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MONITORING CYPERMETHRIN SUSCEPTIBILITY IN LOUISIANA BOLLWORM DURING 2004-2005

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Abstract

The susceptibility of over 2,000 bollworm moths to pyrethroids was determined using the adult vial test (AVT) from May to Sep during 2004 and 2005. In 2004, survival at 5 µg/vial during May, Jun, Jul, Aug, and Sep was 9%, 16%, 30%, 21%, and 30%, respectively, with a mean survival of 23%. In 2005, survival at 5 µg/vial during May, Jun, Jul, Aug, and Sep was 23%, 34%, 43%, 43%, and 38%, respectively, with a mean survival of 38%. Bollworm survival during 2005 was at the highest level recorded in Louisiana. Mean annual survival of bollworm exposed to 10 µg/vial for 2004 and 2005 was 12% and 22%, respectively. In 2004, LD_{50}'s of bollworm larvae from field colonies collected at St. Joseph, Bossier, and Winnsboro in topical bioassays were 1.28, 3.24, and 6.12 µg/g, respectively. The Winnsboro colony tested in 2004 had a resistance ratio that was 7 to 22 fold higher than the pyrethroid-susceptible colonies tested during 1998. In 2005, LD_{50}'s of colonies from Somerset, St. Joseph, Sicily Island, St. Francisville, and Winnsboro were 0.68, 2.04, 2.04, 2.20, and 3.48 µg/g, respectively. Although these data clearly show bollworms are becoming less susceptible to pyrethroids in laboratory tests, no field control failures of bollworms with pyrethroids have been reported in Louisiana to date.

Introduction

Insecticide resistance in key insect pests has constantly been an important issue for producers and crop consultants in the cotton industry. The bollworm, *Helicoverpa zea* (Boddie), has become the key caterpillar pest of cotton since the release of transgenic Bt cotton varieties. Resistance to organochlorines, DDT, organophosphates (Sparks 1981), and carbamates (Elzen et al. 1992) has been reported in this species. Pyrethroid resistance monitoring plans were initially implemented to monitor the susceptibility of the tobacco budworm, *Heliothis virescens* (F.), using the adult vial test (AVT) described by Plapp et al. (1987). Studies to monitor pyrethroid susceptibility of bollworm populations using the AVT began in Louisiana during 1988. In Louisiana, mean annual bollworm survival at a discriminating dose of 5 µg cypermethrin has increased from 2% in 1988 to 34% in 2002 (Cook et al. 2003).

Pyrethroids are still the principal means of bollworm control in cotton, soybeans, grain sorghum, and many vegetables. Pyrethroid resistance in bollworm has been reported in South Carolina (Brown et al. 1998) and Texas (Pietrantonio et al. 2005). Less than acceptable control of the bollworm infesting sweet corn in the Midwestern United States has been reported since 2000 (Hutchison et al. 2005). To date, there have been no bollworm control failures following pyrethroid applications reported related to resistance in Louisiana. This report summarizes the results of bollworm monitoring efforts using the AVT and laboratory topical bioassays during 2004 and 2005.

Materials and Methods

Adult Vial Tests

Male bollworm moths were collected using wire cone traps baited with synthetic pheromone lures (Zealure®, Hercon Environmental, Emigsville, PA) from May through September during 2004 and 2005. Moths were collected from eight and

nine sites within Louisiana cotton production areas during 2004 and 2005, respectively (Figure 1). The most intensive sampling occurred at four research station locations in Bossier, Franklin, Rapides, and Tensas parishes.

Adult vial bioassays similar to those described by Plapp et al. (1987) were utilized to monitor the susceptibility of field collected bollworm moths to cypermethrin (Chem Services, West Chester, PA). Stock solutions of cypermethrin were prepared by dissolving technical grade insecticide (98% pure) in acetone. Dilutions were made from the stock solution to yield desired insecticide concentrations. The interior surface of 20 ml glass scintillation vials was coated with insecticide by pipetting 0.5 ml of the appropriate insecticide solution into the vials. Vials were then rolled on a modified hot dog roller until all acetone evaporated leaving only insecticide residue. Vials were stored in a dark environment at room temperature until utilized.

Insecticide concentrations used in the AVT included 5 and 10 µg/vial. Healthy moths were placed into insecticide treated and non-treated (control) vials (1 moth/vial) and mortality was determined after 24-h of exposure (HAE). Moths were considered dead if they were incapable of sustained flight for three ft. Data were corrected for control mortality using Abbott's (1925) formula.

