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EFFICACY OF AN INSECT GROWTH REGULATOR AND AN INSECTICIDE AGAINST THE SILVERLEAF WHITEFLY ON COTTON

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Abstract

In 1991, large populations of the silverleaf whitefly, (SLW), *Bemisia argentifolia* Perring and Bellows, were reduced 38% to 53% following applications of amitraz and buprofezin to cotton in the Lower Rio Grande Valley (LRGV) of TX. Yields of seed cotton in treated plots were significantly greater than the yields from untreated cotton following seven and four applications of amitraz and buprofezin, respectively. There were no significant differences in percentage reducing sugar and stickiness of the lint caused by adult, larvae and pupae feeding of the whitefly in treated and untreated cotton. Dead and dead + moribund whitefly adults were bioassayed with amitraz and the LC_{50} was 1,703.6 and 234 µg/vial. Most of the adults were moribund after three h.

Introduction

In the LRGV in 1991 yields were reduced 25% when 40,500 ha (100,000 a) of cotton were heavily infested by the SLW (Norman et al. 1992). Population sizes were the greatest determined in the LRGV. The pest was considered to be new and there was the question of which species or strain was present on the cotton. Whitefly adults, collected in the check plots, were identified as SLW or B strain by Brown (1992). Sticky cotton lint can be a problem with high infestations. Producers cannot market their cotton if it is too sticky to make cloth.

Amitraz was toxic to young parasitoid larvae of *Eretmocerus tejanus* at 0 d (Walker et al. 1998). It allowed significant general parasitoid survival after two d. Amitraz had significantly less young parasitoid larvae *E. tejanus* than the check water sprays (Walker et al. 1998). Cotton treated with buprofezin and the check water sprays showed equal populations of parasitoid pupae of *E. tejanus*. Buprofezin had significantly less parasitoid pupae of *E. mundus* than the check water sprays. Buprofezin was not toxic to adults of either species of parasites of the SLW (Walker et al. 1995).

This test was conducted in 1991 to determine efficacy of the insect growth regulator (IGR) buprofezin and the contact insecticide amitraz as foliar sprays against the SLW during the fruiting of cotton. There are no reports on control of high populations of this insect on cotton in the LRGV with amitraz and buprofezin. Both compounds were evaluated as possible selective insecticides of the two parasite species offered above. Insights into timing and number of sprays during the season against these high populations were also a focus. Presumably amitraz is short lived and the IGR was persistent. Two rates of amitraz were tested to determine if they were equally effective or if the greater rate was more effective than the lower rate. Research was also conducted to determine effects of feeding damage by adults and immatures on quantity and quality of lint.

Materials and Methods

Amitraz (Ovasyn) and buprofezin (Applaud), formulated as 180 g/L emulsifiable concentrate and 250 g/L suspendable concentrate, respectively, were applied as aqueous sprays to cotton at Weslaco, TX in LRGV. Technical amitraz was used in laboratory bioassays to determine the LC_{50} to adults of the SLW.

Seed of "DPL 50" was planted on d 79 (3-20), 1991, at 25 kg /ha. Plots of cotton four m wide (four rows) x 30.3 m long were arranged in a randomized complete block design. Plots were separated by four rows of corn with four m between plots down the row to reduce movement of adults between plots. Treatments included an untreated check, two rates of amitraz and one rate of buprofezin. They were replicated five times.

Amitraz was applied seven times at 0.14 and 0.28 kg (AI)/ha from calendar d 157 (6-6) to 210 (7-9). Buprofezin was applied four times at 0.56 kg (AI)/ha from d 175 (6-24) to 210 (7-29). The last application of both insecticides was made two d before the first harvest. Sprays were applied at 479 L/ha at 2,464 g/cm^2 through three flat fan nozzles/row by a four row high clearance sprayer. One nozzle was located above the plants while the other two were placed on flexible drop lines orientated to direct the spray upward and obtain under-leaf coverage.

