SMALL PLOT AND LARGE-SCALE COMPARISONS OF STINK BUG DAMAGE TO BOLLGARD AND CONVENTIONAL COTTON IN NORTH CAROLINA

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Abstract

To help quantify the impact of stinks bugs, mostly the green stink bug, *Acrosternum hilare* (Say), on cotton in North Carolina, a series of small plot and large-scale evaluations of stink bug damage to bolls was taken from 1992 through 1999. In the 8 small plot evaluations, stink bug-damaged bolls averaged 2.04% in the unprotected Bollgard and 0.36% in the pyrethroid-treated conventional plots, or a 5.7-fold greater level of boll damage in the Bollgard plots. In a state-wide survey of stink bug damage to bolls, undertaken from 1989 to 1195 (n =1620 cotton fields) stink bug injury on conventional cotton ranged from 0.20% to 1.17% , with a mean of 0.56%, while boll damage in Cleveland County, a county of limited insecticide use (similar to that required for Bollgard cotton), ranged from 1.67% to 8.50%, with a mean of 3.86%. In a 1996 through 1999 large-scale evaluation of 366 pairs of Bollgard and conventional cotton fields managed by cotton producers, the Bollgard cotton fields averaged 2.60% boll damage and 0.74 insecticide applications, while the conventional cotton fields averaged 0.61% boll damage and 2.53 insecticide treatments. Thus, the Bollgard fields showed approx. a 4.3-fold higher level of stink bug damage, and the conventional cotton required 3.4 times the number of insecticide treatments, primarily for bollworm control. Seventeen untreated Bollgard varieties showed a wide range of boll damage from stink bugs (1% to 20%) in a small plot replicated trial, although no correlation was found between maturity and boll damage.

Introduction

Stink bugs, primarily *Acrosternum hilare* (Say), and to a lesser degree, *Euschistus servus* (Say), have been a minor to moderate pest of cotton in North Carolina since 1978, the beginning of the Boll Weevil Eradication Trial (Barbour 1988). At this time, insecticide use dropped from a pre-eradication annual mean of approximately 10 applications to a post-eradication mean of 2 to 3 (Bacheler 1995), increasing the abundance of other pests, such as stink bugs, previously controlled by the intense bollworm and boll weevil spray regimes. In general, though, cotton fields treated 2 or more times with pyrethroids for late season bollworms have sustained little economic damage from stink bugs. However, in those situations or regions which require either no treatment or a single application for bollworms, such as Cleveland County in the far western North Carolina Piedmont, stink bug feeding can result in significant boll damage. A greater incidence of stink bug damage has also been observed here in small plot research of untreated Bollgard cotton, conducted from 1992 to 1996.

With the commercial introduction of Bollgard cotton in 1996, insecticide applications (essentially all pyrethroids) for bollworms, budworms and European corn borers have dropped sharply, and stink bug damage has correspondingly risen in North Carolina and a number of other cotton-producing states (Williams 1999). Due to a regional rise in stink bug levels and associated damage in Bollgard cotton, entomologists in a number of southeastern states have also initiated research into the damage relationships and thresholds for this species group (Bundy et al. 1999, Greene and Herzog 1999, Bundy et al. 1998, Greene et al. 1998, and Roberts 1998).

Despite the important practical research now being devoted to managing stink bugs on cotton, very little published data are available on the extent to which stink bugs damage cotton under grower conditions in Bollgard and in conventional cotton from year to year. Although useful, the state by state Cotton Insect Losses estimates, published annually by the National Cotton Council in the Beltwide Cotton Conferences Proceedings, are generally based upon interviews and personal experience, not large-scale, state-wide biological assessments of stink bug-damaged bolls.

Although Bollgard varieties have not demonstrated any resistance to stink bugs via their protein endotoxin, some varietal tolerance to stink bug damage may still be expressed, either via early maturity, less varietal attractiveness, perhaps greater carpal wall feeding vulnerability, and/or by other unknown factors.

