THE EFFICACY OF DIFFERENT INSECTICIDES AND RATES AGAINST BOLLWORMS (LEPIDOPTERA: NOCTUIDAE) IN B.T. AND CONVENTIONAL COTTON

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Abstract

Field and laboratory studies were conducted to determine the efficacy of six insecticides of different chemistries against the cotton bollworm (*Helicoverpa zea*) in conventional ('DPL 5415') and transgenic *Bacillus thuringiensis* ('NuCotn 33b') cotton. Treatments included three rates each of Karate®, Tracer®, Larvin®, Pirate®, Steward®, and Proclaim®. The highest rate corresponded to normal grower use rates. Tracer®, Larvin® and Steward® provided good control of bollworms in conventional cotton, with other materials being less effective. However in B.t. cotton, Karate® was highly effective even at lower rates, as was Tracer®, Larvin® and Steward®. Our data indicated that reduced rates of certain of these insecticides showed considerable promise for bollworm control in B.t. cotton.

Introduction

The cotton bollworm (*Helicoverpa zea*) is a serious pest in both conventional and transgenic *Bacillus thuringiensis* (B.t.) cotton. South Carolina growers typically make 1 to 4 pyrethroid applications to B.t cotton for supplemental control of bollworms. While pyrethroid applications have generally been effective in both genotypes, bollworms throughout the state are becoming more tolerant to pyrethroid insecticides. This tolerance intensifies the need for information on pyrethroid and alternative chemistries for bollworm control in transgenic B.t. cotton.

Field and laboratory observations have shown that bollworms which survive in transgenic B.t. cotton are smaller and develop slower than those in conventional cotton (Sims et al. 1996). We hypothesized that the physiological state of surviving bollworms may result in a synergism between the B.t. toxin and certain supplemental insecticides. If a synergistic relationship is revealed, it may be possible to supplement bollworm control in B.t. cotton with lower rates of insecticides.

This study addressed the following questions: 1) Which insecticide classes are most effective for bollworm control in conventional and B.t. cotton? 2) Is it possible to control bollworms in B.t. cotton with lower rates of any of these insecticides?

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:934-936 (1999)
National Cotton Council, Memphis TN

Materials and Methods

Field Study

Three rates of six insecticides of different chemistries (Karate®, Tracer®, Larvin®, Pirate®, Strategy® and Steward®) were compared near Blackville, South Carolina, within adjacent conventional ('DPL 5415') and B.t. ('NuCotn33b') cotton varieties, planted May 12, 1998. Five replications of 19 treatments were established within a randomized complete block design. Plots were 8 rows wide (22.2 ft) by 40 ft. long. Acephate (0.5 lbs. a.i./acre) was applied twice (6/25 and 7/6) to reduce beneficial arthropods and thereby increase bollworm pressure later in July. Treatments consisted of three rates each of a pyrethroid (Karate®), a spinosyn (Tracer®), a carbamate (Larvin®), a pyrrole (Pirate®), an oxadiazine (Steward®), and an avermectin (Proclaim®). The highest rate for each insecticide generally corresponded to normal grower use rates. This rate was divided by either 1/2 and 1/4 or 2/3 and 1/3, for a total of three rates per insecticide (Table I). Initial applications made on July 9, were based on the S.C. B.t. cotton threshold of 75 eggs/100 plants. Treatments were applied weekly for four weeks in both genotypes, using a CO_2 backpack sprayer, with 5 X hollow cone nozzles (55 psi.) that delivered 9.5 gal/acre. Three, 1 meter beat cloth samples were taken within each plot on July 12 (3 days after the second application), July 22 (4 days after the third application), July 27 (4 days after the fourth application) and August 4 (11 days after the fourth application). Only bollworms 1/4 inch or larger in size were recorded. Percent control was calculated separately for each genotype as follows: 100 - (100 x cumulative total no. of bollworms for a treatment ÷ cumulative total no. of bollworms for the check). Cumulative bollworm totals for each treatment were analyzed using the proc glm statement within the SAS statistical program. The four middle rows of each plot were machine harvested on Oct. 23, 1998.

Larval Sizing

Larvae were sampled randomly with a beat cloth within untreated conventional and B.t. cotton, approximately 21 days after the initiation of the bollworm flight, in order to compare the mean weight of bollworms developing on the two genotypes. One hundred bollworms were collected from each, individually placed in a plastic cup, and taken to the laboratory for weighing. Weight variations were analyzed using the proc glm statement within the SAS statistical program.

Larval LC50's

LC50's of Karate®, Larvin®, Tracer®, and Steward® were determined for bollworms collected from untreated conventional and transgenic B.t. cotton. Using beat cloth samples approximately 15 to 20 days after the initial bollworm flight, similar sized (3rd-4th instar) larvae were taken to the laboratory, weighed and placed individually on diet surface treated with a respective insecticide dosage, similar to the protocol described by Mascarenhas et al.

(1996). Approximately five ml of *H. zea* diet (Southland Products INC.) were pipetted into 30 ml cups and allowed to cool. Five serial dilutions of each insecticide were formulated. One hundred µl of a dilution were pipetted in a swirling motion onto the diet surface and allowed to dry for 30 minutes. Twenty five bollworms per dose were exposed separately in cups held in a growing chamber at 15 hr light / 9 hr dark and 22^0C. Percent mortality was observed at two and five days. Larvae were considered dead if unable to crawl away after 10 seconds of prodding with forceps. LC50 concentrations were determined by probit analysis using the SAS statistical program.

