STATUS OF INSECTICIDE RESISTANCE IN TOBACCO BUDWORM AND BOLLWORM IN LOUISIANA DURING 1997

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Abstract

In 1997, resistance was again documented in tobacco budworm populations to pyrethroid insecticides. Over 745 tobacco budworm moths were bioassayed for pyrethroid resistance from May through August 1997 using a discriminating dose of 10 Fg in the adult vial test. Pyrethroid resistance levels were the highest documented since inception of monitoring in 1987. Percent survival in June was 51%. Previously, the highest level of survival observed in June between 1987 and 1996 had been 29%. This data indicates there was an increased use of pyrethroids in June 1997. Over 1821 male bollworm moths were assayed against a 5Fg/vial dose of cypermethrin. Bollworm moth survival levels continue to increase slowly. July survival levels were 14% , the highest observed since inception of monitoring in 1988. This data indicates that bollworm susceptibility to pyrethroid insecticides is changing.

Introduction

During 1986, pyrethroid resistance in tobacco budworm, *Heliothis virescens* (F.), was documented in Arkansas (Plapp et al. 1987), Mississippi (Roush and Luttrell 1987), Louisiana (Leonard et al. 1987) and Texas (Allen et al. 1987, Plapp et al. 1987) using several bioassay techniques. In response to this development, pyrethroid resistance management plans were initiated for the Mid-South states of Arkansas, Louisiana, Mississippi (Anonymous 1986) and Texas. Wide-spread monitoring of male tobacco budworm moths for pyrethroid resistance has been conducted in these states since 1987 using a glass vial technique (Plapp et al. 1987) commonly referred to as the adult vial test (AVT).

Tobacco budworm resistance to pyrethroid insecticides continued to increase from 1986 to 1992 (Graves et al. 1988, Graves et al. 1989, Graves et al. 1990, Graves et al. 1991, Graves et al. 1992, Graves et al. 1993, Graves et al. 1994, Bagwell et al. 1995 and Bagwell et al. 1996). Pyrethroid resistance levels peaked in 1993 when the seasonal mean survival reached 48 percent. Pyrethroid resistance levels declined slightly in 1994 to 39%, but still remained high enough to result in field control failures. Tobacco budworm resistance to profenofos, methomyl and endosulfan also was detected in 1993. Thus, by 1993 tobacco budworm populations had developed resistance to the three major insecticide classes (carbamates, organophosphates and pyrethroids) used for tobacco budworm control. Over 24,500 male tobacco budworm moths were bioassayed for pyrethroid resistance from 1987 to 1993 against the 10 mg dose of cypermethrin utilizing the AVT.

Resistance was again documented to representative chemicals from the three major classes of insecticides (carbamates, organophosphates and pyrethroids) used to control tobacco budworms, *Heliothis virescens* (F.), on cotton in the United States during 1995 (Bagwell et al. 1996). Over 2100 male tobacco budworm moths were bioassayed for pyrethroid resistance from May through September 1995 against a 10 Fg dose of cypermethrin utilizing the AVT. Pyrethroid resistance levels during 1995 were similar to 1994 levels. Also, 200 male tobacco budworm moths were bioassayed for resistance to profenofos using the AVT. Resistance to profenofos was lower than in 1994. Low densities of tobacco budworm populations generally persisted in Louisiana during 1995. However, field control failures did occur in fields with moderate to heavy tobacco budworm populations. Topical application bioassays of larval progeny from several 1995 field collections of tobacco budworms indicated significant resistance to carbamate, pyrethroid and organophosphate insecticides. Resistance to all three classes also was detected from the progeny of an Alabama field collection of tobacco budworm.