This paper represents a compilation of small plot and large-scale comparisons of stink bug damage in Bollgard and conventional cotton production under experimental and grower conditions, an 11-year summary of state-wide boll damage resulting from this pest group, and evidence that Bollgard varieties may differ and their attractiveness and/or susceptibility to stink bug damage.

Materials and Methods

Cleveland County vs. State-wide Stink Bug Damage Comparisons, 1989 to 1995

In order to quantify the temporal (year to year) and spatial (various cotton production regions) variability of stink bug damage to bolls, a large scale damaged boll survey was conducted in North Carolina from 1989 to 1995. This survey

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consisted of taking samples of 100 randomly-selected bolls in 12 or more randomly-selected cotton fields from most of North Carolina's major cotton growing counties. The number of counties and cotton fields sampled during this period ranged from 14 counties and 168 fields in 1989 to 26 counties and 312 fields in 1995. The damaged boll assessment procedures are discussed by Bacheler and Mott (1995). Historical comparisons of stink bug damaged boll levels were made between Cleveland County and the remainder of the state. Cleveland County was selected because it represents an area of low insecticide use for bollworms and other insects (approx. 0.70 applications/year), very similar to the use patterns employed by North Carolina cotton producers on Bollgard cotton from 1996 through 1999 (approx. 0.78 applications/year).

Early Replicated Small Plot Tests, 1992 -1996

A series of Sales Evaluation Plots (SEP's) were conducted in 1994 (Halifax, Hoke and Jones counties) and in 1995 (Halifax, Hoke, Jones and Greene counties) to evaluate the agronomic success and caterpillar tolerance of 2 untreated Bollgard (NuCOTN 33b and NuCOTN 35b) and their pyrethroid-protected, non-transgenic sister lines (DP 5415 and DP 5690). Late season boll damage from bollworms, European corn borers, fall armyworms and stink bugs was assessed under grower conditions. Locations served as replications (3 in 1994 and 4 in 1995, thus serving as 2 total replicated tests), and individual plots were 8 rows by the field length. One hundred randomly-selected bolls were examined from each plot for late season insect damage. Only the stink bug information is presented. In small plot (4 rows by 40 ft.), replicated comparisons of untreated Bollgard (Mon 81, Bt 531, and NuCOTN 33b) vs. 'as-needed' pyrethroid-protected conventional cotton (usually Coker 312) conducted from 1992 to 1996 in Scotland or Onslow County, information was collected on the level of stink bug damaged bolls. Two split 5-acre blocks of Bollgard (MON 95- 086X5 and DP 5415 Bt in 1994 and 1995, respectively) and pyrethroid-protected, non-transgenic (DP 5690 and DP 5415, in 1994 and 1995, respectively) were also evaluated for stink bug damage to bolls. The above are regarded as a single, replicated test.

Stink Bug Damage in Bollgard vs. Conventional Cotton, 1996 to 1999

The damaged boll survey referred to above also served to compare stink bug damage to bolls in grower-managed Bollgard and conventional cotton fields from 1996 through 1999. In these evaluations, paired Bollgard and conventional cotton fields were selected, with each member of the pair grown in close proximity and typically managed by the same producer. In 1996, 1997, 1998 and 1999, respectively, 115, 115, 75 and 51pairs of cotton fields were utilized (712 total fields). A state-wide survey of cotton insecticide use for Bollgard and conventional cotton, completed by certified crop consultants, selected county agents and cotton producers, was also undertaken during this time period.

Bollgard Varietal Differences in Stink Bug Damage, 1999

A small plot, replicated test, including 17 Bollgard (2-row by 50 ft. plots) and 3 conventional cotton (6-row by 50 ft. plots) varieties, was evaluated for maturity, boll damage from stink bugs, and yields. The Bollgard entries received no insecticide applications, while the conventional lines received a single application with Karate Z 2.08 CS at 0.025 lb. ai/acre for bollworms.

