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LABORATORY EVALUATION OF SELECTED INSECTICIDES ON FIELD-COLLECTED POPULATIONS OF BOLLWORM AND TOBACCO BUDWORM LARVAE-2004

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Abstract

Since 1995, samples of tobacco budworm (TBW) and bollworm populations have collected from cotton fields throughout the state of Georgia. Larvae from those field-collected samples were assayed for susceptibility to cypermethrin, MVPII®, and spinosad using an insecticide-treated diet bioassay. Throughout the evaluation period, TBW populations have demonstrated various levels of resistance to MVPII® as compared to the most susceptible field-collected population and two insecticide-susceptible, laboratory-maintained reference strains (HRV and OPS). MVPII® was less effective against bollworm larvae. Decreased susceptibility of several TBW populations and a bollworm population to cypermethrin were noted. Furthermore, an evaluation of LC_{95} values for cypermethrin against TBW larvae has indicated an annual increase throughout the ten-year study period. In general, treated diet 96h activity spectra for the compounds tested against bollworm larvae were: Spinosad >Cypermethrin ≥ MVPII®. Treated diet 96h activity spectra for the compounds tested against TBW larvae were: Spinosad > MVPII® ≥ Cypermethrin.

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 Georgia during the summer of 2004. 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 (Payne et al. 1999; Polizzi and Payne 2004).

Research 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 2004 season: UWG 04-tobacco budworms collected from Carroll County, GA (chickpea); Doo 04-tobacco budworms collected from Dooly County, GA (cotton); Ear 04-bollworms collected from Early County, GA (corn); Mac 04-bollworms collected from Macon County, GA (corn); Pea 04-tobacco budworms collected from Peach County, GA (cotton); TerA 04-tobacco budworms collected from Terrell County, GA (cotton); and TerB 04-bollworms collected from Terrell County, GA (cotton). 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). A bollworm colony collected from Peach County (Pea 04) had a LC_{50} value greater than 250 ppm; this was the highest LC_{50} 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 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). 2004 LC_{50} values were comparable to values obtained during 2003 (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 25-fold levels of resistance to cypermethrin were common. The LC_{50} value for the 2003 (Tif 03) and 2004 (Doo 04 and TerA 04) strains were comparable to the LC_{50} value obtained for a laboratory-selected, pyrethroid-resistant strain (PYR) (Table 2). 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 (0.44 ± 0.07) and TBW larvae (0.42 ± 0.05 ppm) were comparable.

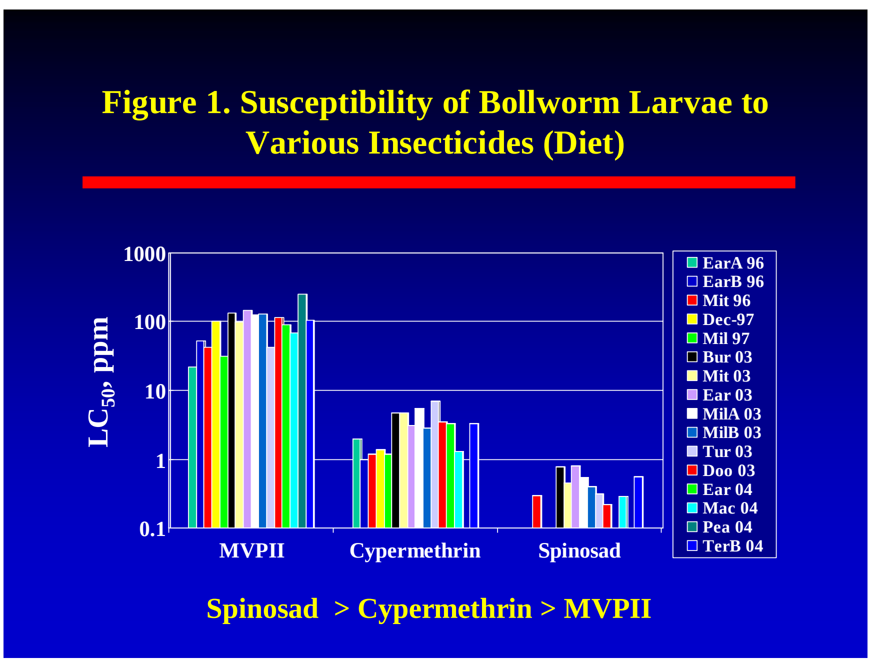
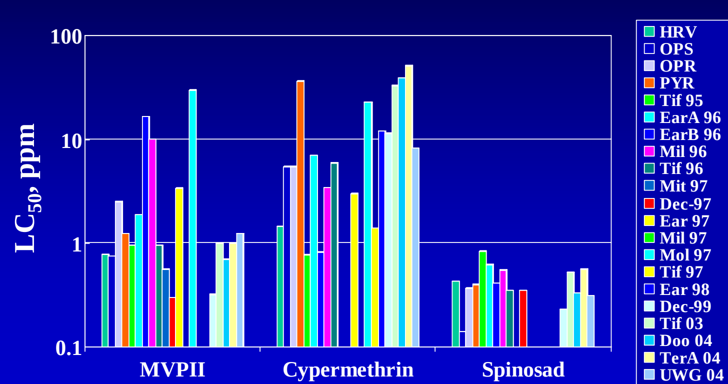


Table 1. Susceptibility of bollworm larvae to MVPII®, Cypermethrin, and Spinosad following a 96 h exposure period.

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)
Mit 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	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)
Doo 03	138 (0.6)*	3.45 (1.3)	0.22 (1.2)
Ear 04 (corn)	88.7 (0.8)*	3.27 (3.4)	ND
Mac 04 (corn)	68.4 (1.2)*	1.29 (3.8)	0.29 (2.3)
Pea 04	>250*	ND	ND
TerB 04	103 (1.2)*	3.33 (3.1)	0.31 (1.8)

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

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



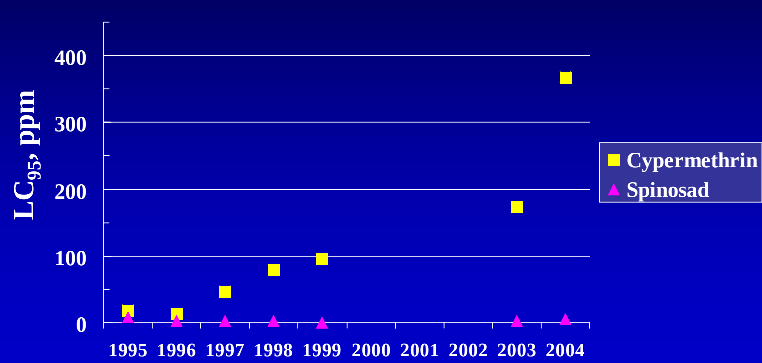
Spinosad > MVPII ≥ Cypermethrin

Table 2. Susceptibility 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)
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)
Mit 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)
Doo 04	0.66 (1.6)*	39.4 (1.3)	0.33 (1.4)
TerA 04	1.69 (1.8)*	51.6 (0.9)	0.56 (1.5)
UWG 04	1.24 (1.5)*	8.27 (2.1)	0.31 (1.8)

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

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



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

Literature Cited

Payne, G., M. Hasty and C. O'Meara. 1999. Susceptibility of field-collected populations of tobacco budworm and cotton bollworm to various insecticides: 1995-1998. In: Proceedings of the Beltwide Cotton Production Research Conferences. National Cotton Council. Memphis, TN.

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