STINK BUG THRESHOLDS IN TRANSGENIC *B.t.* COTTON

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Abstract

Several species of phytophagous Pentatomidae (*Nezara viridula*, *Acrostern-um hilare*, and *Euchistis servus*) have the potential to become major pests on transgenic *B.t.* cotton. These species were observed in transgenic *B.t.* cotton in South Carolina during 1995. Stink bug damage to maturing bolls occurred in mid to late season as adults migrated in from alternate hosts. Stink bug damage to bolls ranged from 15-71% in untreated *B.t.* cotton and 7-53% in *B.t.* cotton treated with methyl parathion. At one site, there were no significant differences in seed cotton yields from *B.t.* cotton that received one, two, or three applications of methyl parathion, whereas untreated *B.t.* cotton yielded significantly less than treated *B.t.* cotton. At all sites, untreated *B.t.* cotton produced numerically lower seed cotton yields than treated *B.t.* cotton. Seed cotton reductions in untreated *B.t.* cotton resulted primarily from stink bug damage to bolls. There were no significant differences between seed cotton yields from non-*B.t.* cotton treated with pyrethroid for bollworm and *B.t.* cotton treated with methyl parathion for stink bugs. Transgenic *B.t.* cotton treated with methyl parathion at South Carolina's arbitrary treatment threshold of one stink bug per six feet of row provided adequate protection during these tests. Economic thresholds for stink bugs should be established in *B.t.* cotton to protect the crop from potentially serious losses.

Introduction

Cotton containing genes for the endotoxin of *Bacillus thuringiensis* (*B.t.*) subspecies *kurstaki* offers potential for control of several lepidopterous pests on cotton. In most areas, this will mean that no insecticides will be necessary for control of pests such as *Heliothis virescens* (F.) and *Helicoverpa zea* (Boddie). Secondary pests such as stink bugs are unaffected by *B.t.* endotoxins, and in situations of little insecticide use, could present a problem to cotton produc-tion. Current thresholds for stink bugs in conventionally treated non-*B.t.* cotton are arbitrary because insect management efforts are primarily focused on controlling the boll weevil and lepidopterous pests, and stink bug pro-blems are usually controlled by insecticides used routinely for these pests. In the Southeast, transgenic *B.t.* cotton and the Boll Weevil Eradication Program will provide situations where insecticide use will be reduced substantially.

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). 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, *Euchistus servus* (Say) are important species that can cause hidden damage to cotton.

Materials and Methods

Cotton was grown using recommended production practices. Site 1 (Sandifer Farm) located near Blackville, SC was planted 8 May 1995 and bordered by oaks, other hardwoods, pines, blackberries, and additional cotton. Site 2 (McDaniel Farm) located near Bishopville, SC was planted 22 May 1995 and bordered by southern peas, non-cultivated areas, and additional cotton.

Large field plots of 24 rows by 80 feet (0.14 acre) were used in a randomized block design with four replications. At least 12 rows of non-*B.t.* border cotton planted on the sides of experimental plots and 40 feet planted at the plot ends remained untreated.

The treatments and treatment thresholds used were:

Treatment	Threshold Level	
	Stink Bug	Bollworm
1) DPL 5415 *B.t.*	1 bug/12 ft	3 med. worms/100 plants
2) DPL 5415 *B.t.*	1 bug/ 6 ft	6 med. worms/100 plants
3) DPL 5415 *B.t.*	1 bug/ 3 ft	12 med. worms/100 plants
4) DPL 5415 *B.t.*	untreated	untreated
5) DPL 5415 Non-*B.t.*	1 bug/ 6 ft	3 small worms/100 plants
6) DPL 5415 Non-*B.t.*	untreated	untreated

Weekly sampling of bollworms, stink bugs, predaceous arthropods, and other insects began in July. Sampling of predators, stink bugs, and lepidopterous pests during the early growth stage (true leaves-squaring freely) was conducted using a 15-quart dishpan. The plants were bent and shaken over the dishpan to dislodge arthropods for counting. On each sampling date, ten dishpan samples were taken randomly in each plot for a total of ten feet of sampled row per plot. At about 24 inches in height, a ground cloth or beat cloth (3 ft x 3 ft) was used to adequately sample the larger plants. The cloth was placed carefully between rows to avoid disturbing adult bugs, and

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plants from one row were bent and shaken over the cloth to dislodge stink bugs and other arthropods. On each sampling date, five beat 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. When a stink bug threshold was reached using an average of all plots in a treatment, methyl parathion (4EC) was applied at 0.50 lb (AI)/acre with a high-clearance sprayer to control populations.

Percentages of stink bug boll damage were determined on three dates by randomly collecting and opening 25 bolls (50 to 75% grown) from the center 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.

Numbers of bollworm eggs and larvae were observed and recorded weekly 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). When a bollworm threshold was reached in a treatment, *lambda*-cyhalothrin (Karate® 1EC) was applied at 0.033 lb (AI)/acre with a high-clearance sprayer.

Seed cotton yields were determined by harvesting either mechanically or manually. At site 1, the four middle rows were machine harvested from all plots using a two-row picker. At site 2, a 13.75 ft section of row (1/1000th of an acre) was hand harvested from the center of each plot. Seed cotton yields were analyzed statistically utilizing a randomized complete block design, analysis of variance, and Duncan's Multiple Range Test.

