HELICOVERPA/HELIOTHIS MANAGEMENT IN NUCOTN AND CONVENTIONAL COTTON CULTIVARS IN LOUISIANA

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Abstract

A series of laboratory and field tests conducted during 1995-96 in Louisiana evaluated the efficacy of Bollgard (Coker and NuCOTN 33b/35b), Pirate (chlorfenapyr, AC303,630) , Tracer (spinosad, DE-105), Proclaim (emamectin benzoate, MK-244), and Intrepid (RH 2485) against the bollworm (BW) and tobacco budworm (TBW) complex. In the laboratory feeding study, Bollgard in Coker and Deltapine cotton lines had no significant effect on 96 HAT mortality values of L3 stage BW larvae, but produced >90% mortality of L3 stage TBW larvae compared to that for non-Bollgard parent lines. In the field tests, the efficacy of the foliar insecticides was generally similar to that of the NuCOTN varieties against the BW/TBW complex. Seed cotton yields were more variable as a result of other non-target insect pest effects, but generally followed trends similar to that of the efficacy data. These results confirm the activity of transgenic and novel foliar control strategies against Louisiana BW/TBW populations and demonstrate that numerous options will be available to cotton producers in the near future.

Introduction

Several Lepidopteran insect pests including the bollworm (BW), Helicoverpa zea (Boddie), tobacco budworm (TBW), Heliothis virescens (F.), beet armyworm, Spodoptera exigua (Hübner), and soybean looper, Pseudoplusia includens (Walker) have the potential of reaching economic injury levels in Louisiana cotton fields during July and August (Bagwell et al. 1996). The BW and TBW are the most common and widespread pests and have caused devastating losses in many fields during recent years.

Although BW and TBW are effectively controlled with labeled insecticides in many areas of the Southern U.S., the frequency of treatments applied and actual use rates have increased dramatically. The cost of controlling these pests in Louisiana has significantly changed and ranged from a low of $25 in 1989 (Head 1989) to a high of $55 in 1995 (Williams 1996). In 1994-95, many producers in Mississippi and Alabama experienced severe yield losses (25-75%) from this insect complex, which further illustrates the importance of these pests and the lack of effective control strategies. In 1996, populations of BW were generally higher than that of TBW and constituted the majority of this pest complex in many areas of the Southern U.S. Although BW can be effectively managed with pyrethroids, multiple applications were needed to control persistent and heavy infestation densities during the season. In addition, over 60% of the Bollgard (NuCotn 33b/35b) fields in Louisiana were treated with at least one application of insecticide specifically to control BW (personal communication; R. Bagwell, LSU Agric. Center). Actual yield losses from BW populations varied considerably depending on the intensity and duration of these infestations. Preliminary estimates of losses in field trials located in northeast Louisiana range from 4-30%.

Novel insect pest control technologies are desperately needed in the cotton production system to maintain profitability. Genetic engineering and conventional plant breeding practices have made available the Bollgard technology in adapted cotton varieties, but non-target insect pest problems and agronomic issues may limit their adoption into production systems. Foliar insecticides to control BW and TBW are needed to efficiently manage crop production costs on conventional and transgenic cotton cultivars. The primary objective of this report is to evaluate the field performance of Bollgard (NuCOTN 33b/35b), Pirate (chlorfenapyr, AC303,630) , Tracer (spinosad, DE-105), Proclaim (emamectin benzoate, MK-244), and Intrepid (RH 2485) against BW and TBW infestations in Louisiana. A second objective is to document the efficacy of Bollgard in Coker and Deltapine cotton lines against BW and TBW in a laboratory feeding study.

