RESPONSE OF THE TOBACCO BUDWORM[1] TO CYPERMETHRIN IN THE SOUTHWEST, 1979-1989

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ABSTRACT

Adult male tobacco budworms, *Heliothis virescens* (F.), were field collected in Arizona, California and Texas during the years 1980 to 1989. Larvae from these population samples were subjected to topical evaluations with cypermethrin. Data from these tests were compared to similarly generated data with larvae from susceptible laboratory and field strains collected in Georgia. Tobacco budworm larvae from the southwestern states were found to be considerably less susceptible to cypermethrin than the reference strains. Susceptibility levels, as shown by the topical tests, remained stable from 1980 to 1986 although some of the least susceptible larvae were identified from population samples collected in Arizona and Texas in 1980 and 1982. The least susceptible population identified was collected from Brazos Co., Texas in 1988 and was from a field which had experienced a tobacco budworm control problem. In 1987, field monitoring was begun using the adult vial test. Results of these tests show there is considerable geographical and seasonal variation in the susceptibility data. Data from the adult vial test also indicated low pyrethroid susceptibility in Brazos Co., Texas. The 10 ug per vial rate was an indicator of changing susceptibility but levels less tha 20% survival between tests were usually not statistically different. Both tests indicated variable pyrethroid susceptibility with location and season.

INTRODUCTION

A pyrethroid resistance monitoring program for the tobacco budworm, *Heliothis virescens* (F.), was initiated by FMC Corporation in 1979. The program was designed to survey tobacco budworm susceptibility to permethrin and measure annual changes in permethrin susceptibility of larvae from selected areas across the Cotton Belt. This was one of the first instances in which an insecticide susceptibility monitoring program was initiated before resistance problems were encountered in the field.

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Although resistance ratios are frequently used, it is change in insdecticide susceptibility relative to baseline values that is most important in evaluating resistance monitoring data. Once baseline values have been established, a good monitoring program should provide data which will detect changes in susceptibility levels over time. The FMC monitoring program utilized the standard topical test method (Anonymous 1970) conducted with third instar larvae. The early results of this work have been reported elsewhere (Staetz 1985). In 1980, cypermethrin was added to the monitoring program. Baseline data and monitoring results for cypermethrin susceptibility for 1980 through 1986 showed considerable year to year variation with some decline in susceptibility; the highest values were generated with larvae from Arizona in 1982 (Staetz, 1987). Susceptibility data for cypermethrin for these and subsequent years are reported in this paper.

In 1987, FMC began using the Adult Vial Test (AVT) (Plapp et al. 1987) to monitor pyrethroid susceptibility changes to cypermethrin in field collected adults as part of the PEG-US program. This bioassay test was selected because tobacco budworm populations could be frequently bioassayed using field collected adult male moths. The relative simplicity of the test allowed the testing of populations at a number of locations across the Cotton Belt. The results of this research with populations from the Southwest (Arizona, California and Texas) are reported in this paper.

MATERIALS AND METHODS

Topical Test. A generally accepted standard topical test method (Anonymous 1970) was adopted for the FMC monitoring program (Staetz 1985) and subsequently used as part of the PEG-US Program (Staetz 1987). Generally adults, occasionally larvae, and eggs, were collected from the field. The larvae (22±3 mg) resulting from these collections were used for testing. These larvae were treated by direct applications of technical insecticide dissolved in acetone. The treatment was made using a Burkard microapplicator to apply selected, equally spaced, logarithmic doses of the insecticide in 1.0 ul droplets to the larval cuticle. Usually 30 larvae per rate (10 per petri dish) were used; no less than 20 larvae per rate, with 5-7 rates generally made up a test. Two or three tests were usually run on separate days with larvae from each collection site.

After treatment, the larvae were provided with artificial diet. Larvae were considered dead if they could not crawl normally or right themselves after being turned over. Moribund larvae (those which demonstrated some movement after being prodded but could not crawl or right themselves) were considered dead for purposes of data analysis. Mortality was recorded 24, 48, and 72 h after treatment with the 48 h data being subjected to probit analysis (SAS 1985) and used for all comparisons. Resulting LD values were corrected for larval weight and expressed in terms of micrograms of insecticide per gram of larval weight. This allowed more precise comparison of data from tests using larvae of different weights.

Adult Vial Test. Adult susceptibility was measured using the coated vial test (Plapp et al. 1987) with some modifications (Simonet et al. 1988). Monitoring sites were established in the Imperial Valley of California, southwest Arizona and three areas of Texas: the Rio Grande Valley, Brazos Co. and the Uvalde area. Monitoring was begun in April and continued through October at various locations depending on the cotton growing season.

