Response of the Tobacco Budworm to Permethrin and Methyl Parathion in Arizona, 1977-1990

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Abstract

Field populations of tobacco budworm, Heliothis virescens (F.), have been monitored annually since 1977 with topical applications of synthetic pyrethroid insecticides (primarily permethrin) and methyl parathion to detect changes in insecticide susceptibility. These data showed that LD_{50}'s fluctuated somewhat from year to year with permethrin, but with one possible exception, the fluctuations were not sufficient to change levels of expected control in the field. Field populations continue to show susceptibility to permethrin even though one Maricopa County population showed an increase in the LD_{50} to 12.4 in 1988. Field populations continue to show resistance to methyl parathion and susceptibility to permethrin.

Introduction

The tobacco budworm, *Heliothis virescens* (F.), (TBW) was recorded for the first time as an economic pest of cotton, *Gossypium* spp., in Arizona in 1972 (Watson 1974). Following the discovery of TBW in cotton in AZ, dosage-mortality studies were conducted by Lentz et al. (1974) to determine the status of their susceptibility to the then currently used classes of insecticides. Their studies indicated that the TBW was more tolerant than the bollworm, *H. zea* (Boddie), to the insecticides tested and that the heterogeneity of the population showed a high probability that the more resistant individuals would be rapidly selected. Both species have been subjected to the more widely used insecticides since ca. 1945 and have developed varying levels of resistance to one or more in the different insecticide classes (Harris et al. 1972). Subsequent studies showed that this did, in fact, occur with methyl parathion (Crowder et al. 1979). The studies of Crowder et al. also provided base-line data for susceptibility to the newer synthetic pyrethroids which were being used on a limited acreage under an Experimental-Use Permit in 1978.

The pyrethroids proved to be extremely effective against the TBW, as well as numerous other cotton pests. Since resistance to pyrethroids had already been found in a number of insect species (Keiding 1976, Chadwick et al. 1977, Priester and Georghiou 1978, Fullbrook and Holden 1980, Liu et al. 1982, Scott et al. 1983). Jensen et al. (1984) conducted a laboratory experiment to determine the capacity of a susceptible field strain of TBW to develop resistance to permethrin and cross-resistance to cypermethrin. Their results showed that after only 11 generations of continuous selection pressure, the LD_{50} in the F_{12} generation had increased 37-fold compared with the LD_{50} of the F_1. Cross-resistance to cypermethrin was also ca. 8-fold greater.

Because of the rapidity of change among field populations of insects subjected to various insecticides, we have annually monitored populations of TBW after each growing season to determine changes in susceptibility to the organophosphate and pyrethroid insecticides. Watson et al. (1986) reported results of such studies with permethrin, fenvalerate and methyl parathion for the period of 1977-85, 1977-80

and 1972-85, respectively. Results of annual assessment of susceptibility of TBW to permethrin and methyl parathion for the period 1977-1990 are reported herein.

Methods and Materials

TBW cultures were established in the laboratory each year during the latter part of the growing season from 1976 to present. These provided populations which had undergone the maximum level of insecticide exposure during that particular year.

Larvae were collected from late-season cotton plants from the same general location in AZ each year. The 1990 Maricopa strain was collected from beans in South Phoenix rather than from cotton, where adequate numbers could not be located. They were then taken to the entomology laboratory at the University of Arizona Campus Agricultural Center, and placed in 29.6 ml plastic cups ca. 1/2 filled with a modified lima bean-agar diet (Patana 1969). Newly-emerged moths were transferred to wide-mouth 3.8 L glass jars, ca. 40 moths per jar. A double layer of cheesecloth was used to cover the tops of the jars and to provide a surface for oviposition. Glass and polytheylene tubes, corked at one end and filled with a 5% sucrose solution, were inverted through the cheesecloth to serve as the food source for adults. Egg sheets were treated as described by Patana (1969) and neonate larvae used in topical treatments were placed in plastic shoe boxes containing diet medium to a depth of ca. 1 cm. Those reared for the next generation were placed 2 per cup in the 29.6-ml plastic cups.

Larvae were maintained in an environator at a temperature of ca. 30°C. After 4 to 7 days, 3rd instar larvae were transferred to individual 29.6 ml 1/2 filled media cups for topical insecticide treatment. LD_{50}'s were determined on early-generation progeny of the field-collected parents, usually F_1 to F_3.

Insecticide applications and mortality counts were done by the standard test method for determining resistance in *Heliothis* (Anon. 1970). Larvae weighing an average of ca. 20 mg were topically treated and held as prescribed. Four to 5 replicates of 20 to 25 larvae each were generally treated at each of 4 to 6 dosage concentrations. The control consisted of a similar group treated only with acetone. A sample of ca. 20% of each group of larvae was weighed prior to treatment and the weights used in determining the LD_{50}.

Mortality counts were made at 48 and 72 h after treatment. Larvae were considered dead if they failed to respond to repeated prodding with a blunt probe. The 48- and 72-h counts were used to compute the dosage-mortality lines for methyl parathion and permethrin, respectively. Data were analyzed using probit-analysis (Finney 1952).

Results and Discussion

Table 1 presents toxicological data on TBW from field collections over a 14-year period. These data show some change in the LD_{50} with permethrin from year to year, but only at one time and one location did it rise to a level that would indicate potential problems with field control. In general, the LD_{50}'s ranged from < 2.0 μg/g to < 6.0. Two exceptions to this were recorded, both in Maricopa County where traditionally heavier insecticide use occurs. These exceptions showed LD_{50}'s of 8.35 and 12.40, respectively, for 1981 and 1988. Even at the outset of permethrin use, field populations were more tolerant to the pyrethroids than was the domestic strain cultured in the laboratory by the USDA-ARS in Tucson, AZ (Table 1).

