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LABORATORY EVALUATION OF SELECTED INSECTICIDES ON FIELD-COLLECTED POPULATIONS OF BOLLWORM AND TOBACCO BUDWORM LARVAE--UPDATE 2005

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Abstract

Tobacco budworm and Bollworm larvae were collected from a variety of host crops throughout the cotton belt of Georgia and evaluated for susceptibility to MVP II®, Cypermethrin and spinosad during the 2005 season. Results were compared to historical data collected throughout a ten-year study period beginning in 1995. During the ten-year study period, tobacco budworm populations have remained susceptible to MVPII®, and as expected, bollworm larvae were more tolerant to the effects of MVPII® as compared to tobacco budworm larvae. Average MVPII® LC_{50}s for bollworm larvae have more than doubled during the ten-year study period. Although cypermethrin remains an effective insecticide to control bollworm larvae, LC_{50}s for cypermethrin against tobacco budworm larvae have steadily increased during the ten-year study period and are comparable to an LC_{50} obtained for a laboratory-selected pyrethroid-resistant strain. This observation was confirmed in one field-collected tobacco budworm strain using an alternative topical application bioassay. Furthermore, average cypermethrin LC_{95} values for tobacco budworm have steadily increased during the ten year study period. Spinosad has remained an effective insecticide against both bollworm and tobacco budworm larvae.

Purpose of the Project

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 Georgia during the summer of 2005. 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 between 1995-1999 and 2003-2004.

Research Methods

Field-collected bollworm and tobacco budworm moths or larvae were transported to facilities at the 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 2005 season: UWG 05-tobacco budworms collected from Carroll County, GA (chickpea); App 05-tobacco budworms collected from Appling County, GA (cotton), Bac 05-tobacco budworms collected from Bacon County, GA (cotton), Cof 05-tobacco budworms collected from Coffee County, GA (cotton), Tay1A 05-tobacco budworms collected from Taylor County, GA (cotton), Tay1B 05-tobacco budworms collected from Taylor County, GA (cotton), Tay2 05-tobacco budworms collected from Taylor County, GA (cotton), Doo 05-bollworms collected from Dooly County, GA (corn); Tay 05-bollworms collected from Taylor County, GA (corn); Tay1A 05-bollworms collected from Taylor County, GA (cotton); Tay1B 05-bollworms collected from Taylor County, GA (cotton); TerA 05-bollworms collected from Terrell County, GA (cotton); and TerB 05-bollworms collected from Terrell County, GA (corn). The insecticides used were MVPII® (20% A.I., Mycogen Corporation, San Diego, CA; USDA-ARS SIMRU; Monsanto Corporation, St. Louis, MO); 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 as compared to TBW larvae; however, the average LC_{50}s have more than doubled during the study period, and in general, the slopes of the "dose"-mortality regressions have decreased indicating an increased heterogeneity within these populations in response to MVPII® (Figure 1; Table 1). Bollworm colony collected from Taylor and Terrell Counties (TerB and Tay1B) had a LC_{50} values greater than 250 ppm; these were the highest LC_{50}s recorded to date. 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 ten year study period have remained fairly constant (Figure 2; Table 2).

Bollworm populations in Georgia have remained susceptible to cypermethrin. LC_{50} values for field populations collected during the 2003-2005 seasons 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). 2005 LC_{50} values were comparable to values obtained during 2004 (Figure 1; Table 1). However, decreases in the susceptibilities of 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 35-fold levels of resistance to cypermethrin were common. The LC_{50} values for the 2003 (Tif 03), 2004 (Doo 04 and TerA 04) and 2005 (Tay2 05 and War 05) strains were comparable to the LC_{50} value obtained for a laboratory-selected, pyrethroid-resistant strain (PYR) (Table 2); pyrethroid resistance in the Tay2 05 strain was confirmed by topical application (LD_{50} = 49.3 µg larva; RR = 31.4). Furthermore, an evaluation of LC_{95} values for cypermethrin against TBW larvae has 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 (0.44 ± 0.07) 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
        - 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
- Monitoring efforts incorporating alternative and novel chemistries should be a continued priority.

