PYRETHROID RESISTANCE AND CARBAMATE TOLERANCE IN A FIELD POPULATION OF TOBACCO BUDWORM[1] IN THE MISSISSIPPI DELTA

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ABSTRACT

Tobacco budworm, *Heliothis virescens* (F.) larvae were collected in 1989 from a cotton field in the Mississippi Delta in which pyrethroid insecticides failed to provide control. Testing with a residual plant bioassay indicated high levels of resistance to two synthetic pyrethroid insecticides and possible tolerance to a carbamate insecticide. A similar bioassay of eggs from the field collected moths indicated reduced susceptibility to carbamates and pyrethroids. The adult vial test method for monitoring resistance appeared to confirm pyrethroid resistance. These data are compared to previous results with known resistant tobacco budworms. The larvae in the present study appear to be much more resistant to synthetic pyrethroids than those collected in 1986.

INTRODUCTION

Pyrethroid resistance in field populations of the tobacco budworm, *Heliothis virescens* (F.), has been known for several years (Plapp and Campanhola 1986, Luttrell et al. 1987). Resistance monitoring programs based on the glass vial technique for pesticide bioassay (Plapp et al. 1987) have been widely implemented and results from these programs have been used to modify resistance management plans. Recently, the glass vial technique was evaluated for utility in resistance monitoring and results were correlated with results from an adult bioassay technique (Roush and Luttrell 1989).

Pyrethroid resistance has been verified but much of these data are now several years old. Resistance management plans and grower compliance with these plans have varied, and it is important to continue monitoring tobacco budworm populations for resistance to insecticides. Herein, pyrethroid resistance in *H. virescens* using the glass vial technique is reported, and the insecticide tolerance of a laboratory colony of *H. virescens* newly removed from the field in August 1989 is evaluated. The purpose of this study was to evaluate resistance to several classes of insecticides, and to determine the response of other life stages. The results may aid in management decisions.

MATERIAL AND METHODS

Failure to control tobacco budworm with pyrethroid insecticides in cotton was reported in 1989 by a grower near Delta City, Miss. The field had been treated with cypermethrin (0.07 kg[AI]/ha) on 28 July, cyfluthrin (0.05 kg[AI]/ha) on 2 August, and cypermethrin (0.08

[1]Lepidoptera: Noctuidae

kg[AI]/ha) on 4 August. Larvae were collected on 8 August, and an application of thiodicarb was made later the same day. Larvae were reared in the laboratory on soybean flour-wheat germ diet (King and Hartley 1985). The first insecticide bioassays on this colony were begun one generation after removal from the field. Evaluations were made as soon as feasible to avoid physiological changes which might occur through long term adaptation to laboratory culture.

To determine the response of the culture to field rates of formulated insecticides, third instar larvae were exposed to recommended rates using a laboratory spray chamber (Bouse et al. 1970) with a modification of methods reported previously (Luttrell et al. 1987, Elzen et al. 1990). Test materials included cypermethrin (3 E; ICI Americas, Wilmington, DE); cyfluthrin (2 EC; Mobay Corp., Kansas City, MO); profenofos (8 EC; Ciba-Geigy Agricultural Div. Greensboro, NC); and thiodicarb (3.2 L; Rhone-Poulenc Ag, Co., Research Triangle Park, NC). Cotton terminals clipped from plants grown in the greenhouse were sprayed and allowed to dry briefly (30 min); a single third instar larva (19-21 mg) was placed on each terminal and then covered with a ventilated paper cup. Each treatment consisted of three replicates of 15 terminals each. All terminals and associated larvae were held for 72 h. Larvae were classified as dead or live. Moribund larvae were considered dead when total mortality was calculated. Percent mortality values were transformed to arcsin square root and analyzed by analysis of variance; means were separated using Least Significant Differences ($P \leq 0.05$) (Anonymous 1982).

To determine the response of the culture to formulated ovicides, eggs were treated using a modification of the spray table method described above. Eggs from a Stoneville susceptible culture of the *H. virescens* were also treated. Test materials include those described above and in addition the following: methomyl (2.4 LV; E. I. Dupont de Nemours & Co., Inc., Wilmington, DE); and amitraz (1.5 EC; Nor-Am Chemical Co., Wilmington, DE). All eggs tested were laid the previous night on organdy material. Eggs were not washed or subjected to chemical treatments before use. Pieces of the oviposition material containing 15-30 eggs each were cut and placed individually in a 9 cm dia petri dish containing water-moistened filter paper. After eggs were collected they were held for 24 h and only eggs which exhibited a germ band were treated; other eggs were punctured and removed. Treatments were replicated three times. Petri dishes containing eggs on organdy were then treated using the spray table; treatments were allowed to dry for 30 min and the petri dish covers were added. Egg and larval mortality were observed at 72 and 96 h after oviposition. Data are reported as percent control obtained from cumulative egg and larval mortality at the end of 96 h after correction using Abbott's (Abbott 1925) formula. Percent control values were transformed and analyzed as described above.

