EFFICACY OF GROWER-MANAGED BT COTTON IN NORTH CAROLINA

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Abstract

In the first large-scale evaluation of the efficacy of commercial Bollgard cotton grown and managed by producers in North Carolina, a statewide, 11-year survey of caterpillar- and stink bug-damaged bolls was expanded in 1996 to include 116 Bollgard, 116 paired conventionally-protected fields (a non-Bollgard field grown in close proximity to the Bollgard field, and typically managed by the same producer), and 180 additional randomly-selected, conventionally-protected fields, for a total of 412 fields. The efficacy of Bollgard cotton, primarily NuCOTN 33b, and various commercial, conventionally-protected (essentially pyrethroids), varieties was compared for boll damage from the cotton bollworm (Helicoverpa zea) (Boddie), the European corn borer (Ostrinia nubilalis) (Hubner), the fall armyworm,(Spodoptera frugiperda) (J.E. Smith) and stink bugs, primarily Acrosternum hilare (Say) and Euschistis servus (Say). In each field, a 100-boll sample was evaluated for damage from the above species.

The 116 Bollgard fields sustained about half as much damage from bollworms, 2.30% (vs. 4.62%) as did the 116 pyrethroid-protected fields. However, the Bollgard fields expressed about 4-fold higher levels of stink bug damage than the conventional fields (3.03% vs. 0.75%). European corn borer (ECB) and fall armyworm (FAW) damage in the Bollgard fields were 1/10 and 2/3 of the boll damage found in the conventional fields, although these pests were present at very low levels in 1996. Based upon a large-scale consultant and grower survey, 0.58 insecticide applications (all pyrethroids) were used on the Bollgard fields, while conventional fields were treated an average of 3.06 times with foliar insecticides, essentially all with pyrethroids. Total boll damage was 5.42% in the 116 Bollgard fields and 5.81% in the 116 pyrethroid-protected fields.

Due to North Carolina's 1996 1) higher-than-average levels of bollworms and stink bugs (a challenge to Bollgard cotton), 2) very low levels of late season budworms and European corn borers (easily controlled by Bollgard cotton) and 3) the generally late maturity of the currently-available NuCOTN 33b and 35b lines (which increases the probability of late season insect damage), over the short term, this new technology can be expected to offer control of late season boll-damaging insects at least on a par with foliar insecticides, such as pyrethroids.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:858-861 (1997)
National Cotton Council, Memphis TN

Introduction

Although a number studies can now be cited from the southeastern cotton belt on the effect of transgenic Bollgard cotton on various lepidopterous larvae, most of these component-oriented studies have dealt with the bollworm complex, or with only single species (Mahaffey, et al., 1995; Durant, 1994; Turnipseed et al., 1995; Turnipseed and Greene, 1996). Only two published research studies focused on the complex of late-season, boll-damaging pests (Mahaffey, et al., 1994; Bacheler and Mott, 1996). Additionally, several evaluations were conducted under either multiple irrigations, and/or were treated with a beneficial arthropod-disrupting overspray (Lambert, et al., 1996; Mahaffey, et al., 1994 and 1995), practices which can serve to increase the survival and establishment of caterpillars beyond that anticipated in a commercial cotton production setting. Finally, no published information on the efficacy of Bollgard cotton compared to conventionally-protected cotton in a large scale commercial setting is available in the southeast.

This report presents the results of large-scale, whole field comparisons of the efficacy of Bollgard and conventionally-protected, untransformed cotton against late-season boll damage under commercial cotton production.

Materials and Methods

Paired Comparison Evaluations

In 1996, 116 representative Bollgard cotton fields were located in 21 counties throughout North Carolina with the assistance of independent crop consultants and county agents. A second sample of 116 untransformed, conventionally-protected fields, grown in close proximity to the Bollgard fields and typically managed by the same producer, was also selected. A final sample of 180 randomly-selected fields from 27 counties was additionally evaluated 1) as a measure of the representativeness of the 116 untransformed fields and 2) to archive the long-term temporal (year to year) and spatial (different North Carolina regions of cotton production) impact of late-season bollworms, European corn borers, fall armyworms and stink bugs and 3) to compare this damage level with previous years' survey results. A total of 412 cotton fields was evaluated in 1996.

In each field a sample of 100 bolls was inspected for damage by bollworms, ECB, FAW and stink bugs, as described by Bacheler and Mott (1995), just prior to boll opening.

Consultants' Bollgard Cotton Survey

To obtain background information on how Bollgard cotton was managed by licensed independent crop consultants, all

22 firms (some businesses have more than 1 licensed crop consultant) were surveyed by mail and asked 1) their total cotton acreage, 2) acres of Bollgard vs. conventional cotton, 3) number of treatments employed for Bollgard and conventional cotton and 4) an estimate of the additional scouting cost required for monitoring Bollgard cotton.

