TREATMENT THRESHOLDS FOR STINK BUGS IN TRANSGENIC *B.t.* COTTON

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Abstract

Several species of phytophagous Pentatomidae (*Nezara viridula*, *Acrosternum hilare*, and *Euschistus servus*) are pests on transgenic *B.t.* cotton in South Carolina. These species were observed on transgenic *B.t.* cotton during the 1995 and 1996 growing seasons. Stink bugs damaged young bolls in mid to late season as adults migrated in from alternate hosts. Results from 1995 indicated that stink bug management in transgenic *B.t.* cotton produced higher yields than non-management. Treating with methyl parathion at a threshold of one stink bug per six feet of row provided adequate protection of developing bolls. Results in 1996 were similar, indicating that management of phytophagous stink bugs is necessary in transgenic *B.t.* cotton. Use of a ground-cloth is recommended in order to determine stink bug density per linear foot of row. We recommend insecticide treatment at a density of one bug per six feet of row. Careful attention should also be given to the percentage of young bolls damaged, and our data indicate that treatment will be necessary if more than 20% of bolls are penetrated in mid to late season.

Introduction

Cotton containing genes for the endotoxin of *Bacillus thuringiensis* Berliner var. *kurstaki* (*B.t.*) offers control of several lepidopterous pests of cotton. In South Carolina, *B.t.* cotton requires no insecticide for control of tobacco budworm, *Heliothis virescens* (F.), but cotton bollworm, *Helicoverpa zea* (Boddie), may require some supplemental control. In the Southeast, transgenic *B.t.* cotton and the Boll Weevil Eradication Program provide situations where insecticide use is reduced substantially. In these locations, secondary pests such as stink bugs, which are unaffected by *B.t.* endotoxins, can become major pests of cotton. Current thresholds for stink bugs in conventionally-treated non-*B.t.* cotton are arbitrary because insect management efforts are primarily focused on controlling lepidopterous pests, and stink bug problems are usually controlled by insecticides used routinely for these pests.

Stink bugs have been reported to cause severe damage to many wild and cultivated plants (Schoene and Underhill 1933, Jones and Sullivan 1982). In situations of limited insecticide use, cotton research has demonstrated the damage potential of stink bugs to yield and lint quality (Wene and Sheets 1964, Toscano and Stern 1976, Roach 1988, Barbour et al. 1990, Turnipseed et al. 1995, Turnipseed and Greene 1996). Stink bugs make tiny puncture wounds in cotton bolls and remove sap from immature seeds and surrounding structures. This kind of boll damage is not externally visible, and bolls must be opened to see damaged locks. The green stink bug, *Acrosternum hilare* (Say), the southern green stink bug, *Nezara viridula* (L.) and the brown stink bug, *Euschistus servus* (Say) are important species that can cause hidden damage to cotton.

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Materials and Methods

Cotton was grown using recommended production practices. Site 1 (Sandifer Farm) located near Blackville, SC was planted 8 May in 1995 and 6 May in 1996. Site 1 was bordered by oaks, other hardwoods, pines, blackberries, and additional cotton. Site 2 (Edisto Research and Education Center [EREC]) located near Blackville, SC was planted 3 May 1996 and bordered by non-cultivated areas, southern peas, and additional cotton. Two Delta Pine (DP) varieties were used: (1) *B.t.* (Bollgard™) NuCOTN33b and (2) the conventional parent DP5415. Large field plots of 24 rows by 80 feet (0.14 acre) were used in a randomized complete block design with four replications. In 1995, at least 12 rows of non-*B.t.* DP5415 border cotton planted on the sides of experimental plots and 40 feet planted at the plot ends remained untreated. Border rows were not used in 1996. The treatments and treatment thresholds tested were:

* added in 1996	Threshold Level	
Treatment	Stink Bug	Bollworm
1) *B.t.* NuCOTN 33b	1 bug/12 ft	untreated
2) *B.t.* NuCOTN33b	1 bug/ 6 ft	untreated
3) *B.t.* NuCOTN33b	1 bug/ 3 ft	untreated
4) *B.t.* NuCOTN33b	untreated	untreated
5) *B.t.* NuCOTN33b*	as #6	as #6
6) Non-*B.t.* DP5415	1 bug/ 6 ft	3 sm bollworms/100
7) Non-*B.t.* DP5415	untreated	untreated

Weekly sampling, using dishpan or ground-cloth methods as described by Greene and Turnipseed (1996), was initiated in July to assess populations of stink bugs, predaceous arthropods, and other insects. On each sampling date, five ground-cloth samples were taken randomly from the 12 middle rows in each plot, and numbers of nymphs and adults were recorded for green, southern green, and brown stink bugs. After a stink bug threshold was reached using an average from all plots in a treatment, methyl parathion (4EC) was applied at 0.50 lb (AI)/acre with a high-clearance sprayer to control populations.