Materials and Methods

Insecticides and Cotton Seed

Formulated samples of Karate 1EC (lambda-cyhalothrin; Zeneca Ag Products, Wilmington, DE), Pirate 3F (chlorfenapyr; American Cyanamid, Princeton, NJ), Curacron 8EC (profenofos; CIBA Crop Protection, Research Triangle Park, NC), Tracer 4SC (spinosad; DowElanco, Indianapolis, IN), Proclaim 0.16EC/5SG (emamectin benzoate; Merck and Company, Inc., Rahway, NJ), Intrepid 80WP (RH-2485; Rohm and Haas Company, Philadelphia, PA), and Larvin 3.2F (thiodicarb; Rhone Poulenc Ag, Research Triangle Park, NC) were obtained from the manufacturers for the field tests.

Cotton seed representing Coker and Deltapine Bt (Bollgard) lines and their recurrent non-Bollgard parental cultivars were obtained from the appropriate companies during each year of the tests.

Feeding Study

The feeding bioassay was used to evaluate the efficacy of the Bt endotoxin in Bollgard cotton lines against L2 stage BW and TBW larvae. The treatments were Coker 312 (parental non-Bt), MON line 531 (Bt), DP 5415 (parental non-Bt), and DP NuCOTN 33b (Bt). Field-collected colonies of BW and TBW were established by collecting

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eggs and/or larvae from cotton (Stoneville LA 887) at the Macon Ridge location of the Northeast Research Station near Winnsboro, LA in 1995. These colonies were reared in the laboratory for one generation to obtain enough insects at the proper stage for the bioassays.

The two colonies were reared in a similar manner. Adults were confined in 3.8-liter cardboard cartons covered with cotton gauze as an oviposition substrate and were fed a 10% sugar water solution. Eggs were removed at least every other day and allowed to hatch at room temperature. Larvae were reared on a pinto bean and wheat germ diet according to procedures described by Leonard et al. (1988).

Cotton flower buds (squares) were collected from the upper one-third of field-grown Coker and Deltapine cotton plants, washed, and allowed to air dry in the laboratory. BW and TBW larvae were individually placed in one oz. plastic cups and offered two squares. Each larvae was checked daily for mortality and surviving larvae were offered additional squares. The mortality values for each comparison were determined from five replicates of 100 insects per cotton line. After treatment, the larvae were held at 27±3°C and 55-65% RH under a 14:10 light:dark (L:D) photoperiod. Mortality was determined at 96 hours after exposure. The criterion for mortality was inability of a larva to move within 15 seconds after being prodded with a blunt probe. Results were analyzed using a microcomputer based ANOVA (SAS Institute 1988).

Field Trials

These tests were conducted during 1995-96 at the Macon Ridge location of the Northeast Research Station near Winnsboro, LA. Recommended cultural practices and integrated pest management strategies were used to maintain all plots in a similar manner within each test. In some instances, planting dates were manipulated to increase the probability of obtaining economic infestations of native populations of BW and TBW. Selective insecticides were applied for control of non-target pests during the tests.

Treatments were arranged in a randomized complete block design and replicated 4 times. Treated plots within each trial consisted of 4-8 rows (40 inch centers) x 50 ft. The treatments in these tests included Bollgard cottons (NuCOTN 33b/35b), Pirate 3F (0.1-0.35 lb AI/acre), Tracer 4SC (0.045-0.075 lb AI/acre), Karate 1EC (0.025-0.04 lb AI/acre), Curacron (0.75 lb AI/acre), Larvin 3.2F (0.25-0.4 lb AI/acre), Proclaim 0.16EC/5SG (0.0075 lb AI/acre), and Intrepid 80WP (0.4 lb AI/acre). The foliar insecticides were applied as oversprays to the NuCOTN 33b/35b plots or to the plots of the parental cultivars. The parental cultivars included DP 5415, DP 5690, and DP 5690, in tests MRTR9501, MRTR9601, and MRTR9602, respectively. Treatments were applied to target hatching eggs and <4 day old larvae of BW and TBW. Four-five applications of each treatment were made within each test. Applications in all tests were made with a tractor mounted boom and compressed air delivery system calibrated to deliver 6 gallons total spray/acre through Teejet TX-8 hollow cone nozzles (2/row) at 42 psi.