The untreated check was sampled on calendar d 151 (5-11) and 21 other sample d to 207 (7-26). Both rates of amitraz were sampled on calendar d 158 (6-7) and 17 other sample d to d 207 (7-26). The buprofezin plots were sampled from calendar d 177 (6-26) and 10 other sample d to 207 (7-26). In each plot a single leaf from the third position below the terminal leaf was sampled for adults, eggs, all larvae to young fourth instar larvae and "red-eye" pupae of SLW on each sample date during the fruiting period. Sampling was done in the morning between 8:15 and 10:15 to insure minimal movements of adults on the

underside of the leaf. A leaf was removed from the plant in each plot and the adults were counted immediately. The leaf was then brought to the laboratory where all other stages were counted on the underside of each leaf with the aid of a dissecting microscope; 30X power was used for eggs and 10X for larvae and pupae.

Five plants/plot were examined on sample d 177 (6-24) to 207 (7-29) for presence or absence of 'sooty" mold on any leaf. Percentage of plants with mold was determined. This was done to relate "sooty" mold on the plant during the season to stickiness of lint and concentrations of reducing sugars at the end of the season.

Cotton was defoliated with 0.56 kg (AI)/ha butifos on d 208 (7-27). Plots were defoliated one d after the last sample date and two d before the last application of both insecticides. The last application of the Insecticide was applied to kill the immatures before their honeydew was deposited on the lint of open bolls.

Seed cotton was hand harvested from all plants in five contiguous m in the center two rows in each plot on d 212 (7-31) and 224 (8-12) for estimates of yields. Samples were ginned. A 40 g sample of the lint from each plot was tested for "stickiness" by minicard rating and percentage reducing sugar by methods of Perkins (1986).

Analysis of variance was determined on each sample date for adult, egg, total larvae and pupae, seed cotton yields, lint "stickiness" and percentage reducing sugars by SAS (1985). Percentage reduction of adults, larvae and "red-eyed" pupae was calculated from the treated cotton based on SLW populations in the check on each sample d. Means of check and each treatment were separated by Tukey's honestly significant difference (hsd) method at P0.05 for the three stadia.

A vial bioassay was conducted with adults of SLW based on the method of Wolfenbarger et al. (1998). Glass vials (100 mm long x 13 mm wide) were coated with 3125, 1562.5, 781.3, 625, 312.5, 156.3, 78.2, 39.1, 9.8, 4.9 and 0 µg amitraz/vial in 0.625 ml acetone and air dried. Adults (10 to 50/vial) from cotton leaves (third to sixth from the terminal) were dislodged into each of two vials for the 0.28 kg (AI)/ha rate of amitraz. Vials were sealed with Parafilm and returned to the laboratory. Three h after collecting the adults they were emptied onto a black paper surface and counted as live (walking in the vial or on the paper), dead (not moving on the paper) or moribund (moving but on their back or side).

Five different days (replicates) of bioassays were conducted in June and July with two vials/concentration/sample date. Total insects and totals of the dead and dead + moribund of the replicates were determined. LC_{50} and 95% confidence interval (CI) as µg/vial and slope ± standard error (SE) after correction for mortalities of two vials from one of the check plots were determined by probit analysis (SAS 1988).

Results and Discussion

Untreated check. Mean adults, eggs, total larvae and pupae of SLW were determined on 22 sample d (Table 1). During the season adult populations ranged from 3.2 to 116/leaf, eggs ranged from 50 to 918.4/leaf, totals of larvae ranged from 0 to 558.4/leaf and pupal counts ranged from 0 to 40.8/leaf. These are very high mean populations of this insect. Three distinct generations of larvae are shown on d 161 (6-10), 179 (6-28) and 198 (7-17), which are 17 to 18 d apart. Larval populations in the first generation rose from 0 on d 151 (5-31) to 55.8 on d 161 (6-10), 10 d later. No d for generations was shown for adults indicating they dispersed from and into the plots and other susceptible hosts in the vicinity. "Red-eyed" pupae were greatest on d 198 (7-10) and fell to 0 nine d later on d 207(7-17).

Percentage of plants with "sooty" mold in the untreated checks was 16%, 52%, 0%, 8% and 92% on d 177 (6-26), 179 (6-28), 182 (7-1), 184 (7-3) and 189 (7-8), respectively. All untreated plants exhibited "sooty" mold from d 191 (7-10) to the last sample d 207 (7-26). The first open boll was found in the cotton on d 191 (7-10). Infestations of larvae greatly increased from this d until the last sample d.