Results

Field Study

The highest rate of Karate® was less effective on conventional cotton than were the middle rates of either Tracer®, Larvin® or Steward® (80% vs. 85%, 83%, 83% control respectively, Table 1). However, the highest rate of Karate® provided excellent control in B.t. cotton, as did Larvin® and Tracer® (99%, 99%, 97% control respectively, Table 1). The relatively poor performance of Karate® in conventional cotton probably represents a low level of pyrethroid resistance within the local bollworm population. The dramatic increase in efficacy of Karate® on B.t. cotton is consistent with the laboratory findings of Harris et al. (1998). They reported that bollworms exposed to sub-lethal doses of B.t. toxins were more susceptible to Karate® than bollworms not exposed to the toxins. The middle and lowest rates of Larvin® were efficacious on B.t. cotton (93.2%, 91.3% control respectively, Table 1). Neither Pirate® nor Proclaim® was effective for bollworm control in conventional cotton. However, the highest rate of Proclaim® provided 90% control in B.t. cotton (Table 1). Plot yields were meaningless due to drought conditions combined with soil type variability within the test area.

Larval Sizing

Bollworms collected from B.t. cotton were significantly smaller than those collected from conventional cotton (101.5 mg vs. 170.1 mg, $P<0.05$).

Larval LC50's

No significant differences were observed between LC50 values (expressed in mg a.i. / kg of body weight) for bollworms collected from conventional cotton and those collected from B.t. cotton. Interestingly, the contact poison Karate® was the only insecticide with a lower LC50 value for bollworms collected from B.t. cotton (Table 2), which is consistent with its increased effectiveness on B.t. cotton in the field study (above).

Summary

All insecticides tested in the field study were more effective on B.t. compared with conventional cotton. Larvin®, Tracer® and Steward® provided good bollworm control on both genotypes. Karate®, at 0.025 lbs. a.i., was not effective on conventional cotton. However, Karate® showed the greatest increase in efficacy when applied to B.t. cotton (80% control in conventional; 99% control in B.t.), followed by Larvin®, Tracer® and Steward®. Lower rates of Karate®, Tracer® and Larvin® provided good supplemental control of bollworms in B.t. cotton. Four applications of the lowest rate of Larvin® (0.2 lbs. a.i.) provided better than 90% control in B.t. cotton. Applications to both genotypes during 1999 will be made on an as-needed basis rather than on a weekly schedule.

Literature Cited

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Table 1. The efficacy of different insecticides and rates against *H. zea* in conventional ('DPL 5415') and B.t. ('NuCotn 33b') cotton.

	Rate	Mean no. larvae / m*		Percent Control	
Chemical	lbs. a.i.	Conv.	B.t.	Conv.	B.t.
Karate®	0.025	0.87 ghi	0.02 f	79.8	99.0
Karate®	0.013	1.51 d-g	0.22 def	65.1	88.4
Karate®	0.006	1.73 cd	0.35 b-e	60.1	81.6
Larvin®	0.8	0.60 hi	0.02 f	86.1	99.0
Larvin®	0.4	0.75 hi	0.13 ef	82.8	93.2
Larvin®	0.2	1.51 d-g	0.18 ef	65.1	91.3
Tracer®	0.09	0.53 hi	0.05 ef	88.2	97.1
Tracer®	0.06	0.65 hi	0.25 c-f	84.9	86.4
Tracer®	0.03	0.96 f-i	0.55 b	77.7	70.9
Steward®	0.09	0.44 i	0.15 ef	89.9	92.2
Steward®	0.045	0.73 hi	0.33 b-e	83.2	80.6
Steward®	0.022	0.98 f-i	0.25 c-f	77.3	86.4
Pirate®	0.3	1.51 d-g	0.36 b-e	65.1	80.6
Pirate®	0.2	1.56 def	0.58 b	63.9	68.9
Pirate®	0.1	2.89 b	0.51 bc	33.2	72.8
Proclaim®	0.013	1.07 e-h	0.18 e-h	75.2	90.3
Proclaim®	0.006	1.64 cde	0.58 b	62.2	68.9
Proclaim®	0.003	2.20 c	0.47 bcd	49.2	74.8
Untreated	0.0	4.33 a	1.87 a		

* Mean derived from total larvae collected on four sampling dates (7/12 - 8/4/98). Treatments followed by the same letter within a column do not differ significantly (ANOVA, P=0.05).

Table 2. LC50 values of third instar *H. zea* larvae collected from conventional ('DPL 5415') and B.t. ('NuCotn 33b') cotton.

		Mean Larval		95% Conf. Interval	
Chemical	Variety	Weight (mg)	LC50*	Lower*	Upper*
Karate®	B.t.	19.63	0.0616	0.0128	0.3979
Karate®	Conv.	18.22	0.1383	0.0900	0.2179
Larvin®	B.t.	19.63	73.6001	50.4086	107.2878
Larvin®	Conv.	18.22	56.2052	37.4649	83.5653
Tracer®	B.t.	16.17	1.0285	0.3581	18.5393
Tracer®	Conv.	13.37	0.4233	0.0641	3.3246
Steward®	B.t.	23.80	1.0719	0.2761	4.7702
Steward®	Conv.	29.20	0.3541	0.1836	0.7171

*mg a.i. per kg larval weight