Treatment efficacy against BW and TBW was determined by examining 50 fruiting forms (squares or bolls)/plot. Plots were sampled at 3-7 days after treatment (DAT) for evidence of damage and larvae infesting squares. The center two rows of each plot in selected tests were mechanically harvested twice to estimate seed cotton yields. Results were subjected ANOVA to determine significant treatment effects. Duncan's Multiple Range test (P=0.05) was used to compare treatment means within each respective test (SAS Institute 1988).

Results and Discussion

Feeding Studies

There were no significant differences in mortality values for BW larvae among Bt and normal cotton lines (Table 1). BW mortality levels were below 10% for both Coker and Deltapine cotton lines. Significantly higher mortality of TBW larvae was observed for both Bt cotton lines compared to that for the parental cultivars. TBW mortality values exceeded 90% for the Coker and Deltapine Bt cotton lines. The differential susceptibility between the two species has been previously reported and should have been expected because of differences in susceptibility between the two species to foliar applied Bt products on cotton.

Field Tests With Tobacco Budworm and Bollworm

The data from the field tests presented in this report summarize the efficacy of novel strategies against the BW/TBW complex and their effect on seed cotton yields during 1995-96 in Louisiana. The species composition of this insect complex consisted primarily of TBW, but BW was common in the plots at some periods during each test.

In 1995, all treatments significantly reduced the number of damaged squares on all sample dates and for the test mean except in the 4 DAT5 sample (Table 2). On that sample date, the number of damaged squares in the NuCOTN 33b and Karate+Larvin plots were not different from that in the untreated plots. For the test mean, all NuCOTN 33b and foliar insecticide-treated plots, except for those treated with Intrepid, had fewer damaged squares compared to that in the standard Karate+Larvin-treated plots. All treatments significantly reduced the number of larvae in squares on all sample dates and for the test mean, except on the 5DAT4 sample (Table 3). In that sample, the number of larvae in squares of the Karate+Larvin-treated plots was not different from that in the untreated plots. For the test mean, all NuCOTN 33b and foliar insecticide-treated plots, except for those treated with Intrepid, had fewer larvae in squares compared to the Karate+Larvin-treated plots. Although there were no significant differences among treatments in percent first harvest, all treatments significantly increased yields above the untreated plots (Table 4). The

Karate+Larvin-treated plots outyielded all other plots probably due to heavy infestations of boll weevils which were difficult to control during the late-season. The NuCOTN 33b (untreated) plots yielded less than several of those plots receiving foliar sprays, including the NuCOTN 33b+Pirate-treated plots. Late-season infestations of BW and beet armyworm were sufficiently high to influence yields in the NuCOTN 33b (untreated) plots.

In 1996, two trials (MRTR9601 and MRTR9602) evaluated treatments against BW and TBW similar to that in 1995. In test MRTR9601, all treatments significantly reduced the number of damaged squares compared to that in the untreated plots on all sample dates and for the test mean (Table 5). All treatments except Proclaim and Intrepid reduced the number of damaged squares equal to or below that of the Karate+Larvin standard for the test mean. All treatments significantly reduced the number of larvae in squares compared to that in the untreated plots across all sample dates and for the test mean, except for Intrepid in the 4 DAT2 sample (Table 6). For the test mean, all treatments except Intrepid reduced the number of larvae in squares comparable to or greater than in the Karate+Larvin treatment. Both NuCOTN 35b plots had significantly higher percent first harvests compared to that for the untreated and Intrepid-treated plots (Table 7). Seed cotton yields were significantly increased by all treatments compared to that in untreated plots. All treatments, except for Intrepid and Proclaim, produced yields comparable to that of the Karate+Larvin standard.

In test MRTR9602, all treatments had significantly fewer damaged squares and squares infested with larvae compared with the untreated plots on all sample dates and for the test means (Tables 8 and 9). All treatments provided control of the BW and TBW complex similar to or greater than that provided by Karate or Curacron+Larvin standard treatments. Although there were no significant differences among treatments in percent first harvest, all treatments significantly increased seed cotton yields above the untreated plots (Table 10). All treatments produced yields similar to or greater than that for the Karate and Curacron+Larvin standards.

