times. After 48 hours, mortality was assessed by observing the thrips under a dissecting microscope and counting the number live and dead.

Data were analyzed using Probit analysis. Non-overlapping 95% confidence limits (CL) were used to separate differences in the LC₅₀s (lethal dose necessary to cause 50% mortality). Since there are no known citrus thrips populations in Arizona that have not been exposed to insecticides, data for the field populations tested here were compared to populations previously evaluated using similar techniques in California.

Results and Discussion

Dimethoate

The LC₅₀s for Dimethoate ranged from 21.68 to 44.67 ppm (Table 1). Among the three field populations of citrus thrips evaluated, resistance to Dimethoate was found to be low to moderate with the highest level detected being a 17.87-fold increase in resistance for the U of A, Mesa Station population relative to a susceptible strain collected and evaluated in California (Immaraju et al. 1989). In California, Dimethoate resistance has been reported as high as 90.3-fold (Immaraju et al. 1989). Ten years ago Dimethoate was much more extensively used for thrips control in Arizona citrus, but with the registration of Success, its use has plummeted. Thus the low to moderate level of resistance detected in this study was not surprising.

Carzol

The level of resistance detected for Carzol, were low to moderate relative to finding reported in the San Joaquin Valley of California. In this study we found resistance ratios ranging from 1.74 to 9.49-fold (Table 2). The highest resistance reported in California was 31-fold (Immaraju et al. 1989). Similar to Dimethoate, the use of Carzol on the Yuma Mesa for citrus thrips management has rapidly declined in the last five years, and theoretically resistance to Carzol should probably have declined as well.

Danitol

Because of the citrus thrips control failures experienced with Danitol since 2002, detecting resistance to Danitol was expected. However, the highest level detected was 3.24-fold for the Co. 16 ½ & 2E population (Table 3). In California, resistance has been reported as high as 24.2-fold relative to the same population we used as the susceptible population in this study, TB84 (Immaraju and Morse, 1990). The resistant California population, SEL 10, was derived from the TB84 population by selecting for resistance to pyrethroids using fluvalinate in the laboratory. The TB84 population was

previously known for moderate resistance to Dimethoate and the pyrethroid fluvalinate. The fact that they detected cross-resistance among the pyrethroids they evaluated suggests that the TB84 population was likely moderate in resistance to Danitol as well. Thus, our results show only a low level of resistance may be misleading. Without a known susceptible reference population, it is not possible to conclusively determine the degree of shift in susceptibility to Danitol. However, since we detected some low level of resistance to Danitol in several of the Yuma populations and based on the fact that the TB84 population was moderately resistant to another pyrethroid, it can be speculated that the Yuma populations are most likely moderately resistant to Danitol. Danitol use for citrus thrips control on the Yuma Mesa had declined substantially before these bioassays were conducted. It is possible that higher levels of resistance may have been encountered had the bioassays been conducted in 2002 when more Danitol was being used. Immaraju and Morse (1990) reported that resistance to the pyrethroid fluvalinate declined rapidly once selection pressure eased.

Baythroid

The highest level of resistance detected for any Yuma citrus thrips population occurred with the Co. 16 ½ & 2E population to Baythroid (Table 4). This population was found to be 48-fold more resistant than the susceptible population, Site 1 (Ventura County), collected and reported by Khan and Morse (1998). Consequently, the Co. 16 ½ & 2E population was the population with the greatest level of resistance to the other pyrethroid evaluated, Danitol. The highest level of resistance to Baythroid reported by Kahn and Morse (1998) was 30.5-fold. Of the pyrethroids used in Arizona citrus for thrips control, Baythroid is the most common. The level of resistance reported here is of concern and may explain some of the variability in thrips control Arizona pest control advisors have reported.

Success

Of the insecticides evaluated for resistance in this study, because of its extensive use, Success susceptibility was of greatest concern. Based on our findings, the Yuma citrus thrips populations appear to be much more susceptible to Success than those reported in California (Khan and Morse 1998) (Table 4). These results are reassuring in that although Success has been extensively used for citrus thrips control on the Yuma Mesa, there is currently no evidence that resistance to Success exists in field populations.

Literature Cited

- Immaraju, J. A. and J. G. Morse. 1990. Selection for pyrethroid resistance, reversion, and cross-resistance with citrus thrips (Thysanoptera: Thripidae). *J. Econ. Entomol.* 83: 698-704.
- Immaraju, J. A., J. G. Morse, and D. J. Kersten. 1989. Citrus thrips (Thysanoptera: Thripidae) pesticide resistance in Coachella and San Joaquin valleys of California. *J. Econ. Entomol.* 82: 374-380.
- Khan, I. and J. G. Morse. 1998. Citrus thrips (Thysanoptera: Thripidae) resistance monitoring in California. *J. Econ. Entomol.* 91: 361-366.

Table 1. Susceptibility of Yuma area citrus thrips to Dimethoate in ppm, 48 hr after treatment using a citrus leaf dip bioassay.

Population ^a	<i>n</i>	Slope	SE	LC ₅₀ (95% CL)	LC ₉₅ (95% CL)	RR ^b	Π ²	df
U of A, Mesa Station	504	1.16	0.09	44.67 (33.53-59.57)	1176 (705.17-2298)	17.87*	31.19 ^c	5
Co. 15 th & Ave C	404	0.59	0.07	35.68 (20.19-62.19)	23580 (6474-175685)	14.27*	33.44 ^c	5
Co. 16 ½ & 2E	316	0.72	0.09	21.68 (12.08-36.94)	4289 (1500-21979)	8.67*	49.91 ^c	5
Baja87	231	3.54	0.49	2.50 (2.10-2.90)	--	--	--	--

^aBaja87 = susceptible population collected and reported by Immaraju et al. (1989); remaining entries are populations collected from the Yuma area.