In 1996, resistance was documented to representative chemicals from the three major classes of insecticides (carbamates, organophosphates and pyrethroids) used to control tobacco budworms, *Heliothis virescens* (F.), on cotton in the United States (Bagwell et al. 1997). Over 1900 male tobacco budworm moths were bioassayed for pyrethroid resistance from May through August 1996 against a 10 Fg dose of cypermethrin utilizing the adult vial test. Pyrethroid resistance levels during 1996 were similar to 1995 levels. Two-hundred male tobacco budworm moths were bioassayed for resistance to profenofos using the adult vial test. Resistance to profenofos was similar to 1995 levels. Also, 199 male tobacco budworm moths were bioassayed for resistance to methomyl using the adult vial test. Resistance to methomyl was similar to 1995 levels. Generally, resistance to carbamates, organophosphates and pyrethroids appears to have stabilized based on monitoring data from 1987 through 1996. Low densities of tobacco budworm populations generally persisted in Louisiana during 1996. However, field control failures did occur in fields with moderate to heavy tobacco budworm populations. Topical application bioassays of larval progeny from several 1996 field collections of tobacco budworms indicated significant resistance to carbamate, pyrethroid and organophosphate insecticides. Over 3600 male bollworm, *Helicoverpa zea* (Boddie), moths were bioassayed against a 5 Fg/vial dose of cypermethrin.

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Over 16,900 male bollworm moths were bioassayed for pyrethroid resistance from 1987 to 1994. Bollworm males were exposed to 1, 2 or 5 Fg dose of cypermethrin utilizing the AVT. No significant changes in bollworm susceptibility to pyrethroids were detected during this period. Over 2100 male bollworm, *Helicoverpa zea* (Boddie), moths were bioassayed against 1,2 or 5 Fg/vial doses of cypermethrin during 1995. Data from these bioassays were similar to those obtained from 1988-1994, but indicated that bollworm susceptibility to pyrethroids may be changing.

The success of insecticide resistance management relies heavily upon the intelligent use of all available classes of insecticides and non-chemical management practices. It is important to monitor susceptibility to the various insecticides to detect any changes or problems which may occur. This study was conducted to evaluate the susceptibility of tobacco budworm and bollworm from Louisiana to selected insecticides in 1997. This information is essential to update and refine current insecticide resistance management guidelines.

Materials and Methods

Wire cone traps (Harstack et al. 1979) baited with artificial sex pheromone lures (Hendricks et al. 1987) were used to collect tobacco budworm and bollworm male moths from May through August. Although males were collected from most cotton production areas of Louisiana, more intensive sampling was conducted on or near the Northeast Research Station (St. Joseph Location, Tensas Parish), Northeast Research Station (Macon Ridge Location, Franklin Parish) and Red River Research Station (Bossier Parish).

The interior of glass scintillation vials (20 ml) were coated with cypermethrin (10 Fg/vial for tobacco budworm and 5 Fg/vial for bollworm). The 10 Fg/vial dose of cypermethrin is lethal to homozygous pyrethroid susceptible tobacco budworm moths as well as moths heterozygous for pyrethroid resistance (Plapp et al. 1987). Only homozygous pyrethroid resistant tobacco budworm moths survive 10 Fg/vial dose, and it can be used as a discriminating dose for this species. A discriminating dose has not been determined for the bollworm. Vials were stored in a dark area to prevent photodegradation of the pyrethroid insecticide. Acetone-treated vials were used to check for natural moth mortality, which was generally less than 10%.

Male moths were removed from the traps early in the morning to prevent desiccation. Only moths that appeared to be young and healthy were used in these tests. One moth was placed in each vial and held at room temperature for 24 hours. Mortality was determined by removing the moths from the vials and tossing them into the air. If the moth was unable to fly or could fly only a short distance (< 3 meters), it was recorded as dead. All data were corrected for control mortality using Abbott's (1925) formula.

Results and Discussion

From May through August 1997, 745 male tobacco budworm moths from 12 parishes were bioassayed for pyrethroid resistance using the AVT at the discriminating dose of 10 Fg of cypermethrin per vial (Tables 1, 2, and 3 and Figure 1). When these data are summarized by location (parish) and month (Table 2), several observations can be made. Pyrethroid resistance (i.e. percent survival) was lowest during May(10-40%), then increased rapidly in June to (30-65%) and remained high through August. This data is thought to reflect an increased use of pyrethroid insecticides during June 1997.