These data demonstrate the effectiveness of several new transgenic Bt cotton varieties and foliar insecticide strategies against the BW/TBW complex in Louisiana. These novel technologies are considered target-specific and will likely need to be supplemented with other products to optimize control of the complete spectrum of pests that typically co-exist in a cotton field. The efficacy of these products against many other cotton insect pests has been characterized in the past few years and additional studies are being done to refine use rates, treatment timing, and application frequency. The immediate challenge for state scientists and agricultural consultants will be to determine a logical and cost-effective use pattern for each of these products in a multiple pest management strategy.

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Table 1. Evaluation of Coker (Bt) and NuCOTN 33b against bollworm/tobacco budworm (BW/TBW) in a laboratory study.

Treatment/Variety	% BW Mortality (96 HAT)	% TBW Mortality (96 HAT)
MON 531 (Bt)	2.7a	94.0a
Coker 312	8.3a	4.0b
NuCOTN 33b (Bt)	9.0a	80.0a
DP 5415	7.6a	8.4b

Means in columns for each variety followed by the same letter are not significantly different (P=0.05;DMRT).

Table 2. Evaluation of treatments for against bollworm/tobacco budworm (BW/TBW) in field test MRTR9501.

		BW/TBW Damage/50 Squares			
Treatment	Rate/Acre (lb AI)	3 DAT3	5 DAT4	4 DAT5	Test Mean
NuCOTN 33b	------	2.8d	2.5b	1.8abc	2.3c
NuCOTN 33b[1]	------	4.0bcd	1.8b	1.5abc	2.4c
Pirate 3F	0.35	4.3bcd	1.8b	1.0bc	2.3c
Tracer 4SC	0.0667	5.5bcd	1.8b	0.8bc	2.7c
Karate 1EC+ Larvin 3.2F	0.033 + 0.4	7.3b	4.0b	2.3ab	4.5b
Proclaim 0.16EC	0.0075	3.8cd	1.8b	0.5c	2.0c
Intrepid 80WP	0.4	2.0b	7.0b	0.8c	3.3bc
Untreated	------	10.5a	8.5a	2.8a	7.2a
(P>F)		<0.01	<0.01	0.01	<0.01

Means in columns followed by the same letter are not significantly different (P=0.05;DMRT).
[1]Treated with Pirate 3F (0.1 lb [AI]/acre).

Table 3. Evaluation of treatments against bollworm/tobacco budworm (BW/TBW) larvae in field test MRTR9501.

Treatment	Rate/Acre (lb AI)	BW/TBW Larvae/50 Squares 3 DAT3	5 DAT4	4 DAT5	Test Mean
NuCOTN 33b	-------	0.0c	0.3b	0.5b	0.3c
NuCOTN 33b[1]	-------	0.5c	0.3b	0.0b	0.2c
Pirate 3F	0.35	1.5bc	0.3b	0.0b	0.6c
Tracer 4SC	0.0667	1.8bc	0.0b	0.0b	0.6c
Karate 1EC + Larvin 3.2F	0.033 + 0.4	3.3b	1.8ab	0.3b	1.8b
Proclaim 0.16EC	0.0075	1.3cde	0.5b	0.5b	0.8c
Intrepid 80WP	0.4	2.5bc	0.5b	0.0b	1.0bc
Untreated	------	7.3a	3.8a	1.8a	4.3a
(P>F)		<0.01	0.01	<0.01	<0.01

Means in columns followed by the same letter are not significantly different (P=0.05;DMRT).
[1]Oversprayed with Pirate 3F (0.1 lb [AI]/acre).

Table 4. Evaluation of treatments on seed cotton yields in field test MRTR9501.

