COMPARISON OF CONTROL IN THE FIELD AND ADULT VIAL BIOASSAYS OF TOBACCO BUDWORM WITH CYPERMETHRIN[1]

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ABSTRACT

In the Brazos Valley, TX, during 1988-1989, sprays of cypermethrin applied to cotton at rates of 0.06, 0.07, and 0.08 lb (a.i.)/A reduced the number of flower buds infested and damaged by larvae of the bollworm, *Helicoverpa zea* (Boddie), and the tobacco budworm, *Heliothis virescens* (F.) by > 89%, compared to the untreated check. To achieve this level of control, sprays were applied to egg and/or neonate larvae. Egg populations were reduced 50 to 80% in the treated plots within 2 to 4 days following 17 of the 19 applications during the 2 years of testing. In another test, 51% of tobacco budworm moths were killed within 24h following a spray application in the field.

LC_{50} values of the tobacco budworm ranged from 0.2 to 50.1 micrograms/vial using the adult vial bioassay technique. Neither these values nor the percentage of tobacco budworm moths that survived for 24h after a spray treatment was indicative of the level of reduction of larvae infested flower buds in plots sprayed at the lowest rate, 0.06 lb (a.i.)/A. The reduction of infested flower buds of bollworm and/or tobacco budworm in treated fields ranged from 61% to 100% following a vial bioassay.

INTRODUCTION

The adult vial testing procedure described by Plapp et al. (1987) has been used since 1986 in the Brazos Valley of Texas to determine response of male tobacco budworm, *Heliothis virescens* (F.), moths to pyrethroid insecticides. However, mortality values (LC_{50}) determined with this method have never been compared with the level of control of this insect in cotton fields.

The objective of the present study was to relate the level of control of the bollworm, *Helicoverpa zea* (Boddie), and the tobacco budworm in cotton fields with cypermethrin to the LC_{50} values and the percentage survival of tobacco budworm moths exposed to the same pesticide in vials.

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MATERIALS AND METHODS

Cypermethrin formulated as a 2.5 lbs/gal emulsifiable concentrate was used for test purposes. In April, 1988 and 1989, 20 fields or small plots of various cotton cultivars were planted within 24 km of Hearne, Robertson County, Texas to evaluate efficacy of cypermethrin for control of bollworm and tobacco budworms. Fifteen fields (5/rate), ranging from 19 to 43 acres, were randomly selected for season long treatment with either 0.06, 0.07 or 0.08 lb (a.i.)/A of cypermethrin. Nine applications were made in 1988 and 10 applications in 1989 in 1 gal/A total solution just before or at egg eclosion. Within five other whole fields, one untreated plot field was used as the untreated check. Fields ranged in size from 0.25 to 1.5 acres during both years. Insect populations were considered to be similar within these treated fields and untreated plots within fields. Cotton around the untreated plots received insecticide treatments.

The tests were conducted as described by Gage et. al (1990). In 1988, the total acreage treated with 0.06, 0.07 and 0.08 lb (a.i.)/A and untreated, were 178, 158, 188 and 4.7 acres, respectively. In 1989, 437, 390, 465 and 11 acres were treated with the same three rates and untreated, respectively. Cotton terminals (75/field/sampling date) were examined for eggs of the bollworm and tobacco budworm. Results were expressed as a percentage of plants with eggs, (1 egg/plant = 100% infestation). Flower buds or small bolls (75/field/sampling date) were selected at random across each field and examined for larval feeding damage and presence of larvae. Results were expressed as percent damaged and infested flower buds.

Plots were sampled 3 to 11 days following each application from day of year 175 to 235 in 1988 and from day 168 to 244 in 1989. A pretreatment count was made 1 to 2 days before the first application in both years. ANOV (SAS 1985) was used to determine significant differences among treatments during each of the two seasons. Seasonal means ($\pm$ SD), percent plants with eggs, damage to the fruit and larvae infesting fruit were separated by Tukey's honestly significant difference at P=0.05 (SAS, 1985).