Numbers of bollworm eggs and larvae were observed and recorded biweekly on the top third of 25 plants per plot with larvae being classified as small (< 0.25 inch) or medium-large ($\geq$ 0.25 inch). Karate® 1EC (cyhalothrin) at 0.033 lb (AI)/acre or Baythroid® 2 (cyfluthrin) at 0.05 lb (AI)/acre were applied with a high-clearance sprayer after reaching threshold levels of bollworm in non-*B.t.* cotton in 1995 and 1996, respectively. In 1996, an additional treatment was added to include *B.t.* cotton treated with pyrethroid each time non-*B.t.* cotton received pyrethroid treatment for bollworm.

Percentages of boll damage by stink bugs were determined on sampling dates by randomly collecting and opening 25 bolls (50 to 75% grown) from the 12 center rows of each plot for a total of 100 bolls per treatment. Each boll was squeezed open by hand and considered damaged if at least one puncture wound/wart was observed on the interior wall.

Seed cotton yields were determined by mechanically harvesting the four middle rows using a two-row picker. Yields are reported as pounds of seed cotton per acre. All data were subjected to ANOVA using PROC GLM, and treatment means were separated ($P \leq 0.05$) using Duncan's Multiple Range Test (SAS Institute 1985, Badarinathi 1992).

Results and Discussion

Budworm/bollworm thresholds were exceeded in plots of non-*B.t.* cotton (DP5415), and pyrethroid applications were made as necessary in treated plots. Pyrethroid insecticide was applied eight times in 1995 and four times in 1996. Transgenic *B.t.* cotton (NuCOTN33b) provided good control of the budworm/bollworm complex (ca. 90% *H. zea* during July-Sept.). Due to combined damage from bollworms and stink bugs, untreated non-*B.t.* plots produced statistically less seed cotton than all other treatments (Tables 1-3).

Stink bugs were the major secondary pests encountered. The predominant species were the green stink bug, *Acrosternum hilare*, and the southern green stink bug, *Nezara viridula*. Data concerning damage by stink bugs demonstrated the effects of insecticide use on pest densities and subsequent levels of boll damage. Applications of methyl parathion reduced boll damage by stink bugs, and pyrethroid use also afforded good control. This is consistent with the findings of Turnipseed et al. (1995) that stink bug damage to developing bolls was directly related to applications of pyrethroid insecticide. On 24 July 1996, damage levels did not differ significantly at sites 1 and 2 (Tables 1 and 2). By the last sampling date, damage levels at all sites provided an indication of potential yield loss due to stink bug feeding and damage (Tables 1-3), with lower percentages of damage producing higher seed cotton yields.

B.t. cotton treated with pyrethroid insecticide each time non-*B.t.* plots received a pyrethroid treatment for bollworm (4 total treatments) produced the highest yields (Tables 1 and 2). Pyrethroid-protected non-*B.t.* plots produced an average of 179 lbs less seed cotton than pyrethroid protected *B.t.* cotton. Stink bug thresholds were not reached in pyrethroid-treated plots. These results indicated that pyrethroid treatments to *B.t.* cotton offered protection against phytophagous pentatomids. Also, some supplemental control may have been provided against *H. zea*. On all sampling dates, boll damage by stink bugs did not differ statistically between the pyrethroid-treated *B.t.* and non-*B.t.* cotton (Tables 1 and 2).

Seed cotton yields from *B.t.* cotton treated with one to four applications of methyl parathion did not differ significantly (Tables 1-3). However, *B.t.* plots treated with methyl parathion at one stink bug per six feet of row generally produced more seed cotton than *B.t.* plots treated at one bug per twelve and three feet of row.

Overall, untreated *B.t.* cotton produced numerically lower seed cotton yields than treated *B.t.* cotton. These reductions resulted primarily from stink bug damage to developing bolls, as there were no measurable differences in density or damage from other pests in *B.t.* plots. The average yield from *B.t.* plots treated at one bug per six feet of row with methyl parathion produced over 500 lbs more seed cotton than did *B.t.* untreated (Avg. Tables 1-3).

Summary

Intensive ground-cloth sampling was conducted during these tests to obtain reliable estimates of arthropod densities. Proper management of phytophagous stink bugs in transgenic *B.t.* cotton should begin with careful ground-cloth sampling in mid-season. Results averaged from both years and sites indicated that insecticide treatment at the density of one stink bug per six feet of row resulted in the highest seed cotton yield (ca. 3473 lbs/acre).

Boll examination for feeding damage by stink bugs is also strongly advised in *B.t.* cotton. A boll was considered ‘damaged’ or ‘affected’ if at least one puncture wound/wart was observed on the inner boll wall. At the density of one stink bug per six feet of row, an average of about 20% boll damage was observed prior to the initial insecticide application. This is a preliminary calculation. Percent boll damage should and will be a part of the final treatment threshold, but the linear threshold of one bug per six feet of row should be used until further investigations are conducted.