Treatment	Rate/Acre (lb AI)	% First Harvest	Yield/Acre (lb Seed cotton)
NuCOTN 33b	------	84.4a	711.5d
NuCOTN 33b[1]	------	79.8a	911.1bc
Pirate 3F	0.35	79.1a	809.5cd
Tracer 4SC	0.0667	75.4a	972.8b
Karate 1EC + Larvin 3.2F	0.033 + 0.4	76.5a	1107.2a
Proclaim 0.16EC	0.0075	79.0a	914.8bc
Intrepid 80WP	0.4	83.6a	856.7bcd
Untreated	------	87.5a	459.3e
(P>F)		0.33	<0.01

Means in columns followed by the same letter are not significantly different (P=0.05;DMRT).
[1]Oversprayed with Pirate 3F (0.1 lb [AI]/acre).

Table 5. Evaluation of treatments against bollworm/tobacco budworm (BW/TBW) in field test MRTR9601.

Treatment	Rate/Acre (lb AI)	BW/TBW Damage/50 Squares 4 DAT2	5 DAT3	7 DAT4	Test Mean
NuCOTN 35b	------	0.0c	0.3c	1.0d	0.4d
NuCOTN 35b[1]	0.2	0.3c	0.5c	0.8d	0.5d
Pirate 3F	0.35	1.3bc	1.0bc	3.3cd	1.8cd
Tracer 4SC	0.075	0.5c	0.5c	2.5cd	1.2d
Proclaim 5SG	0.0075	1.8bc	1.3bc	8.3b	3.7bc
Karate 1EC + Larvin 3.2F	0.033 + 0.4	0.5c	1.5bc	2.0cd	1.3d
Intrepid 80WP	0.4	2.8b	3.5b	6.5bc	4.2b
Untreated	------	5.0a	8.8a	16.3a	10.0a
(P>F)		<0.01	<0.01	<0.01	<0.01

Means in columns followed by the same letter are not significantly different (P=0.05;DMRT).
[1]Oversprayed with Pirate 3F (0.2 lb [AI]/acre).

Table 6. Evaluation of treatments against bollworm/tobacco budworm (BW/TBW) larvae in field test MRTR9601.

Treatment	Rate/Acre (lb AI)	BW/TBW Larvae/50 Squares 4 DAT2	5 DAT3	7 DAT4	Test Mean
NuCOTN 35b	------	0.0b	0.0b	0.0b	0.0c
NuCOTN 35b[1]	------	0.0b	0.3b	2.5b	0.9bc
Pirate 3F	0.35	0.5b	0.5b	1.0b	0.7bc
Tracer 4SC	0.075	0.3b	0.0b	0.5b	0.3c
Proclaim 5SG	0.0075	0.0b	1.3b	3.3b	1.5bc
Karate 1EC + Larvin 3.2F	0.033 + 0.4	0.3b	1.0b	0.5b	0.6c
Intrepid 80WP	0.4	2.3a	1.0b	4.5b	2.6b
Untreated	------	3.5a	4.3a	9.0a	5.6a
(P>F)		<0.01	<0.01	<0.01	<0.01

Means in columns followed by the same letter are not significantly different (P=0.05;DMRT).
[1]Oversprayed with Pirate 3F (0.2 lb [AI]/acre).

Table 7. Evaluation of treatments on seed cotton yields in field test MRTR9601.

Treatment	Rate/Acre (lb AI)	% First Harvest	Yield/Acre (lb Seed cotton)
NuCOTN 35b	------	89.3a	2571.8ab
NuCOTN 35b[1]	------	89.8a	2723.9a
Pirate 3F	0.35	86.4ab	2295.1bc
Tracer 4SC	0.075	86.9ab	2442.1abc
Proclaim 5SG	0.0075	85.0b	2194.4cd
Karate 1EC + Larvin 3.2F	0.033 + 0.4	87.3ab	2576.9ab
Intrepid 80WP	0.4	85.1b	1976.6d
Untreated	------	85.6b	1551.8e
(P>F)		0.03	<0.01

Means in columns followed by the same letter are not significantly different (P=0.05;DMRT).
[1]Oversprayed with Pirate 3F (0.2 lb [AI]/acre).