Pheromone traps were used to collect male tobacco budworm adults. The pheromone traps were checked daily and only vigorous moths were retained for the testing. Moths held for more than one day were fed sugar water.

Technical grade cypermethrin (FMC Corporation) was used as the pyrethroid standard in these tests. The insecticide was applied to 20 ml glass scintillation vials in 0.5 ml of acetone solution. An even coating of the material was achieved by rolling the vials in a hot dog cooker until all acetone had evaporated. The rates used were 1, 5, 10, 30, and 100 ug/vial.

A standard toxicity test with this technique consisted of placing one moth per vial with 20-30 vials being used per rate when possible. Vials were used only once and only one moth was placed in each vial. If only a few moths were collected, they were tested at the 10 ug/vial rate first. The vial caps were loosely attached and the vials kept at room temperature in a horizontal position for 24 hours. At that time the moths were examined and rated as alive, moribund or dead. Moths which were alive but could not fly (moribund) were considered dead. In all cases moths were also placed in untreated vials to determine natural mortality. Only data from tests with less than 20% check mortality were used in any statistical analyses. However, all data were recorded.

RESULTS AND DISCUSSION

Baseline Data. These data are important because it is against these values that data generated later can be compared to determine if susceptibility levels in a particular area are changing. Baseline data are really a range of values rather than a discrete number. The initially reported baseline LD values generated for permethrin and cypermethrin on tobacco budworm larvae varied considerably across the Cotton Belt (Staetz 1987). It is actually change in susceptibility relative to baseline data that is important rather than absolute numbers. It is also important to examine the upper portion of the dose-response line because, in many instances, the first indication of decreasing susceptibility is shown by increases in the LD or LC_{90} values even though little change is observed in the LD or LC_{50} values.

Resistance ratios are often cited to demonstrate levels of resistance in a particular field population. However, the actual resistance ratio calculated could vary significantly depending on the value used from tests with a susceptible reference strain. For example, the average LD_{50} value for our laboratory susceptible strain over the years is 0.3 ug/g for cypermethrin in topical tests. However, in 1987 and 1988 the range of LD_{50} values for 22 tests conducted with the susceptible strain ranged from 0.1 to 0.7 ug/g of cypermethrin (Table 1).

TABLE 1. Variation in LD_{50} and LD_{90} Values (ug/g of Body Weight) for Cypermethrin Applied Topically to a Laboratory Susceptible (BRC) Strain of Tobacco Budworm.

	LD_{50}		LD_{90}	
	1987	1988	1987	1988
	0.3	0.2	1.3	0.5
	0.2	0.2	0.6	0.4
	0.2	0.2	0.4	0.4
	0.1	0.2	0.5	0.6
	0.2	0.3	0.6	0.9
	0.2	0.1	0.7	0.3
	0.7	0.2	3.0	0.7
	0.4	0.3	1.4	0.9
	0.5	0.1	1.5	0.5
	0.4	0.3	1.5	1.2
	0.4		1.7	
	0.5		1.8	
Mean	0.3	0.2	1.3	0.6
Range	0.1-0.7	0.1-0.3	0.4-3.0	0.5-1.2

If the average LD_{50} value is used to calculate a resistance ratio for tobacco budworms from Arizona in 1987 the resistance ratio would be 12.3; with the lowest LD_{50}, the resistance ratio would be 31 while with the highest value the resistance ratio would be 4.4. The true value probably lies somewhere in the range between 4.4 and 31.

Topical Results. The FMC pyrethroid susceptibility monitoring program with cypermethrin on tobacco budworm is based on topical tests with technical cypermethrin applied to third instar larvae. The results of this program with population samples collected in Arizona, California and Texas are shown in Table 2. Resistance ratios, calculated from the average LD_{50} and LD_{90} values, are shown to compare the relative susceptibility of the field strains from Arizona, California, and Texas. Data from tests with larvae from Georgia are provided to illustrate the relative difference in pyrethroid susceptibility of tobacco budworm populations in the southwestern versus those from the southeastern United States.

TABLE 2. Topical LD Values (ug/g) for Cypermethrin on Third Instar Tobacco Budworm Larvae (22±3 mg) for the Years and Locations Shown.