During some years, data were collected for TBW from other locations in AZ, particularly Yuma and Pinal Counties. These data were more limited than were those from Maricopa County but again, variable results were obtained from year to year; in general, the Yuma County populations appeared

to be slightly more susceptible to permethrin.

Table 2 shows data on tolerance of TBW to methyl parathion for a 15-year period. In Pinal County in 1972, field control of the TBW was noticeably difficult to achieve and Lentz et al. (1974) reported an LD_{50} of 19.7 μg/g for field populations collected in 1972. The next determination was in 1976 when the LD_{50} had reached 141 μg/g. In 1977, when yearly monitoring was initiated, the LD_{50} of field-collected TBW was 173 compared to 11.5 for that of the domestic (laboratory) strain. Even though year to year fluctuations have occurred, the LD_{50} has remained high except for 1982, when it dropped to 21.3 μg/g, approaching that of the initial outbreak year of 1972. Methyl parathion is still an ineffective insecticide against the TBW in Arizona.

Even though LD_{50}'s have varied from year to year with the pyrethroids, in general, fluctuating in the 3 to 6 LD_{50} range, field control has still been easily obtained, indicating no resistance problems to date. This is no assurance that control problems will not eventually develop in the field as has occurred in Texas (Plapp and Campanhola 1986) and other locations in the mid-south (Luttrell et al. 1987).

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Table 1. LD_{50} values with confidence limits and b values for permethrin applied topically to tobacco budworm larvae, Tucson, Ariz., 1977-90.

Year	Source of Culture	LD_{50} ($\mu g/g$)	95% Fiducial Limits	b value
1977	Maricopa	1.17	0.89 - 1.56	1.56
	Domestic[a]	0.21	0.18 - 0.26	2.75
1978	Maricopa	5.96	4.15 - 17.00	1.57
	Pinal	4.66	3.84 - 7.39	2.59
1979	Pinal	5.89	4.87 - 7.37	2.20
	Yuma	2.69	2.33 - 3.10	1.79
1980	Maricopa	3.48	2.47 - 4.43	1.41
	Yuma	1.79	1.40 - 2.16	1.70
1981	Maricopa	8.35	6.91 - 10.20	1.25
	Yuma	3.46	3.02 - 4.01	1.93
1982	Maricopa	1.79	1.58 - 2.04	2.42
1983	Pinal	2.12	1.87 - 2.41	2.20
1984	Maricopa	3.68	3.19 - 4.25	1.80
1985	Maricopa	1.80	1.62 - 2.01	2.40
1986	Maricopa	5.71	4.99 - 6.54	1.75
1987	Maricopa	3.73	3.05 - 4.57	1.82
1988	Maricopa			
	W. Phoenix	12.40	10.2 - 15.1	1.26
	Laveen	3.06	2.74 - 3.41	2.81
1989	Maricopa			
	W. Phoenix	4.84	4.21 - 5.56	1.61
	Laveen	5.21	3.44 - 7.18	1.33
	Yuma	5.06	4.39 - 5.84	1.97
1990	Maricopa[b]	3.43	2.81 - 4.22	1.98
	Yuma[c]	6.71	4.47 - 9.58	1.07

[a] Culture established from stock obtained from USDA-ARS Biological Control Laboratory, Tucson, AZ.

[b] Collected from beans in South Phoenix.

[c] Collected from cotton in Texas Hill.

Table 2. LD_{50} values with confidence limits and b values for methyl parathion applied topically to tobacco budworm larvae, Tucson, Ariz., 1972-90.

Year	Source of Culture	LD_{50} ($\mu g/g$)	95% Fiducial Limits	b value
1972	Pinal[a]	19.7	17.2 - 21.9	2.56
1976	Maricopa[b]	141.2	54.9 - 860.3	1.64
1977	Maricopa	173.0	127.0 - 241.0	1.09
	Domestic[c]	11.5	9.4 - 13.7	2.50
1978	Maricopa	259.0	210.0 - 318.0	1.41
	Pinal	211.0	180.0 - 255.0	1.68
1979	Pinal	142.0	117.0 - 172.0	1.40
	Yuma	100.0	79.6 - 120.0	1.53
1980	Maricopa	140.0	95.0 - 191.0	1.69
	Yuma	96.3	86.7 - 107.0	2.47
1981	Maricopa	90.3	64.9 - 118.0	2.07
	Yuma (Spring)	103.0	65.6 - 150.0	1.17
1982	Maricopa	21.3	19.0 - 23.9	2.91
1983	Pinal	76.2	66.4 - 87.5	2.05
1984	Maricopa	62.3	56.2 - 69.1	2.12
1985	Maricopa	67.4	52.9 - 85.7	1.15
1986	Maricopa	62.5	32.1 - 98.6	0.89
1987	Maricopa	75.1	51.3 - 101.4	1.31
1988	Maricopa			
	W. Phoenix	204.0	122.0 - 311.0	1.12
	Laveen	129.0	105.0 - 164.0	1.94
1989	Maricopa			
	W. Phoenix	152.6	97.9 - 222.0	0.97
	Laveen	172.9	140.0 - 214.0	1.19
	Yuma	46.4	30.7 - 64.1	1.63
1990	Maricopa[d]	130.0	106.0 - 158.0	1.38
	Yuma[e]	83.2	59.6 - 108.0	1.36

[a] Data from Lentz et al. (1974).
[b] Data from Crowder et al. (1979).
[c] Culture established from stock obtained from USDA-ARS Biological Control Laboratory, Tucson, AZ.
[d] Collected from beans in South Phoenix.
[e] Collected from cotton in Texas Hill.