Table 8. Evaluation of treatments against bollworm/tobacco budworm (BW/TBW) in field test MRTR9602.

Treatment	Rate/Acre (lb AI)	BW/TBW Damage/50 Squares 4 DAT	5 DAT	7 DAT	Test Mean
NuCOTN 35b	------	0.0b	0.3c	1.5cd	0.6c
NuCOTN 35b[1]	------	0.0b	0.5bc	1.8bcd	0.7c
NuCOTN 35b[2]	------	0.3b	0.5bc	0.8d	0.5c
NuCOTN 35b[3]	------	0.5b	0.3c	1.3cd	0.7c
Tracer 4SC	0.075	1.3b	1.0bc	2.8bcd	1.7bc
Karate 1EC	0.04	2.0b	2.3bc	5.5bc	3.3b
Curacron 8EC+ Larvin 3.2F	0.75 + 0.25	0.0b	2.8b	6.0b	2.9b
Untreated	------	4.8a	10.5a	19.5a	11.6a
(P>F)		<0.01	<0.01	<0.01	<0.01

Means in columns followed by the same letter are not significantly different (P=0.05;DMRT).
[1]Oversprayed with Karate 1EC (0.025 lb [AI]/acre).
[2]Oversprayed with Tracer 4SC (0.045 lb [AI]/acre).
[3]Oversprayed with Larvin 3.2F (0.4 lb [AI]/acre).

Table 9. Evaluation of treatments against bollworm/tobacco budworm (BW/TBW) larvae in field test MRTR9602.

		BW/TBW			
	Rate/Acre	Larvae/50 Squares			Test
Treatment	(lb AI)	4 DAT2	5 DAT3	7 DAT4	Mean
NuCOTN 35b	------	0.0b	0.5b	0.5c	0.3c
NuCOTN 35b[1]	------	0.0b	0.0b	0.5c	0.2c
NuCOTN 35b[2]	------	0.0b	0.3b	0.0c	0.1c
NuCOTN 35b[3]	------	0.0b	0.3b	0.0c	0.1c
Tracer 4SC	0.075	0.0b	0.0b	1.5bc	0.5bc
Karate 1EC	0.04	1.3b	1.3b	3.3b	1.9b
Curacron 8EC + Larvin 3.2F	0.75 + 0.25	0.3b	1.3b	2.5bc	1.4bc
Untreated	------	3.8a	7.0a	9.8a	6.8a
(<u>P</u>>F)		<0.01	<0.01	<0.01	<0.01

Means in columns followed by the same letter are not significantly different (<u>P</u>=0.05;DMRT).
[1]Oversprayed with Karate 1EC (0.025 lb [AI]/acre).
[2]Oversprayed with Tracer 4SC (0.045 lb [AI]/acre).
[3]Oversprayed with Larvin 3.2F (0.4 lb [AI]/acre).

Table 10. Evaluation of treatments seed cotton yields in field test MRTR9602.

	Rate/Acre	% First	Yield/Acre
Treatment	(lb AI)	Harvest	(lb Seed cotton)
NuCOTN 35b	------	88.3a	2711.5abc
NuCOTN 35b[1]	------	87.8a	2899.3ab
NuCOTN 35b[2]	------	89.8a	2887.1ab
NuCOTN 35b[3]	------	89.4a	3013.7a
Tracer 4SC	0.075	86.9a	2629.8bc
Karate 1EC	0.04	87.3a	2450.1c
Larvin 3.2F + Curacron 8EC	0.75 + 0.25	87.6a	2446.1c
Untreated	------	86.3a	1547.7d
(<u>P</u>>F)		0.15	<0.01

Means in columns followed by the same letter are not significantly different (<u>P</u>=0.05;DMRT).
[1]Oversprayed with Karate 1EC (0.025 lb [AI]/acre).
[2]Oversprayed with Tracer 4SC (0.045 lb [AI]/acre).
[3]Oversprayed with Larvin 3.2F (0.4 lb [AI]/acre).