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LABORATORY EVALUATION OF SELECTED INSECTICIDES ON FIELD-COLLECTED POPULATIONS OF BOLLWORM AND TOBACCO BUDWORM LARVAE

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Abstract

Although Bt insecticides remain effective, LC_{50} values recorded for bollworm larvae, collected and evaluated in 2003, were approximately 2-3 times higher than previously recorded during 1996 through 1997. Bollworm populations have remained susceptible to pyrethroid insecticides; however, tobacco budworm larvae are 10-25 times more resistant to cypermethrin when compared to the most susceptible field strain and laboratory susceptible strains. Furthermore, LC_{95} values gave increased sharply during the nine year study period. Spinosad remains the most effective insecticide tested to date.

Introduction

The bollworm (*Helicoverpa zea*) and the tobacco budworm (*Heliothis virescens*) are two of the more economically important pests of cotton in the United States, and without proper control methods, populations of these pest insects could reach damaging levels and severely reduce crop yields. Because the bollworm and tobacco budworm have developed resistance to many of the insecticides used for their control, it is critical that research efforts and agricultural practices be devoted to the preservation of those insecticides that are still effective and to the development of new replacement compounds and technologies. Programs to monitor insecticide susceptibilities in field-collected populations of bollworm and tobacco budworm are critical to the development of effective management strategies.

Samples of bollworm and tobacco budworm (TBW) populations were collected from cotton, tobacco and corn fields throughout south Georgia during the summer of 2003. Larvae from those field-collected samples were assayed for susceptibility to a variety of insecticides using a treated-diet bioassay. Results were compared to baseline data collected from 1995-1999.

Materials and Methods

Field-collected bollworm and tobacco budworm moths or larvae were transported to facilities at the State University of West Georgia. Larvae were transferred to a pinto bean/wheat germ, agar-based diet, and adults were placed in mating cages to produce adequate numbers of larvae for testing. Larvae and adults were maintained at 27˚C, LD 14:10 and ca. 40% RH. The following strains were collected during the 2003 season: Bur 03-bollworms collected Burke County, GA; Cam 03-bollworms collected from Camilla, GA (Mitchell County); Ear 03-bollworms collected from Early County, GA; MilA 03-bollworms collected from Miller County, GA; MilB 03-bollworms collected from Miller County, GA; Tur 03-bollworms collected from Turner County, GA; Vie 03-bollworms collected from Dooly County, GA; and Tif 03-tobacco budworms collected from Tift County, GA. The insecticides used were MVPII® (20% A.I., Mycogen Corporation, San Diego, CA; USDA-ARS SIMRU); Cypermethrin (94.3% pure, FMC Corporation, Princeton, NJ); and Spinosad (91.3% pure, Dow AgroSciences, Indianapolis, IN).

Larvae were evaluated using a modified insecticide-treated diet bioassay. An insecticide test solution (100 µl) was added to 50 ml of liquefied pinto bean/wheat germ, agar-based diet at ca. 57˚C while mixing with a variable speed stirrer. The insecticide-treated diet (ca 2.5 ml) was distributed into 1 oz. clear plastic medicine cups. The treated diets were allowed to cool and gel. One late second-instar larva was added to each cup, and mortality was monitored over a 5 day period. Ideally, at least two replicates of twenty cups each at a minimum of five rates plus a control served as a test. Mortality was defined as the inability of the larva to move across the diet surface when probed. During the treatment period, larvae were held in an environmental chamber at 27˚C, LD 14:10 and ca. 40% RH.

Results

MVPII® was less effective against bollworm larvae; however, the average LC_{50}s have more than doubled during the study period, and the slopes of the "dose"-mortality regressions have decreased indicating an increased heterogeneity within these populations in response to MVPII® (Figure 1; Table 1). Although several TBW strains (i.e., EarB 96, Mil 96 and Mol 97) were more resistant to MVPII® as compared to the most susceptible field strain and insecticide-susceptible, laboratory-maintained reference strains (HRV and OPS), LC_{50} values over the nine year study period have remained fairly constant (Figure 2; Table 2).

Bollworm populations in Georgia have remained fairly susceptible to cypermethrin. LC_{50} values for field populations collected during the 2003 season were only two-fold to four-fold greater than LC_{50} values obtained for field populations collected during the 1996 and 1997 seasons (Figure 1; Table 1). However, decreases in the susceptibilities TBW larvae to cypermethrin have been noted throughout the study period (Figure 2; Table 2). During the later part of this study period, 10-fold to 25-fold levels of resistance to cypermethrin were common. The LC_{50} value for the Tif 03 strain was comparable to the LC_{50} value obtained for a laboratory-selected, pyrethroid-resistant strain (PYR). Furthermore, an evaluation of LC_{95} values for cypermethrin against TBW larvae indicated an annual and sharp increase in LC_{95} values since the monitoring project began (Figure 3).

To date, spinosad (Tracer®) has remained effective against all strains tested. Mean LC_{50} values for bollworm larvae (0.48 ± 0.08) and TBW larvae (0.42 ± 0.05 ppm) were comparable.