Year	State	Gen.	n	LD_{50}	(95% C.I.)	LD_{90}	(95% C.I.)	Slope	S.E.	$RR@LC_{50}$ Resistance Ratio Compared to Lab-S Strain	$RR@LC_{90}$ Resistance Ratio Compared to Lab-S Strain
Mean Lab-S Strain				0.3	0.1-0.5	0.9	0.5-10.9	2.54	0.21	1.0	1.0
1980	LAB	Fn	360	0.9	0.01-1.8	3.0	0.9-99.8	2.57	0.16	3.8	3.2
	GA	F1	360	0.4	0.1-1.0	1.9	0.8-42.3	1.92	0.01	1.6	2.1
	AZ	F1	1080	3.4	0.5-7.6	24.0	9.9-111.4	1.68	0.30	13.5	25.6
	CA	F1	720	2.4	1.0-4.6	15.0	7.2-103.2	1.76	0.39	9.8	16.0
	TX-R	F1	720	1.3	0.5-2.7	27.8	9.5-254.1	0.95	0.02	4.3	30.9

TABLE 2. (Cont'd).

Year	State	Gen.	n	LD_{50}	(95% C.I.)	LD_{90}	(95% C.I.)	Slope	S.E.	RR@LC_{50} Resistance Ratio Compared to Lab-S Strain	RR@LC_{90} Resistance Ratio Compared to Lab-S Strain
1981	LAB	Fn	540	0.1	0.01-0.2	0.5	0.1-0.7	1.73	0.11	0.2	0.5
	GA	F1	210	0.1	0.03-0.2	0.9	0.5-2.2	1.41	----	0.4	0.9
	AZ	F1	360	2.0	0.7-3.2	8.0	4.9-34.2	2.25	0.45	8.1	8.5
	AZ	F2	180	0.6	0.3-0.8	1.7	1.3-3.1	2.71	----	2.4	1.9
	CA	F1	540	0.7	0.1-1.5	4.6	2.4-13.1	1.59	0.12	2.8	4.9
	TX-R	F1	900	0.8	0.5-1.3	6.5	3.7-19.8	1.34	0.10	2.7	7.2
1982	GA	F2	210	0.3	0.1-0.6	1.3	0.7-3.6	2.27	----	1.4	1.4
	AZ	F1	360	1.6	1.1-4.3	29.5	12.4-177.5	3.22	0.65	6.6	31.5
	AZ	F2	900	2.0	0.5-5.2	12.2	5.0-56.5	1.75	0.22	8.2	13.0
	AZ	F3	720	3.0	0.3-3.6	11.4	4.1-131	2.48	0.29	12.1	12.2
	AZ	F4	360	0.8	0.3-1.6	7.4	3.3-8.3	1.47	0.20	3.2	7.9
	CA	F1	720	3.2	0.7-5.8	15.1	8.5-120.0	1.90	0.01	12.7	16.2
	TX-R	F1	900	0.9	0.6-1.2	5.6	3.5-15.0	1.78	0.27	3.0	6.2
	TX-B	F1	1470	0.6	0.7-0.8	4.1	2.4-8.5	1.67	2.20	2.0	4.6
1983	AZ	F1	540	0.2	0.03-0.7	2.2	0.8-41.1	1.10	0.17	0.9	2.4
	AZ	F2	720	0.9	0.2-2.0	4.6	1.5-15.7	2.34	0.60	3.5	5.0
	AZ	F3	720	0.6	0.2-1.0	2.8	1.8-5.5	2.00	0.16	2.5	3.0
	CA	F1	360	1.0	0.2-1.6	3.4	2.1-20.0	1.98	0.05	3.9	3.7
	CA	F2	720	0.6	0.3-1.2	2.6	1.5-6.8	2.17	0.23	2.6	2.8
	TX-R	F1	210	0.8	0.5-1.5	2.6	1.8-7.6	2.60	----	2.7	2.9
	TX-U	F1	1800	0.5	0.3-1.5	5.0	2.5-20.0	1.50	0.10	1.7	5.6
1984	Very light year; insufficient larvae for testing.										
1985	AZ	F1	900	1.3	0.3-2.6	6.5	3.6-20.1	1.98	0.21	5.2	7.0
	TX-R	F1	360	2.2	0.8-3.0	5.0	3.4-70.0	3.95	0.35	7.3	5.6
	TX-U	F1	540	4.0	2.9-4.9	28.3	20.8-42.8	2.12	0.42	13.3	31.4
1986	GA	F1	540	0.6	0.2-0.7	1.6	1.1-2.6	3.08	0.70	2.3	1.7
	AZ	F1	1080	2.4	0.5-3.5	6.2	4.2-71.0	3.16	0.35	9.6	6.6
	TX-U	F1	540	3.4	0.6-9.0	17.4	7.4-24.3	1.96	0.50	11.3	19.3
1987	LAB-S	Fn	720	0.2	0.1-0.3	0.5	0.3-1.2	3.25	0.65	0.7	0.5
	GA	F1	360	0.5	0.3-0.7	1.3	1.0-2.6	3.12	0.35	2.0	1.4
	AZ	F1	720	3.1	1.4-4.8	14.3	9.0-30.0	1.94	0.07	12.3	15.3
	TX-R	F1	1080	4.1	0.7-6.3	17.8	7.4-24.3	2.26	0.40	13.7	19.8
	TX-B	F1	540	13.2	0.1-31.3	81.2	28.9-358	1.74	0.37	44.0	270.72
	TX-U	F1	540	5.3	1.2-10.9	30.4	13.2-196.8	2.11	0.50	17.7	33.8
1988	LAB-S	Fn	940	0.2	0.1-0.3	0.7	0.4-1.5	2.66	0.37	0.7	0.8
	AZ	F1	1080	9.4	2.6-13.2	62.8	17.3-94.0	1.90	0.26	37.7	67.1
	TX-R	F2	540	2.8	0.7-4.6	9.0	4.5-53.8	4.25	1.8	9.3	10.0
	TX-B	F1	360	14.4	2.7-26.4	112.4	57.2-1329	1.44	0.03	48.0	124.92
	TX-B	F2	720	6.5	1.4-19.0	41.7	19.1-94.2	1.67	0.16	21.7	46.3
	TX-B	F3	720	20.3	3.8-9.5	29.6	10.6-72.8	1.68	0.29	67.7	32.9
	TX-U	F1	360	15.8	3.8-23.9	50.3	32.2-3704.	2.58	0.34	52.7	55.9
1989	LAB-S	Fn	540	0.3	0.1-0.5	1.2	0.8-2.9	2.08	0.08	1.1	1.3
	GA	F1	210	0.6	0.3-1.0	3.0	1.1-6.8	1.76	0.13	2.4	3.2
	AZ	F1	210	16.2	0.1-28.5	42.2	24.8-108.4	3.08	0.21	65.0	45.1
	TX-B	F1	540	12.4	4.7-20.5	59.2	35.6-243.9	1.88	0.32	41.3	65.8