Amitraz. Four applications were made at and after peak larval populations of SLW in generation one and before peak larval populations in generation two. The fifth application was made two d before peak larval populations in generation three. At the low and high use rate of amitraz significant reductions of adults were observed after the second and fourth application (Table 2). The low and high rates were equally effective since significant differences in adults and larvae in these plots and the check were determined on the same d. Significant reductions in two populations (11% of total) of adults were equal at both rates on 19 sample dates. A significant reduction in larval counts was shown on various sample dates after the third and fourth application. Significant differences of reductions of larvae were determined in 22% of the d between the check and each rate of amitraz until 14 d following the fourth application. The fifth and sixth applications at both rates showed no significant reductions of either adults or larvae on any sample dates. Both of these rates were applied following first open boll. The last and seventh application was made three d after the last sample d.

There were no significant differences in "red-eyed" pupae of SLW compared to the check on any of the 19 sample d on amitraz treated cotton (Table 2). Control of these populations is not considered to be as important as control of the adult and larval stages because their populations are lower and their duration is shorter than either the adults or larvae.

Mean percentage reduction of SLW adults was 49% and 43% to seven d after each application at the low and high rate, respectively. Mean percentage reduction of larvae was 53% and 46% to 14 d after each application at the low and high rate, respectively. There was no difference in efficacy at either rate.

Amitraz did not show consistent control of SLW following each application. Mortalities of adults, larvae or pupae were not reduced consistently on indicated d following each application. As hypothesized amitraz was not a long residual compound.

Buprofezin. Two applications were made two d apart with the second application made before generation two (d 179, 6-28) (Table 3). Sprays showed significant percentage reduction of larvae of SLW on d 177 (6-26) and 179 (6-28) (Table 3). This was the only significant difference in percentage reduction of larvae. After application three, made seven d after generation three (d 205, 7-24), there was no significant difference in reduced populations after zero and two d. However, 62-66% reduction of larval populations was determined for the season five and seven d after the first and second applications. but the reductions were not significantly different from the check., Buprofezin showed short-lived affects against larvae. Thus, hypothesis of long residual life was not correct. No reduction of larvae occurred later than 14 d after the second application. Also, there were no significant differences in percentage reduction for adults and "red-eyed" pupae on any of the 12 sample d in buprofezin treated plots.

Buprofezin did not show consistent control of SLW on indicated d following each application. Mean percentage reduction of adults and larvae following the 12 sample d was 38% and 49%, respectively.

Seed cotton yields following sprays of amitraz, at both rates, were significantly greater than the check (Table 4). Seed cotton yields following sprays of buprofezin were also significantly greater. There was no significant difference in the treated and the check in stickiness and reducing sugar of the lint samples. The reducing sugar content in this test was >0.3% in all the treatments. Elsner et al. (1983) used this percentage as a threshold level for maximum sugar content to be present on lint. The levels did not adversely affect the lint quality in this test so the minimum level could be increased. There was no significant difference in "sooty" mold incidence in treated and untreated plots so the results are not presented.

Vial bioassays of amitraz show that high concentrations (LC_{50} =1703.6 µg/vial) killed adults of the SLW (Table 5). In adults which were moribund and dead the LC_{50} was 87% less (234 µg/vial). This bioassay serves as a resistance monitoring method for adults of this insect. It is completed in three h. The calculated dose of LC_{50} will reflect its response to the insecticide if a wide range of doses are evaluated.

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Table 1. Populations of silverleaf whitefly in check on third leaf from terminal/plot. 1991. Weslaco, TX.

	Mean on third leaf from terminal			
Calendar d	**Adults**	**Eggs**	**Total larvae**	**Pupae**
151	6.4		0	0
154	3.2		12.6	0
156	9.0		76.0	0
158	40.0		48.6	0
161	30.8		55.8	3.2
163	44.4		24.4	2.4
165	67.4		17.6	1.6
168	56.3		3.7	0
171	43.2		9.2	0
175	40.2		29.6	0.4
177	62.5		49.8	3.0
179	63.8		60.5	1.0
182	23.0		5.4	0
184	31.4		3.2	0.6
189	48.4		17.0	6.4
191	12.4	135.6	48.6	8.4
193	34.0	198.4	181.6	5.6
196	84.0	50.0	341.2	17.6
198	116.0	918.4	558.4	40.8
203	45.6	526.6	155.6	9.6
205	12.8	293.6	158.6	9.6
207	11.2	64.0	42.4	0

Table 2. Percentage reduction[a] of silverleaf whitefly by Amitraz applied during the growing season. 1991. Weslaco, TX.