Results and Discussion

Budworm/bollworm thresholds were exceeded in plots of non-*B.t.* cotton, and pyrethroid applications were made as necessary in treated plots. Transgenic *B.t.* cotton provided excellent control of the budworm/bollworm complex (ca. 90% *H. zea* during July-Sept.), as the treatment thresholds were not exceeded. 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 from site 1 showed that *B.t.* cotton treated with one, two, or three applications of methyl parathion produced significantly higher yields than untreated *B.t.* cotton (Table 1). Methyl parathion reduced boll damage by stink bugs with damage peaking at 65% in untreated *B.t.* plots and 38% in treated *B.t.* plots after at least one application. (Table 1). There were no measurable differences in damage from other pests in *B.t.* plots, which indicates that stink bugs were responsible for yield differences between treated and untreated transgenic *B.t.* cotton.

In treated non-*B.t.* cotton at both sites, pyrethroid use suppressed stink bug numbers and damage when compared to untreated non-*B.t.* plots (Tables 1 and 2). 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. Stink bug thresholds were not reached in treated non-*B.t.* plots. At site 1, yields from non-*B.t.* plots treated with pyrethroid and *B.t.* plots treated with methyl parathion did not differ significantly (Table 1).

At site 2, non-*B.t.* plots treated with Karate® produced the highest seed cotton yields (Table 2). There were no significant differences in seed cotton yields among the *B.t.* plots at site 2. However, transgenic cotton receiving one and three applications of methyl parathion produced 181 and 400 lbs more seed cotton than average untreated *B.t.* cotton. Again, at site 2, stink bug boll damage was greater in untreated cotton than in treated plots. At both sites, untreated non-*B.t.* cotton yielded significantly less seed cotton than all other treatments (Tables 1 and 2). This was due primarily to combined damage caused by stink bugs and the cotton bollworm. There were no significant differences in yield between *B.t.* cotton treated with methyl parathion at treatment thresholds of 1 bug/6 ft and 1 bug/12 ft and non-*B.t.* cotton protected from bollworm with a pyrethroid. 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. This justifies the rapid development of treatment thresholds for stink bugs on *B.t.* cotton.

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Table 1. Stink bug damaged bolls and seed cotton yields in treated and untreated *B.t.* and non-*B.t.* 5415 cotton. Site 1, Blackville, SC (1995).

	%Damaged bolls			Seed cotton[a]
Treatment	**8-29**	**9-8**	**9-22**	**(lbs./acre)**
B.t. 1 bug/12 ft	[m] 11	33	[m] 35	[m] 2566 a
B.t. 1 bug/ 6 ft	[m] 16	38	[m] 32	2588 a
B.t. 1 bug/ 3 ft	31	50	[m] 25	2463 a
B.t. untreated	26	38	65	1844 b
non-*B.t.* 1 bug/6 ft & 3 worms/100 plants	[p] 12	[p] 8	[p] 9	2468 a
non-*B.t.* untreated	32	58	77	662 c

[a] Treatment means not followed by the same letter are significantly different at the 5% level of significance (Duncan's Multiple Range Test).
[m] Methyl parathion 4EC application at 0.50 lb (AI)/acre between dates.
[p] Pyrethroid application (Karate® 1EC) at 0.033 lb (AI)/acre prior to dates.

Table 2. Stink bug damaged bolls and seed cotton yields in treated and untreated *B.t.* and non-*B.t.* 5415 cotton. Site 2, Bishopville, SC (1995).

	%Damaged bolls			Seed cotton[a]
Treatment	**8-31**	**9-14**	**9-21**	**(lbs./acre)**
B.t. 1 bug/12 ft	[mm] 7	[m] 30	42	1769 ab
B.t. 1 bug/ 6 ft	17	[m] 53	48	1550 ab
B.t. 1 bug/ 3 ft	15	56	71	1438 ab
B.t. untreated	23	54	71	1300 b
non-*B.t.* 1 bug/6 ft & 3 worms/100 plants	[pppp] 14	38	43	1875 a
non-*B.t.* untreated	23	55	72	394 c

[a] Treatment means not followed by the same letter are significantly different at the 5% level of significance (Duncan's Multiple Range Test).
[m] Methyl parathion 4EC application at 0.50 lb (AI)/acre prior to dates.
[p] Pyrethroid application (Karate® 1EC) at 0.033 lb (AI)/acre prior to date.

Table 3. Stink bug damaged bolls and seed cotton yields in treated and untreated *B.t.* and non-*B.t.* 5415 cotton. Site 3, Blackville, SC (1995).

	%Damaged bolls			Seed cotton[a]
Treatment	**8-30**	**9-12**	**9-20**	**(lbs./acre)**
B.t. 1 bug/12 ft	[m] 21	[m] 18	14	1806 a
B.t. 1 bug/ 6 ft	23	[m] 38	24	1530 a
B.t. 1 bug/ 3 ft	26	43	31	1616 a
B.t. untreated	35	63	34	1507 a
non-*B.t.* 1 bug/6 ft and 3 worms/100 plants	[ppp] 14	[p] 38	21	1645 a
non-*B.t.* untreated	34	55	35	854 b

[a] Treatment means not followed by the same letter are significantly different at the 5% level of significance (Duncan's Multiple Range Test).
[m] Methyl parathion 4EC application at 0.50 lb (AI)/acre prior to sampling dates.
[p] Pyrethroid application (Karate® 1EC) at 0.33 lb (AI)/acre prior to dates.