TX-R = Rio Grande Valley, TX
TX-B = Brazos River, TX
TX-U = Uvalde, TX

Note that tobacco budworm susceptibility (as indicated by LD_{50} values) remained relatively stable from 1980 through 1986 although some of the higher LD_{90} values were observed with larvae from Arizona, California and Texas in 1980 and 1982.

In 1987, LD values began to increase substantially in Texas and some field control problems were encountered in Brazos Co., Texas. The highest LD_{90} value to date from topical studies was generated with larvae from that area in 1988. This value (LD_{90}=112.4 ug/g) was about 125 times higher than that of the mean value of the laboratory susceptible strain and about 80 times higher than the average LD_{90} value for Georgia for the years 1980 - 1987 (Table 2). Values for Arizona and the Uvalde, Texas area also showed substantial increases but larvae from the Rio Grande Valley of Texas were much more susceptible with an LD_{90} value of only 9.0 ug/g. Tests with F2 and F3 Brazos strain larvae showed a considerable increase in susceptibility from one generation to the next (LD_{90}: F1= 112.4 ug/g, F2= 41.7 ug/g, F3= 29.6 ug/g). This increase in susceptibility from the F1 to the F3 generation indicated that the genes for pyrethroid resistance may not yet have become fixed in that population. Although the LD_{50} value for larvae from the Brazos area in 1989 was similar to the 1988 value, the LD_{90} declined from 112.4 ug/g to 59.2 ug/g.

Adult Vial Test. In 1987, PEG-US was founded and bioassays utiliting the AVT were initiated over large areas of the Cotton Belt. These tests were conducted in conjunction with the topical tests.

The results of all rates used in the adult vial tests are summarized by year, state and week in Table 3. In general, adult survival tended to be lower in the early and late portion of each season and higher in the middle portion of each season. Additionally, adult survival was higher in Brazos Co., Texas than in any other area tested in 1987, 1988 and 1989, particularly at rates of 10 ug/vial and higher.

TABLE 3. Survival of Adult Male Tobacco Budworms Collected in the Areas Indicated After 24h Exposure to Cypermethrin using the Adult Vial Test.