Methyl parathion is an effective and economical material for stink bugs, but pyrethroids should be considered as an alternative for protection from both pentatomids and bollworm. In 1997, we will compare pyrethroids and methyl parathion for stink bug control on *B.t.* cotton.

These results demonstrate that stink bugs can cause significant damage to untreated *B.t.* cotton and their management is important, particularly where stink bugs have caused problems in other crops.

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Table 1. Percent boll damage by stink bugs and seed cotton yields in treated and untreated *B.t.* (NuCOTN 33) and non-*B.t.* (DPL 5415) cotton. Site 1 (Sandifer) in Blackville, SC (1996).

Treatment	% Damaged[a,b]			Seed Cotton (lbs / acre)[a]
	24 July	6 Aug.	20 Aug.	
B.t. 1bug/ 12 ft	16 a	**m** 27 a	**mm** 10 bc	3523 ab
B.t. 1 bug/ 6 ft	13 a	**m** 20ab	**m** 9 bc	3904 a
B.t. 1 bug/ 3 ft	15 a	30 a	**m** 25 ab	3665 a
B.t. untreated	16 a	34 a	32 a	3052 bc
B.t. pyrethroid	**p** 10 a	**pp** 8 c	**p** 1 c	4065 a
5415 pyrethroid	**p** 14 a	**pp** 8bc	**p** 2 c	3830 a
5415 untreated	25 a	36 a	38 a	2655 c

a Treatment means within a column followed by the same letter do not significantly differ (α = 0.05), Duncan's Multiple Range Test.
b Sample proportions presented. Analyses performed on arsine-transformed data.
m Methyl parathion 4EC application at 0.50 lb (AI)/acre between sampling dates.
p Pyrethroid application (Baythroid 2® at 0.05 lb [AI]/acre) between sampling dates.

Table 2. Percent boll damage by stink bugs and seed cotton yields in treated and untreated *B.t.* (NuCOTN 33) and non-*B.t.* (DPL 5415) cotton. Site 2 (EREC) in Blackville, SC (1996).

Treat-ment	% Damaged[a,b]				Seed Cotton (lbs/a)[a]
	24 July	7 Aug.	20 Aug.	4 Sept.	
B.t. 1bug/ 12 ft	25 a	**m** 22ab	**m** **m** 14 b	**m** 20 b	3844 ab
B.t. 1 bug/ 6 ft	19 a	**m**18abc	20 ab	**m** 21 b	3927 ab
B.t. 1 bug/ 3 ft	17 a	21 abc	28 a	**m** 24 b	3663 b
B.t. untreated	22 a	32 a	25 ab	29 b	3893 ab
B.t. pyrethroid	**p** 10 a	**pp**12bc	**p** 3 c	6 c	4142 a
5415 pyrethroid	**p** 16 a	**pp** 6 c	**p** 4 c	13 bc	4019 ab
5415 untreated	21 a	41 a	32 a	54 a	2533 c

a Treatment means within a column followed by the same letter do not significantly differ (α = 0.05), Duncan's Multiple Range Test.
b Sample proportions presented. Analyses performed on arsine-transformed data.
m Methyl parathion 4EC application at 0.50 lb (AI)/acre between sampling dates.
p Pyrethroid application (Baythroid 2® at 0.05 lb [AI]/acre) between sampling dates.

Table 3. Percent boll damage by stink bugs and seed cotton yields in treated and untreated *B.t.* (NuCOTN 33) and non-*B.t.* (DPL 5415) cotton. Site 1 (Sandifer) in Blackville, SC (1995).

	% Damaged[a,b]			
Treatment	**29 Aug.**	**8 Sept**	**22 Sept.**	**Seed Cotton (lbs / acre)[a]**
B.t. 1bug/ 12 ft	**m** 11 b	33 b	**m** 35 bc **m**	2566 a
B.t. 1 bug/ 6 ft	**m** 16 ab	38 ab	**m** 32 c	2588 a
B.t. 1 bug/ 3 ft	31 a	50 ab	**m** 25 c	2463 a
B.t. untreated	26 ab	38 ab	65 ab	1844 b
5415 pyrethroid	**ppp** **ppp** 12 b	**p** 8 c	**p** 9 c	2468 a
5415 untreated	32 a	58 a	77 a	662 c

a Treatment means within a column followed by the same letter do not significantly differ ($\alpha = 0.05$), Duncan's Multiple Range Test.

b Sample proportions presented. Analyses performed on arsine-transformed data.

m Methyl parathion 4EC application at 0.50 lb (AI)/acre between sampling dates.

p Pyrethroid application (Karate® 1EC at 0.033 lb [AI]/acre) between sampling dates.