Results

Paired Comparison Evaluations

Boll damage to the 116 conventionally-protected paired fields was almost identical to that found in the remaining 180 randomly-selected conventional cotton fields (which form the basis for our project's historical damaged boll survey information). Boll damage in the former and latter categories was: bollworms- 4.62% vs. 4.44%, ECB- 0.34 vs. 0.29%, FAW- 0.10% vs. 0.06%, and stink bugs- 0.75% vs. 0.71%, respectively. Therefore, the boll damage means from the 116 paired conventional fields are utilized for comparisons to both the Bollgard fields as well as to the historical survey averages (1985-1995).

In the 116 conventionally-protected fields (over 99% were treated with pyrethroids, essentially all against bollworms), average boll damage from bollworms, at 4.62%, was higher than the 11-year historical average of 3.91%, while the 116 Bollgard fields averaged 2.3% (Figure 1). European corn borer damage in the randomly-selected conventional fields, at 0.34%, was the 2nd lowest in the 11-year survey history, which averaged 1.68%, compared to 0.03% in the Bollgard fields (Figure 2). Fall armyworm damaged boll levels were extremely low in both the conventional and the Bollgard fields in 1996 (Figure 3). Stink bug damaged bolls in the paired conventional fields was 0.75%, while stink bug damage in the Bollgard fields was about 4-fold higher, at 3.03%. The 7-year historical average for stink bugs was 0.56% (Figure 4). Overall boll damage to the conventional fields was 5.81%, essentially the same as the total boll damage to the Bollgard fields, 5.42% damage, while the historical total boll damage was also approximately the same, at 5.86%, with a range of 2.7% in 1987 to a high of 12.8% in 1985 (Figure 5). Interestingly, out of 116 Bollgard fields, the field with the highest bollworm damaged boll level was the only field in the study under irrigation.

When one looks at the distribution of bollworm damaged boll categories, the 1996 Bollgard sample had 61 of its 116 fields in the 0% to 1% damaged boll category and only 2 fields at or above 10% damage, while the conventional sample had only 30 of its fields in the 0% to 2% damage category and 16 fields at or above 10% or more boll damage (Figure 6). In observing the distribution of the stink bug damaged boll categories, the Bollgard sample had 36 fields in the 0% to 1% damaged boll group and 16 fields over 5% boll damage, while the conventional sample had 96 fields in the 0% to 1% damage group, and only 1 field over 5% boll damage (Figure 7).

Consultants' Bollgard Cotton Survey

Twenty one of 22 consulting firms working on cotton responded to the survey, representing 267,530 acres, or 37.3% of North Carolina's 718,000 acres in 1996. Consultants reported scouting 7,418 acres of Bollgard cotton, or 2.8% of their total acreage, almost identical to the 2.9% of the state's acreage planted to Bollgard cotton. Consultants recommended treatment on 55.7% of this acreage: 44.3% of the acreage was untreated, 52.5% treated 1 time and 3.2% treated 2 times, for an average of 0.58% treatments per acre on Bollgard cotton managed by consultants in North Carolina in 1996. No Bollgard cotton was treated for early (June through early July) tobacco budworms by this group, although only 7.1% of the non-Bollgard acreage was treated for budworms by consultants in 1996, about average for North Carolina. In 1996, conventional cotton managed by crop consultants was treated an average of 3.06 times per acre, almost exclusively for bollworms. In a small informal survey of approximately 20 producers and 12 county agents, accounting for about 40,000 acres of cotton not managed by consultants, the average number of foliar insecticide applications on conventional cotton was 2.9.

Consultants indicated that a realistic estimate of the extra cost for scouting Bollgard cotton, taking into consideration the higher monitoring frequency, the more exacting and different monitoring requirements (not overreacting to eggs or to the tiny 1st-stage larvae, judging what constitutes a 2nd-stage larva, monitoring for stink bugs, etc.), would be in the range of $2.50 to $5.00 per acre compared with conventionally-protected non-Bollgard cotton. However, given an anticipated producer/client reluctance to pay this much of a scouting cost increase, most in this group indicated the actual additional charge would be in the range of no extra charge to approximately $3.00/acre for Bollgard cotton until producers had a better appreciation for the additional training and labor requirements in effectively monitoring Bollgard cotton.

Conclusions

In a 21 county, 232-field comparison of the efficacy of Bollgard vs. conventionally-protected, non-Bollgard cotton under grower management, both protection systems sustained approximately the same level of boll damage to late-season insects, primarily bollworms and stink bugs. Over most of the state, the spectrum and intensity of late season insects represented more of a challenge to Bollgard cotton than to conventionally-protected cotton in 1996. When compared with the insect pressure averaged over the past 11 years, bollworm and stink bug levels were somewhat higher than average, while populations of late season budworms (ie., the proportion and number of budworms in the late July to August Heliothis/Helicoverpa complex) and European corn borers were very low. According to all research conducted here to date (JSB, Bradley, pers. comm.), Bollgard's endotoxin is far more

efficacious than foliar insecticides on both budworms and ECB, and offers no protection against stink bugs. Therefore, in a more typical year of higher ECB and tobacco budworm levels and lower bollworm and stink bug levels, the efficacy of Bollgard lines could be somewhat higher than was the case in 1996, if consultants and producers respond to threshold levels of these insects in a manner similar to this past year.