Comparing the mean yearly responses of tobacco budworm moths bioassayed at 10 Fg cypermethrin per vial during 1997 to that determined for the period of 1987-1996 revealed that pyrethroid resistance levels were the highest recorded (Table 3 and Figure 1). Overall survival in 1997 was 55%, 39% in 1996, 39% in 1995, 39% in 1994, 48% in 1993, 40% in 1992, 36% in 1991, 37% in 1990, 25% in 1989, 16% in 1988 and 15% in 1987.

From May through August 1997, 1821 male bollworm moths from 14 parishes were bioassayed for pyrethroid resistance using the AVT at a dose of 5 Fg of cypermethrin per vial (Tables 4,5 and 6). Survival at 5 Fg per vial by parish ranged from 0-5%, 0-5%, 8-21%, and 0-17% in May, June, July and August, respectively (Table 5). Survival was similar in all parishes regardless of pyrethroid usage. Survival was highest during July. July is the time that bollworms occur in cotton in the greatest numbers and pyrethroid insecticides are recommended for use (Bagwell 1996). Survival at 5 mg of cypermethrin per vial during 1996 appeared to be similar to survival at these doses during 1988-1995 (Table 6 and Figure 2). There is no clear indication that bollworms are developing resistance to pyrethroids although susceptibility appears to be decreasing.

Implications

Resistance levels to pyrethroids in tobacco budworm in 1997 was the highest documented since monitoring was first initiated in 1987. High levels of pyrethroid resistance are thought to be due to increased use of pyrethroids in June. Several fields that were reported to have had pyrethroid application in June were also reported as high insect pest control cost fields. Overall populations of tobacco budworm were low in 1997. However, in those fields where tobacco budworm populations were high, insecticide control was not satisfactory and control costs were high. There appears to be a trend for increased bollworm survival, however, there have been no reported cases of inadequate field control of bollworm populations. These data indicate that the Insecticide Resistance Management Plan has helped forestall the loss of pyrethroid insecticides for bollworm/tobacco budworm control in cotton.

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Table 1. Responses of tobacco budworm male moths to cypermethrin during 1997.

Parish[1] (Location)	% Survival[2](No. Tested) Date	(10 µg/vial)
Tensas	May 21	10(10)
Caddo	May 27	25(8)
Natchitoches (Powhatan)	May 27	30(10)
Bossier (Red River Res. Sta.)	May 27 & 29	40(10)
Natchitoches (Derry)	June 17	40(15)
Bossier (Red River Res. Sta.)	June 18	65(20)
Natchitoches	June 23	60(20)
Caddo	June 23	50(18)
Ouachita	June 24	30(10)
Bossier (Red River Res. Sta.)	July 1 & 2	45(20)
Caddo	July 1	25(20)
Natchitoches (Derry)	July 1	33(15)
Grant (Colfax)	July 1	40(10)
Natchitoches (Derry)	July 9	60(10)
Caddo	July 9	45(20)
Caddo	July 14	58(12)
Pointe Coupee (Lettsworth)	July 15	50(20)
Bossier (Red River Res. Sta.)	July 16 & 17	44(27)
Caddo	July 22	67(9)
Franklin (Fort Necessity)	July 22	58(12)
Pointe Coupee (Lettsworth)	July 23	50(20)
Tensas	July 23	60(10)
Natchitoches	July 28	87(8)
Red River (Coushatta)	July 28	60(20)
Caddo	July 28	43(14)
Franklin (Fort Necessity)	July 29	75(8)
Bossier (Red River Res. Sta.)	July 30	65(20)
Natchitoches	Aug 5	50(12)
Red River (Coushatta)	Aug 5	60(20)
Caddo	Aug 5	70(30)
Concordia (Shaw)	Aug 6	58(12)
Pointe Coupee (Lettsworth)	Aug 6	44(18)
Caddo	Aug 12	75(12)
Bossier (Red River Res. Sta.)	Aug 13-14	75(20)
Franklin (Bayou Macon)	Aug 13-14	88(25)
Franklin (Bayou Macon)	Aug 19	25(20)
Avoyelles (Bunkie)	Aug 19	57(7)
Grant (Colfax)	Aug 19	50(8)
Natchitoches	Aug 19	56(9)
Caddo	Aug 19	77(30)
Pointe Coupee (Lettsworth)	Aug 20	57(7)
Natchitoches	Aug 26	60(20)
Red River (Coushatta)	Aug 26	70(10)
Caddo	Aug 26	65(20)
Rapides (Dean Lee Sta)	Aug 26	50(10)
Grant (Colfax)	Aug 26	60(10)
Franklin (Fort Necessity)	Aug 26	73(15)
Tensas	Aug 27	70(10)
Concordia (Shaw)	Aug 27	56(9)
Bossier (Red River Res. Sta.)	Aug 28	60(20)