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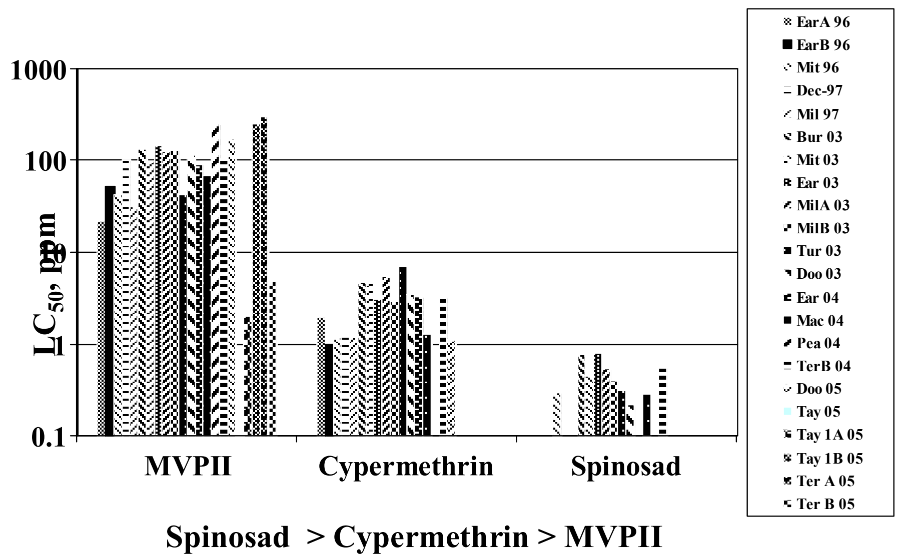
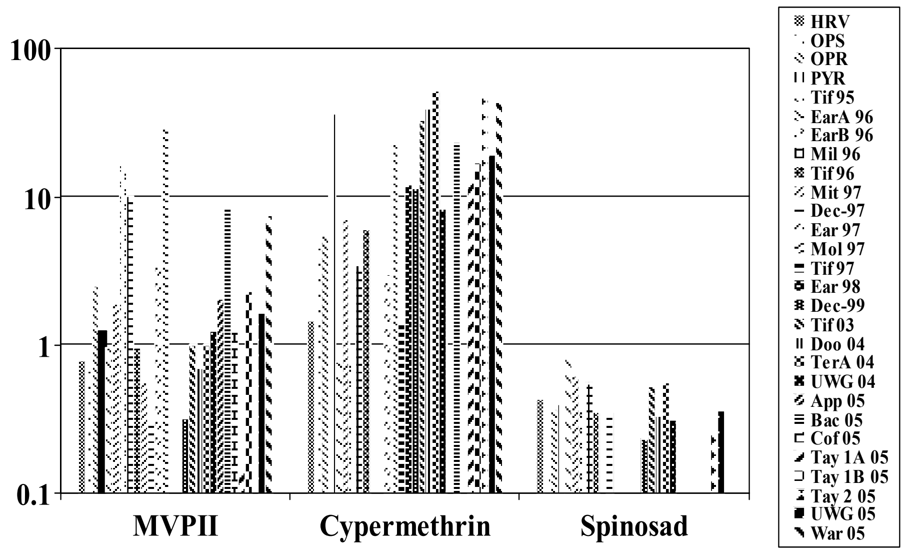


Figure 1. Susceptibility of bollworm larvae to various insecticides following a 96 h exposure period to insecticide-treated diet.

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

Year	**LC_{50} (Slope)**		
	MVPII®	**Cypermethrin**	**Spinosad**
1996	**38.9 (1.7)**	**1.40 (2.1)**	**0.30 (1.6)**
1997	**68.3 (1.6)**	**1.31 (2.2)**	**ND**
2003	**110 (0.6)***	**4.49 (1.8)**	**0.51 (1.5)**
2004	**128 (1.1)***	**2.63 (3.4)**	**0.30 (2.1)**
2005	**122 (0.3)***	**1.13 (0.8)**	**ND**

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



Spinosad > MVPII ≥ Cypermethrin

Figure 2. Susceptibility of tobacco budworm larvae to various insecticides following a 96 h exposure period to insecticide-treated diet.

Table 2. Mean susceptibilities of second-instar tobacco budworm larvae to MVPII®, Cypermethrin and Spinosad following a 96 h exposure period using an 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)**
1995	**0.95 (1.0)**	**0.46 (1.1)**	**0.84 (1.7)**
1996	**9.63 (1.0)**	**4.32 (3.0)**	**0.48 (3.1)**
1997	**8.68 (1.2)**	**7.55 (2.5)**	**0.35 (1.8)**
1998	**ND**	**12.1 (1.7)**	**ND**
1999	**ND**	**11.5 (0.9)**	**0.20 (1.9)**
2003	**1.00 (0.5)***	**33.1 (1.4)**	**0.52 (1.1)**
2004	**1.20 (1.6)***	**33.1 (1.3)**	**0.40 (1.6)**
2005	**3.33 (0.5)***	**27.6 (1.2)**	**0.32 (1.2)**

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

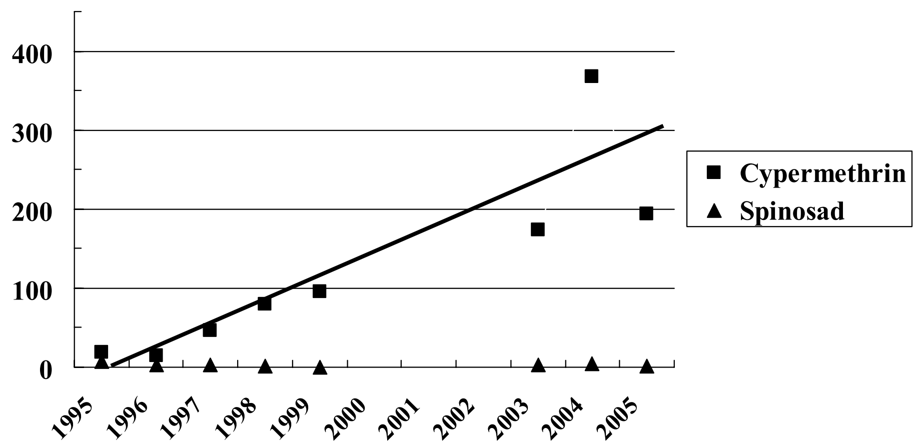


Figure 3. Susceptibility of tobacco budworm to cypermethrin and spinosad expressed as the LC_{95} following a 96 h exposure period to insecticide-treated diet.