Topical Application Procedure

Bollworm larvae were collected from clover at St. Francisville and Sicily Island (May 2005), sweet corn at St. Joseph (June 2004 and 2005), and cotton at Bossier City (August 2004), Somerset (August 2005), and Winnsboro (August 2004 and 2005). These larvae were placed on diet (Heliothis Pre-Mix, Stonefly Ind., Bryan, TX) in 1 oz cups (Solo Cup Co., Urbana, IL) and allowed to complete one generation in the laboratory to achieve adequate numbers of larvae for laboratory topical bioassays. Technical grade cypermethrin was dissolved in acetone and dilutions were made yield the desired insecticide concentrations. One µl of insecticide solution was applied to the thoracic dorsum of larvae using a Hamilton micro-syringe. Control larvae were treated with 1 µl of acetone. A minimum of 30 larvae (20-30 mg larval weight; average of 25mg) per dose were utilized in all bioassays. Mortality was determined at 72 hours after treatment. A larva was considered dead if it could not right itself after being placed on its dorsal surface. Data were corrected for control mortality and analyzed with probit analysis using Polo PC (LeOra Software 1987). LD_{50} values were obtained from probit analysis and resistance ratios (RR) were calculated from pyrethroid-susceptible reference colonies (Louisiana Lab and Field 1998). Non-overlapping confidence limits (95%) were used indicate significant differences among colonies.

Results and Discussion

Over 2,000 bollworm moths were assayed for pyrethroid susceptibility during 2004 and 2005 with the AVT. In 2004, survival at 5 µg/vial during May, Jun, Jul, Aug, and Sep was 9%, 16%, 30%, 21%, and 30%, respectively, with a mean annual survival of 23% (Table 1). Bollworm survival for each month in 2004 was slightly lower for each respective month compared to 2003. In 2005, survival at 5 µg/vial during May, Jun, Jul, Aug, and Sep was 23%, 34%, 43%, 43%, and 38%, respectively, with a mean annual survival of 38%. During 2005, bollworm survival was the highest ever recorded in Louisiana. Mean annual bollworm survival at 10 µg/vial for 2004 and 2005 was 12% and 22%, respectively (Figure 2).

The LD_{50}'s of field colony bollworm larvae from St. Joe, Bossier, and Winnsboro in topical bioassays were 1.28, 3.24, and 6.12 µg/g larval weight, respectively in 2004 (Table 2). The LD_{50} for Winnsboro colony tested during 2004 was the highest observed for a field colony from Louisiana and had a resistance ratios of 7 to 22 fold.. The LD_{50}'s of field colonies from Somerset, St. Joe, Sicily Island, St. Francisville, and Winnsboro were 0.68, 2.04, 2.04, 2.20, and 3.48 µg/g, respectively during 2005. Six of the eight field colonies from 2004 and 2005 had LD_{50} values that were significantly higher than the pyrethroid-susceptible reference colonies. The LD_{50} values of those colonies ranged from 2.04 to 6.12 µg/g and had resistance ratios of 2 to 22 fold.

No field control failures of bollworms with pyrethroids have been reported in Louisiana to date, but crop consultants have reported reduced efficacy against late-season infestations. The low cost of pyrethroids allows them to be viable option for many insect pest problems not only in cotton, but also in many other crops that are grown adjacent to cotton in Louisiana. Bollworms are possibly receiving inadvertent selection pressure from pyrethroid sprays in field corn, grain sorghum, and soybeans. A reduction in pyrethroid susceptibility of bollworms is probably due to fewer non-treated (insecticides) hosts in Louisiana.

Acknowledgments

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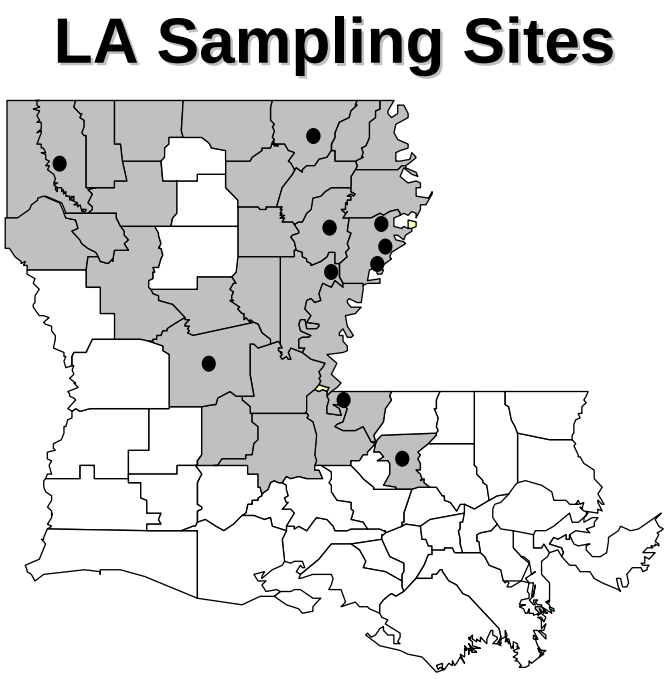

Figure 1. Bollworm collection sites during 2004 and 2005.