^bRR, resistance ratio calculated by dividing the LC₅₀ of the strain tested by the LC₅₀ of the susceptible Baja87 population; * indicates a significant differences based on non-overlapping 95% confidence limits..

^cChi-square significant ($P > 0.05$).

Table 2. Susceptibility of Yuma area citrus thrips to Carzol in ppm, 48 hr after treatment using a citrus leaf dip bioassay.

Population ^a	<i>n</i>	Slope	SE	LC ₅₀ (95% CL)	LC ₉₅ (95% CL)	RR ^b	Π ²	df
U of A, Mesa Station	421	0.87 ± 0.08		7.75 (5.10-11.41)	599.79 (296.58-1595)	3.88*	13.32	5
Co. 15 th & Ave C	625	1.34 ± 0.10		3.47 (2.69-4.42)	57.93 (39.52-94.37)	1.74*	14.62	5
Co. 16 ½ & 2E	446	0.99 ± 0.09		18.97 (13.16-28.97)	873.96 (394.93-2681)	9.49*	59.52 ^c	5
Baja87	314	3.54 ± 0.40		2.0 (1.8-2.3)	--	--	--	--

^aBaja87 = susceptible population collected and reported by Immaraju et al. (1989); remaining entries are populations collected from the Yuma area.

^bRR, resistance ratio calculated by dividing the LC₅₀ of the strain tested by the LC₅₀ of the susceptible Baja87 population; * indicates a significant differences based on non-overlapping 95% confidence limits..

^cChi-square significant ($P > 0.05$).

Table 3. Susceptibility of Yuma area citrus thrips to Danitol in ppm, 48 hr after treatment using a citrus leaf dip bioassay.

Population ^a	<i>n</i>	Slope SE	LC ₅₀ (95% CL)	LC ₉₅ (95% CL)	RR ^b	Π ²	df
U of A, Mesa Station	393	0.88 ± 0.09	66.45 (43.52-98.24)	4941 (2404-13638)	2.75*	4.26	5
Co. 15 th & Ave C	491	0.72 ± 0.07	16.67 (10.65-25.31)	3169 (1329-10943)	0.69	19.70 ^c	6
Co. 16 ½ & 2E	575	0.52 ± 0.04	78.38 (45.40-133.18)	115175 (39220-485606)	3.24*	53.78 ^c	9
TB84	309	3.91 ± 0.45	24.2 (20.4-27.9)	--	--	--	--

^aTB84 = Dimethoate resistant population collected and reported by Immaraju and Morse (1990). This population may have some low level of resistance to Danitol; remaining entries are populations collected from the Yuma area.
^bRR, resistance ratio calculated by dividing the LC₅₀ of the strain tested by the LC₅₀ of the Dimethoate and fluvalinate resistant TB84 population; * indicates a significant differences based on non-overlapping 95% confidence limits..

^cChi-square significant ($P > 0.05$).

Table 4. Susceptibility of Yuma area citrus thrips to Baythroid in ppm, 48 hr after treatment using a citrus leaf dip bioassay.

Population ^a	<i>n</i>	Slope SE	LC ₅₀ (95% CL)	LC ₉₅ (95% CL)	RR ^b	Π ²	df
U of A, Mesa Station	472	0.69 ± 0.08	0.39 (0.20-0.67)	97.43 (42.56-325.37)	4.88*	19.63 ^c	5
Co. 15 th & Ave C	601	0.76 ± 0.07	0.65 (0.38-1.01)	95.41 (48.79-241.37)	8.13*	34.51 ^c	5
Co. 16 ½ & 2E	628	0.87 ± 0.06	3.84 (2.76-5.32)	306.37 (164.75-682.91)	48.00*	53.78 ^c	5
Site 1 (Ventura County)	--	2.53 ± 0.28	0.08 (0.06-0.09)	--	--	--	--

^aSite 1 (Ventura County) = susceptible population collected and reported by Khan and Morse (1998); remaining entries are populations collected from the Yuma area.

^bRR, resistance ratio calculated by dividing the LC₅₀ of the strain tested by the LC₅₀ of the susceptible Site 1 (Ventura County) population; * indicates a significant differences based on non-overlapping 95% confidence limits..

^cChi-square significant ($P > 0.05$).

Table 5. Susceptibility of Yuma area citrus thrips to Success in ppm, 48 hr after treatment using a citrus leaf dip bioassay.

Population ^a	<i>n</i>	Slope SE	LC ₅₀ (95% CL)	LC ₉₅ (95% CL)	RR ^b	Π ²	df
U of A, Mesa Station	503	0.88 ± 0.08	0.010 (0.007-0.014)	0.72 (0.35-1.88)	0.008*	15.26 ^c	5
Co. 15 th & Ave C	377	0.74 ± 0.08	0.004 (0.002-0.006)	0.64 (0.25-2.67)	0.003*	17.75 ^c	5
Co. 16 ½ & 2E	601	0.96 ± 0.08	0.006 (0.004-0.008)	0.30 (0.17-0.62)	0.005*	39.60 ^c	6
Site 2 (Ventura County)	--	2.38 ± 0.41	1.326 (0.940-1.654)	--	--	--	--

^aSite 2 (Ventura County) = susceptible population collected and reported by Khan and Morse (1998); remaining entries are populations collected from the Yuma area.

^bRR, resistance ratio calculated by dividing the LC₅₀ of the strain tested by the LC₅₀ of the susceptible Site 2 (Ventura County) population; * indicates a significant differences based on non-overlapping 95% confidence limits..

^cChi-square significant ($P > 0.05$).