Results

Cleveland County vs. State-wide Stink Bug Damage Comparisons, 1989 to 1995

In conventional cotton, the of 3.1 mean number of applications, used for late season insect control from 1985 through 1995, held stink bug damage to bolls to a low statewide mean of 0.56%, with a range of 0.20 to 1.17%, while in Cleveland County, with an average of 0.7 applications during the same time period, boll damage averaged 3.86%, with a range of 1.67 to 8.50% (Figure 1). The application mean of 0.7 for late season insect control in Cleveland County turned out to be very close to that required for Bollgard cotton in North Carolina from 1996 to 1999. The annual stink bug damage means in conventional cotton, taken from 1989 to 1995, suggested that this damage would be at generally low levels on conventional cotton as long as pyrethroids (or other stink bug-active insecticides) are used to control other insects, such as bollworms an average of 2 or more times a year.

Early Replicated Small Plot Tests, 1992 -1996

In the 7, SEP trials (serving as 2 replicated tests) conducted in 1994 and 1995, stink bug damage to bolls was light, with the untreated transgenic lines showing 2.2% boll damage, and the protected non-transgenic lines revealing 1.2% damage (Table 1). In the 5 small plot screening trials, undertaken from 1992 to 1996, stink bug damage averaged 2.4% in the unprotected Bollgard plots and 0.2% in the treated untransformed plots (Table 1). In the 5-acre split blocks, evaluated in 1994 and 1995 (we regarded this as a single replicated test), stink bug pressure was very low, with the unprotected Bollgard lines only showing 1.0% boll damage and the protected untransformed varieties remaining undamaged. In the 8-test average of these replicated small plot tests, stink bug damage to bolls averaged 0.36% in the pyrethroid-protected plots and 2.04% in the unprotected Bollgard plots, or 5.6-fold more stink bug damage in the Bollgard plots (Table 1).

Stink Bug Damage in Bollgard vs. Conventional Cotton, 1996 to 1999

In the large-scale, damaged boll survey (n = 712 cotton fields), on Bollgard cotton, stink bug damage varied from a low of 1.88% boll damage in 1998 to a high of 3.18% boll damage in 1999, with a mean of 2.60% (Figure 2). Insecticide applications required for Bollgard cotton varied from 0.48 in 1997 to 1.24 in 1998, with a mean of 0.75. Stink bug damage continued to fluctuate at low levels in conventional cotton from 1996 to 1999, varying from a low of 0.45% in 1998 to a high of 0.75% in 1996, with a mean of 0.61% (Figure 3). During this period, insecticide applications to conventional cotton ranged from a low of 1.99 in 1997 to a high of 3.03 in both 1996 and 1998, with a mean of 2.53 (Figure 3). With its fewer insecticide treatments, Bollgard cotton has sustained consistently higher state-wide boll damage from stink bugs than has conventional cotton.

For each of the last 4 years of the damaged boll survey, stink bug damage on Bollgard cotton was approximately 4-fold higher than on conventional cotton, while conventional cotton was treated 2.44 to 5.20-fold more times (Table 2). Less than 1% of the state's Bollgard cotton fields were treated specifically for stink bugs in 1996 or 1997, although 3.1% and 5% of the Bollgard fields were treated specifically for stink bugs in 1998 and 1999, respectively. However, stink bugs and their damage are sometimes one of the factors weighed when making bollworm treatment decisions in Bollgard cotton, and the above data do not reveal the range of stink bug damage found in the 732 cotton fields surveyed from 1996 to 1999. Occasional surveyed fields sustained damage in the 10 to 20% range. Additionally, in several far eastern North Carolina counties, a high proportion of the Bollgard acreage was treated for the more scarce, and also more Pyrethroid- tolerant, brown stink bug, *Euschistus servus*, in 1999.