On day 171, 188 and 196 in 1988 and day 169, 187, 219 and 226 in 1989, 5th or 6th instar larvae were collected from each untreated plot for species determination. Treated plots were not sampled because few larvae at these stages were ever observed during the sampling procedure. Results were summarized as mean percent tobacco budworms based on examination of the mandibular processes of 125 larvae on each date.

To determine toxicity of field sprays on adult tobacco budworm in 1988, an aerial application of cypermethrin at 0.08 lb (a.i.)/A in 1.5 qts cottonseed oil/acre was applied on day 288 to 425 moths in four wire cone traps (Hartstack 1979) (one trap/replicate). Untreated moths were obtained from four traps (one trap/replicate) located in the same field during the same night. Percent mortality values were determined after 24 hours.

The adult vial bioassay procedure was conducted as described by Gage et al. (1990) to determine the amount of control of adult tobacco budworm obtained with a field spray.

Adults (25 to 510 per trap night in 1988 and 50 to 630 per trap night in 1989) were collected from a total of 26 wire cone traps (Hartstack 1979) located 0 to 3 miles (1.8 mile average) and 0 to 12 miles (2.0 mile average) from the 20 treated and untreated fields and plots in 1988 and 1989, respectively. Percent survival of moths tested at 10, 30, 100 and 300 ug cypermethrin/vial after 24h was determined and compared to the LC_{50}, and field control during the season. Significant differences between LC_{50} values were calculated and shown when the 95% confidence intervals did not overlap.

In addition, linear regression analysis of LC_{50} and percentage control obtained in fields was conducted and resulting coefficient of determination, R^2, and level of significance at P=0.05 determined.

RESULTS AND DISCUSSION

Eggs of *H. zea* and *H. virescens* observed in this study were reduced by 17 to 34% in fields receiving nine applications of cypermethrin in 1988 (Table 1). Also, egg populations were significantly lower in plots treated with 0.07 and 0.08 lb (a.i.)/A cypermethrin than in untreated plots. In 1989, fields receiving ten applications had 45 to 52% fewer eggs than the untreated check. Egg populations were significantly lower in all treatment fields than those in the untreated check fields.

Seasonal mean percent damaged flower buds and larval infested flower buds in treated fields were reduced 89 to 95% compared to untreated check fields, regardless of the rate of cypermethrin applied or the year the test was conducted (Table 1). The percentage of damaged flower buds and infested flower buds treated with all rates of cypermethrin was significantly lower than the untreated check. These season long damage levels in treated fields were below the economic threshold level cited by the Texas Agricultural Extension Service (Anonymous 1989). Thus, cypermethrin provided effective control against these insects.

TABLE 1. Seasonal Mean Percent Plants with Eggs, Damaged Flower Buds and Infested Flower Buds in Brazos Valley, TX, 1988-89.

		Mean % ± SD					
Treatment	Amt lbs. Applied lb (a.i.)/A	Plants With Eggs	% Reduction	Damaged Flower Buds	% Reduction	Infested Flower Buds	% Reduction
		1988					
Cypermethrin[ab]	0.06	24±23	17	3 ± 3	93	4 ± 4	89
	0.07	21±21	28	2 ± 2	95	3 ± 3	92
	0.08	19±19	34	2 ± 2	95	3 ± 3	92
Untreated		29±15	-	42 ± 22	-	38 ± 18	-
Tukey's hsd	0.05	4.8		6.3		5.9	
		1989					
Cypermethrin[cd]	0.06	17±14	45	3 ± 4	93	3 ± 3	90
	0.07	16±14	48	3 ± 3	93	3 ± 3	90
	0.08	15±15	52	2 ± 3	95	2 ± 2	94
Untreated		31±14	-	42 ± 24	-	31 ± 18	-
Tukey's hsd	0.05	7.3		8.4		5.3	

[a] Sampled on calendar days 177, 175, 181, 185, 188, 192, 195, 199, 202, 207, 210, 213, 216, 224, 226, 230 and 235.

[b] Sprays applied on calendar days 172, 182, 189, 196, 204, 210, 221, 227 and 232.

[c] Sampled on calendar days 166, 168, 171, 175, 178, 181, 183, 187, 190, 193, 198, 201, 204, 208, 211, 216, 219, 222, 226, 229, 233, 236, 240 and 244.