In addition, the glass vial technique (Plapp 1979) was used to test adults of both sexes from the Delta City collection. Single moths were exposed to a 5 ug residue of technical grade cypermethrin in 20 ml glass scintillation vials. Treatments were made to 43 females and 35 males. Control moths numbered 15 females and 10 males. Treatments were limited due to low numbers of adults at this time. Mortality of three day old moths was determined 24 hours after placement in treated or control vials.

RESULTS AND DISCUSSION

Results of the spray table bioassay are shown in Table 1. All treatments were significantly different from the control and the pyrethroid treatments were significantly different from the thiodicarb

and profenofos treatments. For comparison, a cypermethrin treatment (0.09 kg[AI]/ha) applied to a susceptible laboratory colony (Stoneville strain) of *H. virescens* resulted in 93% mortality (data not shown). The results indicate that the population from which the larval sample was collected in 1989 was resistant to synthetic pyrethroids. Cyfluthrin caused significantly greater mortality than cypermethrin at 0.07 kg[AI]/ha, but was not significantly different from the 0.09 kg[AI]/ha rate of cypermethrin. One profenofos treatment (1.12 kg[AI]/ha) resulted in 93% mortality which compares well with this treatment to susceptible larvae (97% mortality) (data not shown). Elzen et al. (1990) found 68% mortality with cypermethrin treatment (0.09 kg[AI]/ha) in a tobacco budworm strain obtained from a field control failure in the Mississippi Delta in 1986. The techniques in the previous study were identical to the present techniques except that the previous evaluations were made 48 hours after treatment (Elzen et al. 1990). Further, cyfluthrin (although at a higher rate of 0.037 kg[AI]/ha) produced 100% mortality (48 hours post-treatment) in the colony collected in 1986.

TABLE 1. Percent Mortality of Tobacco Budworm Larvae 72 h Following Spray Treatment with Various Insecticides[y].

Treatment	kg[AI]/ha	% Mortality
Control	--	0 a[z]
cypermethrin	0.07	23 b
cypermethrin	0.09	35 bc
cyfluthrin	0.034	38 c
thiodicarb	0.67	71 d
thiodicarb	1.0	80 de
profenofos	0.9	83 de
profenofos	1.12	93 e

[z]Means followed by the same letter are not significantly different ($P > 0.05$; LSD).

[y]Insecticides applied with a spray table.

Table 2 shows the results of the spray table treatment of eggs. There were significant differences in percent control by the various treatments in the Stoneville susceptible culture versus the recently collected pyrethroid resistant culture. For example, cypermethrin and cyfluthrin percent control values were significantly greater ($P < 0.05$) for the susceptible culture than for the resistant culture. This indicates that the expressed resistance seen in 3rd instar larvae (Table 1) is present in eggs and neonates. Percent control was also significantly lower with carbamate treatment in the resistant culture; 100% control was achieved on the susceptible culture. Complete control on both cultures occurred only with the organophosphate profenofos (Table 2). These data are in agreement with those of Leonard et al. (1990) who found that LC_{50}'s for all insecticides tested except profenofos on eggs of a pyrethroid resistant strain of *H. virescens* were significantly higher than LC_{50}'s for a pyrethroid susceptible strain. The low percent control seen with amitraz on both cultures is probably a consequence of the bioassay technique; amitraz action is invoked through incompletely understood mechanisms which may not have been present using the current technique. The present study did not determine if the resistance expressed in eggs would result in control problems in the field.

TABLE 2. Percent Control of Tobacco Budworm Eggs After Treatment with Various Insecticides[y].

Treatment	kg[AI]/ha	STV-lab susceptible	1989-Field resistant
cypermethrin	0.07	94 b *[z]	66 a
amitraz	0.14	73 a	73 ab
cyfluthrin	0.034	92 b *	74 ab
thiodicarb	0.14	100 c *	80 ab
methomyl	0.14	100 c *	81 ab
profenofos	0.14	100 c	100 b

[z] Means within columns followed by the same letter are not significantly different (P > 0.05; LSD); asterisk indicates significant differences within treatments across columns (P < 0.05; t-test).
[y] Insecticides applied with a spray table.

The adult vial test (5 ug, cypermethrin) performed on the Delta City colony resulted in 42% mortality of females (n=43) and 43% mortality of males (n=35). There was no control mortality of either sex (females, n=15; males, n=10). In comparison, Roush and Luttrell (1989) and Luttrell et al. (1987) found mean mortalities of 53% among females and 61% among males of three colonies collected from Mississippi. Results indicate that the resistance level in the population studied herein is now considerably greater than in populations from previous years.

In conclusion, these data indicate the susceptibility of tobacco budworm to other classes of insecticides needs to be monitored. While further testing may be required, attention should be given to the mortality produced on application of the high rate of thiodicarb (i. e. 80%, Table 1). Recent data obtained from Louisiana indicates resistance to carbamates in tobacco budworm (Elzen in press). In the face of pyrethroid control failures, alternative classes of insecticides should be used. However, no insecticide should be used to the exclusion of other effective classes. Furthermore, proper management and scouting are needed to insure that applications are made only when necessary.

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