Conclusions

- This study has generated valuable baseline data that may be critical to the development and implementation of effective resistance management strategies.
- Based on this study:
  - Bt insecticides such as MVPII® are effective against bollworm and TBW larvae; however, increases in LC_{50} values and decreased slopes of "dose"-mortality regressions warrant continued study
  - Many TBW populations throughout Georgia have developed resistance to pyrethroid insecticides; however, pyrethroids remain to be a cost-effective insecticide for bollworm control on cotton
  - Spinosad (Tracer®) was the most effective insecticide evaluated
  - In general, 96h activity spectrum for the compounds tested were:
    - Bollworm: Spinosad > Cypermethrin > MVPII®
    - TBW: Spinosad > MVPII® ≥ Cypermethrin
- Monitoring efforts should be a continued priority

Acknowledgments

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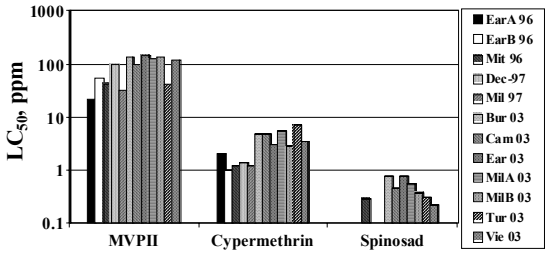
Table 1. Susceptibility of bollworm larvae to MVPII®, Cypermethrin, and Spinosad following a 96 h exposure period.

Strain	LC_{50} (Slope)		
	MVPII®	Cypermethrin	Spinosad
EarA 96	21.8 (1.2)	1.95 (1.8)	ND
EarB 96	51.8 (1.6)	1.00 (1.3)	ND
Mit 96	43.2 (2.3)	1.24 (3.1)	0.30 (1.6)
Dec 97	105 (0.6)	1.23 (2.1)	ND
Mil 97	31.6 (2.6)	1.39 (2.4)	ND
Bur 03	96.6 (0.7)*	4.78 (2.7)	0.79 (1.4)
Cam 03	97.6 (0.8)*	4.79 (1.5)	0.46 (1.2)
Ear 03	145 (0.7)*	3.12 (1.6)	0.80 (1.2)
MilA 03 (corn)	125 (0.6)*	5.48 (1.9)	0.55 (1.9)
MilB 03 (cotton)	129 (0.5)*	2.88 (1.8)	0.40 (1.7)
Tur 03	41.8 (0.4)*	6.90 (2.0)	0.32 (1.7)
Vie 03	138 (0.6)*	3.45 (1.3)	0.22 (1.2)

ND = Not Determined
•Data based on tests using neonate larvae



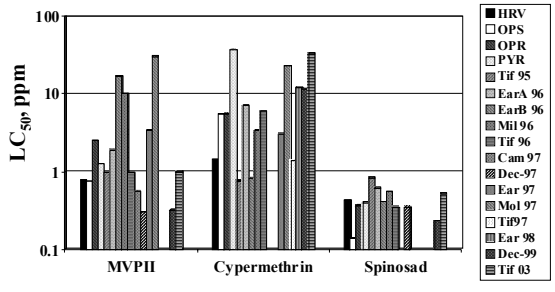
Spinosad > Cypermethrin > MVPII

Figure 1. Susceptibility of Bollworm Larvae to Various Insecticides (Diet).

Table 2. Susceptibility of second-instar tobacco burworm larvae to MVPII®, Cypermethrin and Spinosad following a 96 h exposure period using and insecticide-treated diet bioassay.

Strain	LC_{50} (Slope)		
	MVPII®	Cypermethrin	Spinosad
HRV	ND	1.42 (5.2)	0.38 (1.4)
OPS	0.75 (0.7)	5.01 (3.2)	0.14 (3.3)
OPR	ND	5.48 (2.7)	0.37 (2.2)
PYR	1.23 (1.9)	36.5 (2.1)	0.40 (3.4)
Tif 95	0.95 (1.0)	0.46 (1.1)	0.84 (1.7)
EarA 96	1.87 (0.8)	7.05 (3.1)	0.62 (1.5)
EarB 96	16.6 (1.5)	0.82 (2.2)	0.41 (2.6)
Mil 96	10.1 (0.7)	3.44 (2.6)	0.55 (6.3)
Tif 96	0.95 (1.0)	5.96 (4.3)	0.35 (1.8)
Cam 97	0.56 (1.4)	ND	ND
Dec 97	0.30 (1.7)	ND	0.35 (1.8)
Ear 97	3.38 (1.0)	3.00 (2.5)	ND
Mol 97	30.5 (0.9)	12.1 (2.6)	ND
Ear 98	ND	12.1 (1.7)	ND
Dec 99	ND	11.5 (0.9)	0.20 (1.9)
Tif 03	1.00 (0.5)*	33.1 (1.4)	0.52 (1.1)

ND = Not Determined
* Data based on tests using neonate larvae



Spinosad > MVPII = Cypermethrin

Figure 2. Susceptibility of Tobacco Budworm Larvae to Various Insecticides (Diet).

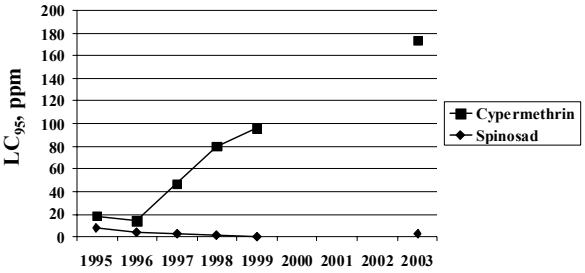


Figure 3. Susceptibility of TBW to Cypermethrin and Spinosad expressed as the LC_{95} (Diet).