[d] Sprays applied on calendar days 168, 175, 181, 187, 194, 201, 208, 219, 226, 233 and 236.

Percent of plants infested with eggs in plots sprayed with cypermethrin at 0.06 lb (a.i.)/A and the untreated check during 1988 and 1989 is shown in Fig. 1. The highest two rates of cypermethrin were not shown because the results were similar to the lowest rate. In 1988, 13 to 86% of the plants were infested with eggs prior to initiation of the sprays. In 1989, 12 to 71% of the plants had eggs prior to initiation of the sprays. Four days after applicaiton, the percentage of egg bearing plants ranged from 0 to 83% in 1988 and 0 to 82% in 1989. This reduction in egg population in treated fields could have been the result of adult mortality, repellency of females, ovicidal activity or combinations of all of these factors. Adult mortality was confirmed in an experiment where moths were sprayed directly by air. Percent mortality (51%) of moths sprayed with 0.08 lb (a.i.)/A after 24h was significantly higher ($t=14.09$, $df=6$, $t=0.05 = >0.001$) than the mortality (7%) of untreated moths.

The tobacco budworm comprised at least 98% of the larval population on and after day 199 in 1988 and day 229 in 1989 (Fig. 1). Following days 199 and 229, populations of larvae in squares were reduced an average of 92%. In 1988, 79% of the 15 sampling dates showed 90% or greater control and the minimum control level was 61% during the season. In 1989, 80% of the 16 sampling dates indicated 90% or greater control with a minimum control level of 87%. These results indicated equal and effective control of larvae of both species present in the plots treated with the lowest rate of cypermethrin.

The high level of control was most likely due to the direction of treatments to eggs and/or neonate larval stages. Previous work has demonstrated that neonate larvae, even of resistant strains, are far more susceptible to pyrethroids than 2nd or 3rd instar larvae (Campanhola and Plapp 1989a, Campanhola and Plapp, 1989b, Gage and Hatfield 1989). Timing of application is obviously critical in obtaining high levels of control of these pests.

The LC_{50} values (also shown by Gage et al. 1990) of vial bioassays for both 1988 and 1989 are arranged in a continuum from the lowest to highest values in Table 2.

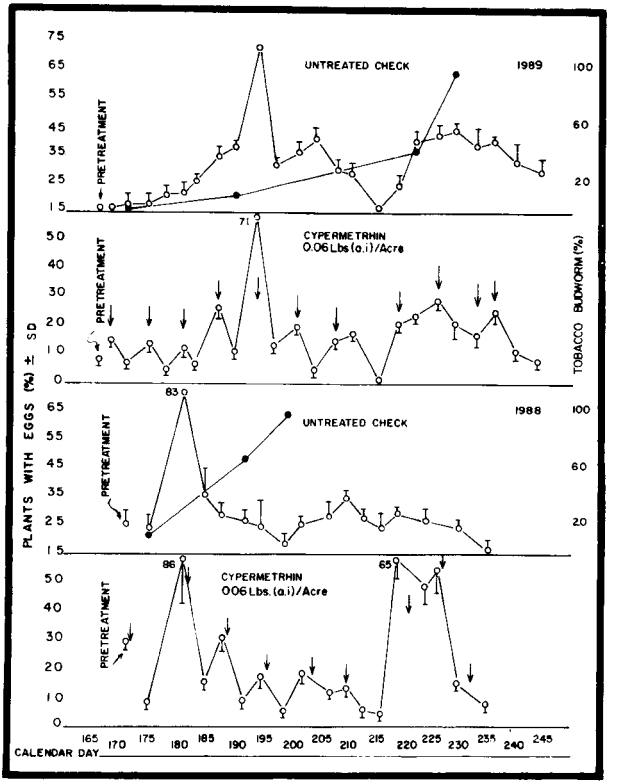

FIG. 1. Percent of plants with eggs in untreated plots and those sprayed (applications indicated by arrows) with cypermethrin (0.06 lb ai/A) during fruiting of cotton, Brazos Valley, TX, 1988-89. Solid black circles indicate percent tobacco budworm of total larvae sampled.