[1] If a specific location is not given for a parish, the data represent collections from two or more locations in the parish.

[2] Percent Survival at 10 Fg/vial is an estimate of the percent homozygous pyrethroid-resistant males present.

Table 2. Percent survival of tobacco budworm male moths at 10 Fg cypermethrin per vial by parish and month during 1997.[1]

Parish	May	June	July	August
Avoyelles	--	--	--	57
Bossier	40	65	51	68
Caddo	25	50	44	71
Concordia	--	--	--	57
Franklin	--	--	65	63
Grant	--	--	40	56
Natchitoches	30	50	55	56
Ouachita	--	30	--	--
Pointe Coupee	--	--	50	48
Rapides	--	--	--	50
Red River	--	--	60	63
Tensas	10	--	60	70

[1]Percent survival is an estimate of the percent homozygous pyrethroid-resistant males present.

Table 3. Monthly summary of cypermethrin resistance monitoring data for tobacco budworms obtained using a discriminating dose of 10 Fg/vial, 1987-1997.

	Percent survival[1] (Number Tested)						
Year	May	June	July	Aug.	Sept.	Oct.	Total
1987	20	13	18	12	15	---	15(2607)
1988	12	5	14	26	30	---	16(2214)
1989	11	9	19	40	36	28	25(3057)
1990	12	14	36	43	48	44	37(3605)
1991	16	21	31	42	49	36	36(3539)
1992	14	22	39	58	56	37	40(4281)
1993	22	29	46	58	68	---	48(2823)
1994	20	26	44	50	59	---	39(1716)
1995	18	20	37	49	49	---	39(2131)
1996	23	24	50	43	---	---	39(1966)
1997	26	51	51	63	---	---	55(745)

[1]Percent survival is an estimate of the percent homozygous pyrethroid-resistant males present.

Table 4. Responses of bollworm male moths to cypermethrin during 1997.

Parish (Location)	Date	% Survival (Number Tested) (5 µg/vial)
Grant(Colfax)	May 205(20)	
Natchitoches(Powhatan)	May 20	0(10)
Red River (Coushatta)	May 20	2(50)
Caddo (Dixie)	May 20	4(50)
Caddo (Gilliam)	May 20	0(40)
Franklin (Ft Necessity)	May 20	2(50)
Tensas	May 21	0(10)
Pointe Coupee(Lettsworth)	May 21	0(15)
Caddo (Dixie)	May 27	5(20)
Caddo (Belcher)	May 27	20(20)
Red River (Coushatta)	May 27	0(10)
Bossier (Red River Station)	May 27 & 28	0(20)
Franklin (Fort Necessity	May 28	12(25)
Concordia (Shaw)	May 28	0(10)
Natchitoches	June 3	0(10)
Red River (Coushatta)	June 3	5(20)
Caddo	June 3	3(30)
Ouachita	June 4	0(14)
Franklin (Ft. Necessity)	June 4	0(20)
Caddo	June 17	10(30)
Bossier (Red River Sta.)	June 18	0(20)
Caddo	June 23	4(50)
Caddo	July 1	18(50)
Natchitoches (Derry)	July 1	12(16)
Bossier (Red River Sta.)	July 1 & 2	20(20)
Avoyelles (Bunkie)	July 9	5(20)