Calendar d	D after last application	Percentage reduction[b]		
		Adults	Total larvae	Pupae
0.14 kg (AI)/ha				
Applied d 157				
158	1	60	60	0
161	4	43	28	50
163	6	0	28	33
Applied d 164				
165	1	82*	85	75
168	4	88	92	0
Applied d 170				
171	1	57	98	0
175	5	54	95*	100
Applied d 175				
177	2	28	66*	44
179	4	85*	97*	80
182	7	12	70	0
184	9	66	0	0
189	14	0	85 b	91
191	16	0	0	100
193	18	0	18	0
196	21	0	0	0
Applied d 196				
198	2	50	18	0
203	7	1	0	0
Applied d 205				
205	0	58	20	58
207	2	67	0	0
0.28 kg (AI)/ha				
Applied d 157				
158	1	0	44	0
161	4	45	0	0
163	6	0	36	83
Applied d 164				
165	1	91*	44	58
168	4	79	82	0
Applied d 170				
171	1	68	89	0
175	5	31	91*	100
Applied d 175				
177	2	59	91*	87
179	4	76*	89*	40
182	7	0	0	0
184	9	59	66	67
189	14	0	78*	81
191	16	0	75	97
193	18	0	0	0
196	21	0	12	81
Applied d 196				
198	2	37	8	33
203	7	0	0	92
Applied d 205				
205	0	50	0	100
207	2	67	25	0

[a] Compared to the check.

[b] *Indicates significant difference from check by Tukey hsd at $P_{0.05.}$

Table 3. Percentage reduction[a] of silverleaf whitefly by buprofezin (0.56 kg (AI)/ha) applied during the season. 1991. Weslaco, TX.

Calendar d	D after last application	Percentage reduction[b]		
		Adults	Total larvae	Pupae
		Applied d 177		
177	0	17	96*	100
179	2	42	97*	100
182	5	43	66	0
184	7	52	62	0
189	12	0	0	0
191	14	0	0	0
193	16	0	71	0
196	19	0	89	27
198	21	0	0	0
203	26	35	0	0
		Applied d 205		
205	0	28	8	100
207	2	46	66	0

[a] Compared to the check.
[b] * Indicates significant difference from check by Tukey hsd at $P_{0.05.}$

Table 4. Kgs seed cotton/ha, stickiness and sugar on lint of treated and untreated cotton. Weslaco, TX, 1991[a].

Insecticide	Kg (AI)/ha	Seed cotton kg/ha [d]	Lint stickiness rating [e]	Sugar content (%)
Amitraz [b]	0.14	687 b	1.0 a	0.49 a
	0.28	695 b	0.8 a	0.45 a
Buprofezin [c]	0.56	689 b	0 a	0.42 a
Check		547 a	0 a	0.47 a

[a] Any two means followed by the same letter on vertical were not significantly different by Tukeys hsd at P0.05.
[b] Applied d 157 (6-6), 164 (6-13), 170 (6-19), 175 (6-24), 196 (7-15) 205 (7-24) and 210 (7-29).
[c] Applied d 175 (6-24), 177 (6-26), 205 (7-24) and 210 (7-29).
[d] Harvested 8-31 and 9-12.
[e] Based on 0 = no stickiness and 1 =light stickiness by minicard rating.

Table 5. LC_{50} values for adults of silverleaf whitefly following treatment of glass vial with Amitraz. Weslaco, TX. 1991.

Number treated	LC_{50} (µg/vial)	95% Confidence Interval	Slope ± SE
		Dead + moribund whiteflies[a]	
1937	234	109.9 - 721.4	1.67 ± 0.5
		Dead whiteflies[b]	
1937	1703.6	532.0 - $5x10^7$	0.97 ± 0.36

[a] Check mortalities were 10% for 405 adults.
[b] Check mortalities were 3.7% for 405 adults.