Table 1. Percent survival by month of male bollworm adults exposed to 5 µg/vial cypermethrin.

	Month-Percent Survival					Annual	No.
Year	May	Jun	Jul	Aug	Sep	Mean	Tested
1988	0	0	3	2	3	2	439
1989	-	-	5	6	3	4	170
1990	0	0	6	1	2	2	561
1991	2	5	7	4	8	5	1666
1992	3	2	11	7	12	8	932
1993	-	0	7	7	9	7	483
1994	3	9	10	8	-	8	500
1995	3	0	8	7	-	6	580
1996	4	3	9	5	-	7	3697
1997	4	4	14	7	-	9	1821
1998	12	14	27	19	-	18	1950
1999	18	13	15	16	-	16	809
2000	13	20	19	14	-	16	1445
2001	10	6	32	13	16	21	829
2002	-	28	42	26	28	34	1119
2003	50	27	33	34	-	31	1050
2004	9	16	30	21	30	23	1010
2005	23	34	43	43	38	38	1300

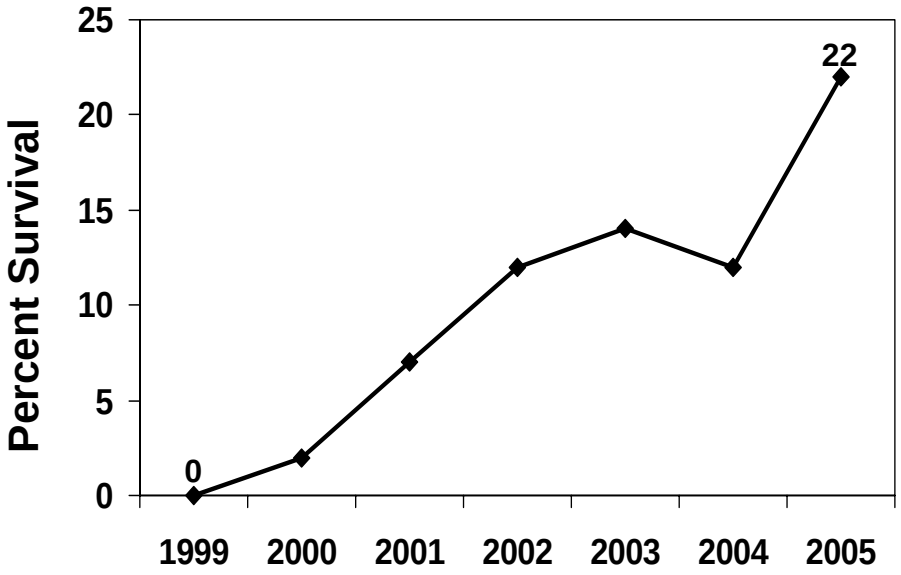

Figure 2. Mean percent survival by year of male bollworm adults exposed to 10 µg/vial cypermethrin.

Table 2. Response of Louisiana bollworm larvae exposed to cypermethrin in topical bioassays.

LA Colony	Host	N	LD_{50}[1]	95% CL	Slope	X^2	RR
Lab & Field-98	Diet/Corn	>200	0.28-0.88	0.15-1.35	1.83±0.21		
St. Joseph-04	Corn	150	1.28	0.6-2.08	1.15±0.22	4.93	1-4
Winnsboro-04	Cotton	159	6.12	4.92-7.76	2.92±0.37	4.65	7-22
Bossier-04	Cotton	164	3.24	2.44-4.16	2.19±0.30	4.34	3-11
St. Francisville-05	Clover	248	2.20	1.4-3.08	1.56±0.19	7.68	2-8
Sicily Island-05	Clover	313	2.04	1.4-2.68	1.40±0.16	3.22	2-7
St. Joseph-05	Corn	184	2.04	1.48-2.68	1.96±0.27	2.81	2-7
Somerset-05	Cotton	105	0.68	0.16-1.28	1.26±0.33	3.85	0-2
Winnsboro-05	Cotton	115	3.48	2.36-4.8	1.99±0.33	3.82	4-12

Resistance Ratios (RR) calculated from LD_{50}[1] data (0.28 to 0.88 µg/g larval weight) derived from Louisiana lab and field collections 1998 (Unpublished Data, J. Adamczyk and J. Gore LSU Dept. of Entomology).
[1]µg/g larval weight.