Table 4 Continued

Parish (Location)	Date	% Survival (Number Tested) (5 µg/vial)
Natchitoches (Derry)	July 9	25(20)
Red River (Coushatta)	July 9	30(10)
Caddo	July 9	18(50)
Caldwell (Columbia)	July 10	12(8)
Franklin (Ft. Necessity)	July 10	20(10)
Pointee Coupee (Morganza)	July 10	15(13)
Bossier (Red River Sta.)	July 14	10(60)
Red River (Coushatta)	July 14	5(20)
Caddo	July 14	13(30)
Avoyelles (Bunkie)	July 14	20(10)
Rapides (Dean Lee Sta.)	July 14	17(12)
Grant (Colfax)	July 14	22(9)
Natchitoches	July 14	9(11)
Tensas	July 15	12(8)
Franklin (Ft. Necessity)	July 15	8(12)
Caldwell (Columbia)	July 15	12(8)
Ouachita	July 15	20(20)
Bossier (Red River Sta.)	July 16	20(25)
Bossier (Red River Sta.)	July 28	24(50)
Caddo	July 28	5(40)
Red River (Coushatta)	July 28	7(15)
Natchitoches	July 28	5(20)
Grant (Colfax)	July 28	0(10)
Rapides (Dean Lee Sta.)	July 28	7(15)
Avoyelles (Bunkie)	July 28	5(20)
Bossier (Red River Sta.)	July 29	16(50)
Tensas	July 29	23(30)
Franklin (Ft. Necessity)	July 29	12(16)
Caldwell (Columbia)	July 29	7(30)
Ouachita	July 29	0(10)
Bossier (Red River Sta.)	July 30	20(20)
Avoyelles (Bunkie)	Aug 5	10(10)
Rapides (Dean Lee Sta.)	Aug 5	0(12)
Natchitoches	Aug 5	8(25)
Red River (Coushatta)	Aug 5	0(8)
Caddo	Aug 5	10(20)
Ouachita (Fondale)	Aug 5	13(30)
Caldwell (Columbia)	Aug 5	15(20)
Franklin (Ft. Necessity)	Aug 5	20(10)
Tensas	Aug 6	30(10)
Franklin (Ft. Necessity)	Aug 12	6(18)
Caldwell (Columbia)	Aug 12	8(12)
Ouachita	Aug 12	9(11)
Caddo (Dixie)	Aug 12	7(15)
Red River (Coushatta)	Aug 12	0(8)
Natchitoches	Aug 12	5(21)
Grant (Colfax)	Aug 12	0(9)
Rapides (Dean Lee Sta.)	Aug 12	7(14)
Avoyelles (Bunkie)	Aug 12	3(30)
Bossier (Red River Sta.)	Aug 13-14	10(20)
Richland (Start)	Aug 18	10(20)
West Carroll (Epps)	Aug 18	0(8)
Avoyelles (Bunkie)	Aug 19	0(13)
Caddo	Aug 19	5(19)
Pointe Coupee	Aug 20	0(8)
Rapides (Dean Lee Sta.)	Aug 26	5(20)
Natchitoches	Aug 26	0(20)
Red River (Coushatta)	Aug 26	5(20)
Caddo	Aug 26	0(20)
Franklin (Ft. Necessity)	Aug 26	7(30)
Tensas	Aug 27	0(8)
Bossier (Red River Sta.)	Aug 28	5(20)

Table 5. Percent survival of bollworm male moths at 5 µg cypermethrin per vial by parish and month during 1997.[1]

Parish	May	June	July	August
Avoyelles	-	-	8	4
Bossier	0	0	17	8
Caddo	5	5	14	9
Caldwell	-	-	9	13
Concordia	0	-	-	-
Wast Carroll	-	-	-	0
Franklin	5	0	11	9
Grant	5	-	11	0
Natchitoches	0	0	13	5
Ouachita	-	0	13	12
Pointe Coupee	0	-	15	0
Rapides	-	-	11	4
Red River	2	5	11	3
Tensas	0	-	21	17

Table 6. Monthly summary of cypermethrin resistance monitoring data for bollworm moths, 1988-1997.