Year	State	Date	Moths/rate	ug/Vial					
				100	30	10	5	1	0
1987	GA	SP3-SP9	30	0	0	0	13	27	7
	AZ	AG13-AG19	16	0	13	0	75	62	88
		SP3-SP9	6	0	0	17	67	83	83
		SP10-SP16	68	1	13	37	64	80	95
		SP17-SP23	62	5	19	40	79	76	92
		SP24-SP30	47	4	30	49	74	89	88
	CA	SP10-SP16	25	0	29	29	100	100	100
		SP17-SP23	13	4	33	29	65	80	98
	TX-R	AG20-AG26	20	11	13	54	58	82	94
	TX-B	JL16-JL22	60	0	0	0	40	80	100
		AG20-AG26	166	23	61	59	85	96	100
		AG27-SP2	363	48	49	67	89	94	95
	TX-U	JL30-AG5	177	7	15	21	81	81	97
1988	GA	MY14-MY20	12		10	0	0	0	85
		JN11-JN17	20		0	0	10	0	85
		JN18-JN24	20		0	0	0	0	70
		JL2-JL8	10		0	0	0	0	80
		JL9-JL15	20		0	0	0	5	80
		JL16-JL22	18		0	0	0	0	30
		JL23-JL29	20		0	0	0	5	55
		AG13-AG19	20		0	0	28	50	80
		AG20-AG26	20		0	0	5	35	85

TABLE 3. (Cont'd).

Year	State	Date	Moths/rate	ug/Vial 100	30	10	5	1	0
1988	AZ	SP3-SP9	85	5	17	52	77	95	100
	CA	OT1-OT7	15		0	10	10		90
		OT8-OT14	17	10	5	24	35	90	95
		OT15-OT21	32	3	10	23	30	60	87
		OT22-OT29	10	0	0	30	40	30	90
1988	TX-R	AP23-AP29	14	0	17	25	75	91	100
		AP30-MY6	24	0	0	17	21	54	92
		MY21-MY27	20	5	5	27	32	50	100
		JN4-JN10	32	2	8	10	20	70	97
		JN11-JN17	96	3	10	26	50	80	99
		JN18-JN24	90	8	25	40	52	80	99
		JN25-JL1	89	9	19	47	44	88	90
		JL2-JL8	70	3	16	35	35	77	100
		JL9-JL15	37	21	21	55	40	87	100
		JL16-JL22	50	6	16	52	54	98	100
		JL23-JL29	24	0	12	19	15	69	100
1988	TX-B	JN11-JN17	10	0	0	9	36	27	86
		JL9-JL15	127	3	13	34	43	91	99
		JL16-JL22	151	1	12	42	41	93	100
		JL23-JL29	155	8	29	51	51	96	99
		JL30-AG5	60	0	0	45	70	90	100
		AG6-AG12	20	15	25	40	55	--	100
		AG13-AG19	312	23	37	66	77	92	93
		AG27-SP2	100	19	51	59	87	--	97
		SP17-SP23	25	5	35	69	60	100	90
1988	TX-U	MY28-JN3	16	0	6	0	35	33	69
		JN25-JL1	24	0	0	0	12	10	100
		AG6-AG12	57	10	27	53	71	--	100
		AG13-AG19	18	--	--	42	53	--	94
		SP3-SP9	26	10	10	10	10	--	10
1989	GA	AG6-AG12	94	--	0	2	19	48	100
		AG13-AG19	40	--	0	5	35	50	100
		AG20-AG26	98	--	0	6	1	53	95
		AG27-SP2	68	--	0	8	1	34	93
		SP3-SP9	10	--	0	20	0	70	100
		SP10-SP16	8	--	10	10	0	15	100
		SP17-SP23	45	--	0	0	2	25	96
		SP24-SP30	57	--	2	2	8	17	86
1989	TX-B	JL2-JL8	94	3	26	45	50	85	100
		JL9-JL15	36	3	22	50	58	86	100
		JL16-JL22	30	10	20	60	63	90	97
		JL23-JL29	20	15	30	75	75	90	100
		JL30-AG5	100	20	30	40	70	100	90
		AG27-SP2	200	54	42	81	88	90	96

TX-R = Rio Grande Valley, TX
TX-U = Uvalde, TX
TX-B = Brazos River, TX

The 10 ug/vial rate was chosen as a standard rate to be included in all tests. While this rate is sensitive enough to detect changes in susceptibility, it is not high enough to predict the efficacy of field applications of cypermethrin (Gage et al. 1990). In addition, increased survival at 10 ug/vial does not always indicate increased survival at higher rates, particularly at rates which are equivalent to actual field rates (Gage et al. 1990).