Bollgard Varietal Differences in Stink Bug Damage, 1999

Stink bug damage to bolls varied widely between a number of the 17 Bollgard cotton varieties evaluated, ranging from 1% (Sure Grow 125 BR) to 20% (DP 655 B/RR) (Table 3). The open boll count, taken as an index of maturity, revealed no correlation between stink bug damage and maturity (Figure 4), however, a slight, but positive correlation was noted between the amount of stink bug damage and yields (Figure 5). The low positive correlation was likely due to the widely varying agronomic yields of the different Bollgard varieties. All 3 of the once-treated, untransformed lines showed no stink bug damaged bolls, somewhat surprising given the small plot size (2 rows for the 17 Bollgard varieties and 6 rows for the untransformed lines)(Table 3). This illustrates how effective some the pyrethroids (in this case, Karate Z) are against the green stink bug, *Acrosternum hilare*, the only species observed in this test in 1999.

Conclusions

Stink bug damage to bolls by the green stink bug, *Acrosternum hilare* (Say), the predominant species in North Carolina, generally occurs at very low levels in cotton which has been treated 2 or more times with stink bug-active insecticides, such as pyrethroids. With the introduction of Bollgard cotton in 1996, low insecticide use (a mean of 0.75 applications from 1996 to 1999) for late season insects, such as bollworms, has resulted in a 4-fold average increase in the level of stink bug-caused boll damage when compared with conventional cotton during the same time period. In situations in which Bollgard is untreated, or with higher stink bug populations, potential damage to cotton fields can be significant. Presently, although Bollgard cotton fields average approximately 3/4 of an application per year, essentially all of these treatments are with stink bug-active pyrethroids.

Additionally, because some Bollgard varieties appear to be more susceptible to stink bug damage than others, scouts evaluating different varieties can not generalize from one field to the next, even with identical planting dates.

As the pyrethroids are replaced with new bollworm chemistry, such as spinosads, avermectins, pyrroles, IGR's and others, the potential for stink bug damage can be expected to rise, putting a greater emphasis on stink bug scouting, thresholds and tank mixes for complexes of stink bugs and other insects. It would appear that North Carolina consultants and scouts will be faced with sting bugs as an increasingly significant potential pest of cotton in the coming years.

Acknowledgments

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Table 1. Stink bug damage to bolls in Bollgard and conventional cotton, 1992-1996.

Study	Year	% SB Boll Damage	
		Conventional*	B.t.**
SEP Tests (2)	1994 - 1995	1.20	2.20
Small Plot (5)	1992 - 1996	0.20	2.40
5-Acre Block (1)	1994 - 1995	0.00	1.00
	Weighted mean:	0.36	2.04
	Ratio:	1.0 :	5.7

* Pyrethroid protected
** Untreated

Table 2. Ratios of stink bug damage to bolls and insecticide use: Bollgard vs. conventional cotton, Rocky Mount, NC, 1996 to 1999.

Year	Bollgard : Conventional Cotton Ratios	
	SB Boll Damage	Insecticide Use
1996	4.04 : 1	1 : 5.20
1997	4.20 : 1	1 : 4.15
1998	4.17 : 1	1 : 2.44
1999	7.61 :1	1 : 3.00

Table 3. Stink bug damage to bolls in 17 untreated Bollgard and 3 treated conventional cotton varieties, Rocky Mount, NC, 1999.

Variety	% SB Boll Damage	Variety	% SB Boll Damage
DP 655 B/RR	20 a	STX 9901	6 c-f
DP 458 B/RR	18 ab	DP 422 B/RR	6 c-f
PM 1218 BG/RR	16 abc	SG 501 BR	6 c-f
DP 428 B	15 a-d	PM 1330 BG/RR	5 d-f
DP 409 B/RR	11 a-e	PM 1560 BG/RR	4 e-f
PM 1560 BG	10 a-f	STX 9902 BT/RR	4 e-f
PM 1220 BG/RR	9 b-f	SG 125 BR	1 ef
DP NuCOTN 33B	8 b-f	ST 474*	0 f
DP 488 B	7 c-f	DP 51*	0 f
DP 451 B/RR	7 c-f	FIBER MAX 989*	0 f

*1 pyrethroid application on conventional cotton; Bollgard varieties untreated.