TABLE 2. LC_{50} Value (ug/vial) of Male *H. virescens*, Percentage Survivors at 10, 30, 100 and 300 ug cypermethrin/vial and Percentage Control Based on Infested Flower Buds from Replicated Field Plots, Brazos Valley, TX, 1988-89.

LC_{50} (ug/vial) as Dead and Moribund	Date Determined Day[a]	Year	Field Control (%) At 0.07 kg (a.i.)/ha %	Day	Percentage Adult Survivors At ug/vial 10	30	100	300
0.2	154	1988			17	0	0	
	166	1988	61	175	20	0	0	
3.3	194	1988	89	195	20	15	0	
3.7	197	1988	100	199	71	21	0	
4.6	188	1989	97	190	29	16	2	
6.0	224	1988	87	226	40	25	15	
7.1	195	1988	100	199	29	16	2	
7.5	190	1989	96	194	50	22	3	
9.5	189	1989						
10.1	203	1989	99	204	60	20	10	
10.4	207	1989	98	208	53	20	13	
11.7	260	1988			55	28	5	0
12.8	230	1988			60			
12.8	224	1988	87	226	36	24	28	0
16.8	204	1989	99	211	75	30	15	
18.1	214	1989	99	216	70	30	20	
20.5	228	1988			52	66	8	22
22.5	239	1988			59	51	22	7
26.2	228	1988	91	230	83	42	22	7
36.7	242	1989	92	244	82	48	27	
50.1	252	1989			76	66	40	21

[a] Day of collection shown by Gage, et al. (1990).

The associated percent survival was aligned with this continuum, and with some exceptions reflects the direct relationship of these parameters. However, control under field conditions when based on percent infested flower buds does not align with the arranged continuum of the LC_{50} values with cypermethrin in this two year study (Table 2). The coefficient of determination, R^2, of LD_{50} vs. percentage field control was 0.045 and the P=0.05 was not significant. This indicates no relationship between the toxicity indices. Control in the field (87-99%) remained high even when percent survival in vial tests reached high levels (36-83%). Also, the 95% confidence interval (C.I.) of each LC_{50} overlapped the 95% C.I. value of LC_{50}'s which were immediately higher or lower. Slope values were similar and flat as they ranged from 0.7 to 1.8 (Gage et al. 1990).

Limited work has been done to relate resistance monitoring techniques to actual control in the field. Wolfenbarger et al. (1984) showed an inverse relationship between percentage control of tobacco budworm larvae with methyl parathion in the field and LD_{50} values obtained with the standard topical bioassay. Luttrell et al. (1987) indicated that one strain of tobacco budworm seemed to be susceptible

to pyrethroids, as determined by the standard topical bioassay, although control problems were reported at the collection site. They suggested that this assay may not be completely reliable for detecting pyrethroid resistance in tobacco budworm. Subsequently, Roush and Luttrell (1989) showed a significant positive correlation between laboratory bioassays of treated plant tissue and the adult vial test using tobacco budworm. This cotton terminal assay technique simulated field conditions since it involved spraying formulated insecticides on cotton plants and determining mortality of third instar larvae placed on treated buds (Luttrell et al. 1987). Results from our studies indicate that the LC_{50} or percent tobacco budworm moth survival, at any adult vial assay rate, did not relate to the level of reduction of larvae infested flower buds achieved in the field with applications of cypermethrin. These results are based on conditions of high tobacco budworm infestation in the field plots during both years, frequent field sampling and adequate numbers of moths for adult vial testing. Differences noted could be attributed to factors such as the frequency of resistance individuals in the test population, discriminatory ability of the adult vial test (McCaffery et al. 1989), ability of the adult vial assay to reflect all possible resistance mechanism (McCaffery et al. 1989) and inappropriate vial rates (Gage and Hatfield 1989).

The adult vial test has been used effectively as a monitoring tool to establish responses to insecticide by tobacco budworms from different geograpical locations, among years and within a single season. However, we suggest that it currently is not a reliable technique to predict field performance of a particular insecticide. More research is necessary to determine if modifications such as increased concentrations/vial, will allow the adult vial assay to serve as an accurate predictor of the field performance of a given insecticide.

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