Although the 10 ug/vial rate does indicate changing levels of pyrethroid susceptibility, there is a large enough range in the confidence limits that differences of less than

20% between tests are usually not statistically significant (Table 4). Changes in survival to this degree are rarely seen from one weekly sampling date to another in a given location.

TABLE 4. Summary of Adult Vial Survival Data for Adult Tobacco Budworms Collected in the Areas Indicated and Treated at the 10 ug/vial Rate.

Year	State	Date Range	n	% Survival	95% C.I.
1987	GA	SP3-SP9	30	0	(0 - 23)
	AZ	AG13-AG19	16	0	(0 - 22)
		SP3-SP9	6	17	(0 - 54)
		SP10-SP16	70	37	(26 - 48)
		SP17-SP23	62	40	(28 - 52)
		SP24-SP30	47	49	(36 - 62
	CA	SP10-SP16	25	29	(11 - 47)
		SP17-SP23	13	29	(4 - 54)
	TX-R	AG20-AG26	20	54	(32 - 76)
	TX-B	JL16-JL22	10	0	(0 - 31)
		AG20-AG26	27	59	(40 - 78)
		AG27-SP2	60	67	(54 - 80)
	TX-U	JL30-AG5	33	21	(32 - 76)
1988	AZ	SP3-SP9	52	40	(36 - 68)
	CA	OT1-OT7	15	10	(0 - 31)
		OT8-OT14	17	24	(4 - 44)
		OT15-OT21	32	23	(8 - 38)
		OT22-OT29	10	30	(4 - 56)
1988	TX-R	AP23-AP29	12	25	(0 - 52)
		AP30-MY6	23	17	(0 - 36)
		MY21-MY27	21	27	(7 - 47)
		JN4-JN10	16	10	(0 - 33)
		JN11-JN17	10	26	(0 - 56)
		JN18-JN24	74	40	(29 - 51)
		JN25-JL1	89	47	(37 - 57)
		JL2-JL8	25	35	(16 - 54)
		JL9-JL15)	25	55	(36 - 74)
		JL16-JL22	54	52	(39 - 65)
		JL23-JL29	26	19	(1 - 37)
1988	TX-B	JN11-JN17	11	9	(0 - 39)
		JL9-JL15	128	34	(25 - 43)
		JL16-JL22	150	42	(34 - 50)
		JL23-JL29	20	51	(43 - 59)
		JL30-AG5	20	45	(23 - 67)
		AG6-AG12	333	40	(18 - 62)
		AG13-AG19	100	66	(61 - 71)
		AG27-SP2	29	59	(49 - 69)
		SP17-SP23	29	69	(50 - 88)

TABLE 4. (Cont'd).

Year	State	Date Range	n	% Survival	95% C.I.
1989	GA	AG6-AG12	91	2	(0 - 7)
		AG13-G19	40	5	(0 - 13)
		AG20-AG26	108	6	(1 - 11)
		AG27-SP2	60	8	(1 - 15)
		SP3-SP9	10	20	(4 - 36)
		SP10-SP16	8	10	(0 - 28)
		SP17-SP23	47	0	(0 - 7)
		SP24-SP30	50	2	(0 - 9)
	TX-B	JL2- JL8	94	45	(35 - 55)
		JL9-JL15	36	50	(33 - 67)
		JL16-JL22	30	60	(42 - 78)
		JL23-JL29	20	75	(53 - 97)
		JL30-AG5	10	40	(9 - 71)
		AG27-SP5	140	81	(73 - 89)

The data in Table 4 also shows that at least 20 to 30 moths should be used per test rate in order to reduce the confidence limits to the extent that the susceptibility data generated by the test are meaningful.

In summary, data from both the topical and adult vial tests show there is a considerable amount of variation in tobacco budworm susceptibility to pyrethroids across the Cotton Belt and within seasons at specific locations. Susceptibility tends to be highest in the southeast and lowest in Arizona and Texas. It also changes throughout the season with the lowest susceptibility levels occurring mid-season and highest susceptibility early in the season or at the end of the season. However, a better understanding of the relationship between bioassay test results and control in the field, tobacco budworm population movement patterns throughout the season and inheritance patterns of resistance mechanisms are needed so that monitoring data can be used to develop effective resistance management strategies.

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