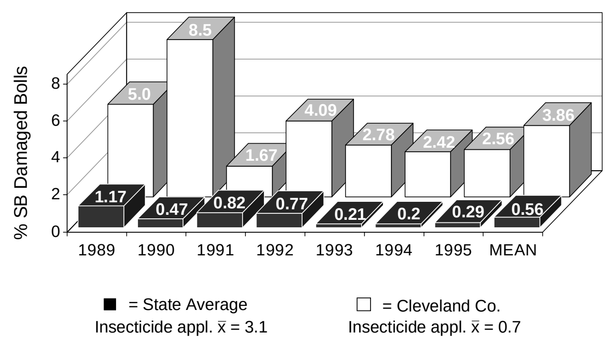

Figure 1. Boll damaged caused by stink bugs in Cleveland county, an area of low insecticide use vs. the remainder of North Carolina (n = 1620 fields).

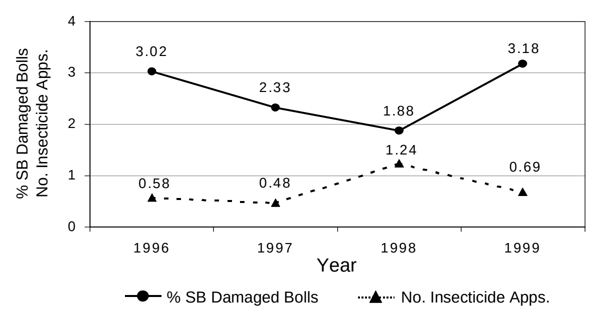

Figure 2. Stink bug damage to bolls and insecticide applications in Bollegard Cotton, 1996 to 1999 (n = 712 fields).

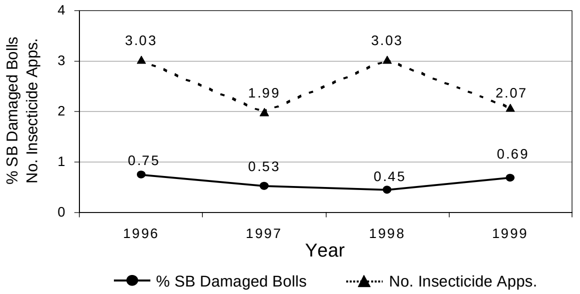

Figure 3. Stink bug damage to bolls and insecticide applications in conventional Cotton, 1996 to 1999 (n=712 fields).

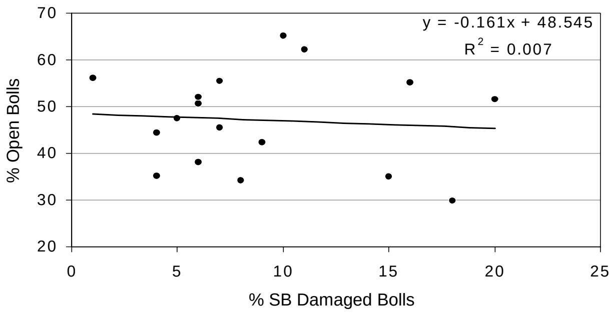

Figure 4. Relationship between stink bug damage and maturity; Rocky Mount, NC, 1999.

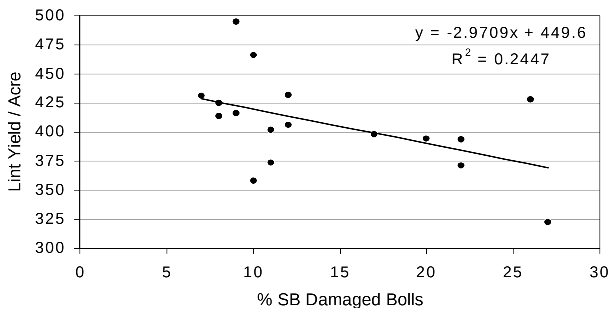

Figure 5. Relationship between stink bug damage and yields; Rocky Mount, NC, 1999.