Dose	Year	May	June	July	Aug	Sept.	Total
1	1988	10[1]	0	64	34	30	43(515)[2]
2		0	-	7	15	20	13(253)
5		0	0	3	2	3	2(439)
1	1989	-	-	57	60	38	53(220)
2		-	-	49	48	30	43(220)
5		-	-	5	6	3	4(170)
1	1990	19	33	44	34	24	33(1064)
2		5	25	28	16	15	21(1040)
5		0	0	6	1	2	2(561)
1	1991	25	54	50	43	37	44(1909)
2		11	23	31	23	26	24(1830)
5		2	5	7	4	8	5(1666)
1	1992	31	32	55	45	46	42(1241)
2		24	19	41	34	19	31(1295)
5		3	2	11	7	12	8(932)
1	1993	-	22	53	50	55	49(530)
2		-	21	36	30	48	33(733)
5		-	0	7	7	9	7(483)
1	1994	37	50	60	56	-	55(643)
2		27	33	45	42	-	40(683)
5		3	9	10	8	-	8(500)
1	1995	53	40	67	58	-	59(773)
2		20	23	45	38	-	36(767)
5		3	0	8	7	-	6(580)
5	1996	4	3	9	5	-	7(3697)
5	1997	4	4	14	7	-	9 (1821)

[1] Percent survival at indicated dose.

[2] Number in parenthesis indicates number of moths tested.

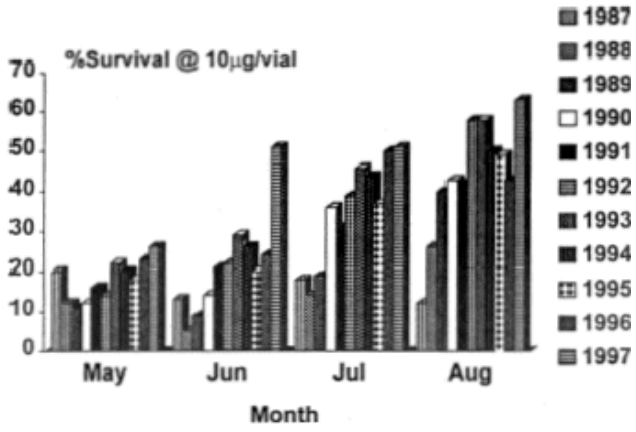

Figure 1. Percent survival of tobacco budworm male moths exposed to a discriminating dose (10 Fg/vial) of a pyrethroid (cypermethrin) by month and year, 1987-1997.

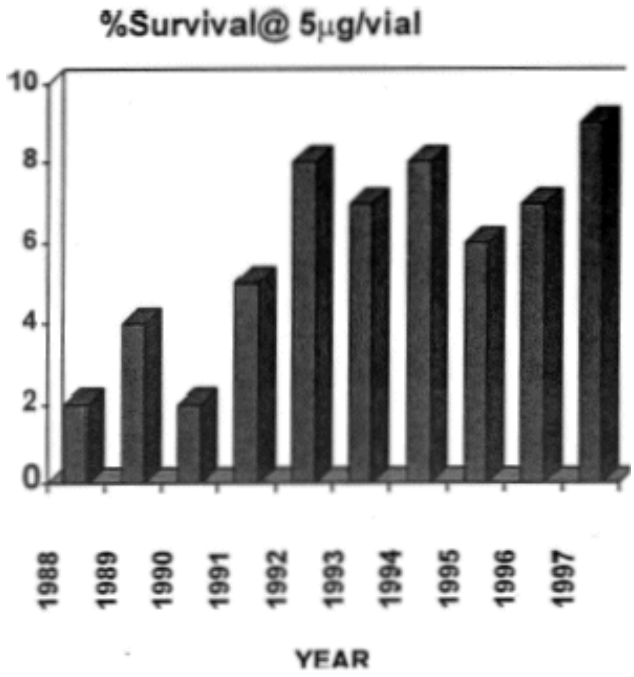

Figure 2. Percent survival of bollworm male moths exposed to 5 Fg/vial dose of a pyrethroid (cypermethrin) by year, 1988-1997.