Aside from the apparent advantage of planting Bollgard cotton adjacent to urban areas, in remote locations into which the moving of spray equipment may be prohibitive, or in certain environmentally sensitive areas, if one considers only the economics of Bollgard cotton, at the current technology fee of $32.00/acre and extra scouting expenses, this technology will likely remain a niche market in North Carolina (Table 1). Given the somewhat simplified cost figures shown in the table, and using 1996 insect pressure and our damaged boll survey results (all of which are subject to change), to gain an economic return in using Bollgard cotton, a producer would need to be treating non-Bollgard cotton in the 4.0 to 4.5 application range. In areas where growers presently treat more than this, in wet-natured fields where spraying with ground equipment may sometimes be difficult or in areas which are subject to high populations of ECB, the use of this technology can be expected to increase.

Presently, it would appear that Bollgard cotton under most conditions encountered in NC can be expected to provide protection from boll damage on a par with pyrethroid-protected, non-transformed lines. Under extreme conditions of high bollworm pressure coupled with a broad-spectrum, disruptive spray prior to the major bollworm moth flight and/or under irrigation, the pyrethroid-protected cotton may well show lower boll damage and higher yields (Mahaffey, et al., 1995; Lambert, et al., 1996). In our small-plot research conducted in 1995 and 1996, a single overspray with Orthene at 0.75 lb active/acre on Bollgard cotton just prior to the major bollworm moth flight resulted in a 2.4 to 3.8-fold increase in boll damage, or an yield decrease of 102 to 162 lb lint/acre, or 12.3 to 14.9% (JSB). Interestingly, the one Bollgard cotton field out of 116 that had the greatest boll damage (12%) was grown under irrigation. At the present time, however, approximately 4% of the state's cotton is irrigated (Edmisten, pers. comm.), and a disruptive spray just prior to the major bollworm moth flight is rare in North Carolina. However, if the boll weevil became reestablished as a treatable economic pest, if the plant bug were elevated to significant pest status into the bloom period or if the cotton aphid were no longer held in check by natural enemies, this situation could change.

Acknowledgment

The 1996 Bollgard field comparison study was primarily supported by a grant from Cotton Incorporated through North Carolina's State Support Program.

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Table 1. Simplified economic compairison of Bollgard vs. conventional cotton based upon 1996 insect pressure and costs.

Input	Bollgard	Conventional
Seed	1.40	0.00
Scouting[1]	2.50	0.00
Technology Fee	32.00	0.00
Insect Damage[2]	0.00	2.09
Yield[3]	0.00	0.00
Insect Control (early budworm)[4]	0.00	0.63
Insect Control (late-season insects)	5.43	28.15
Total	$41.33	$30.87

[1] Projected for 1997; [2] Cost of slightly higher damage; [3] Bollgard lines show maturity, yield and fiber quality very similar to thier untransformed parent lines;[4] 7.1% acreage treated for early budworms, application costs @ $9.20 / acre / application.

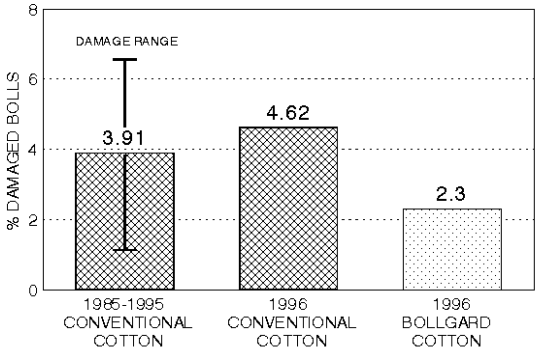

Figure 1. Boll damage by bollworms in 116 Bollgard vs. 116 conventional cotton fields in 1996 vs. 1985-1995 historical average in North Carolina.

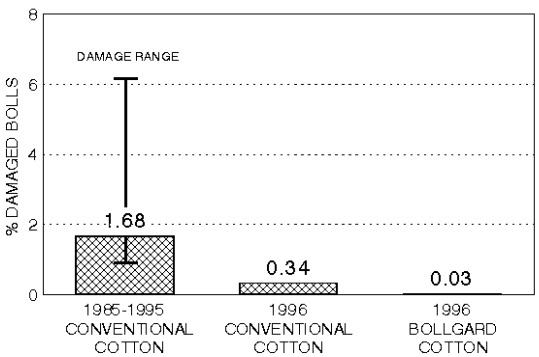

Figure 2. Boll damage by European corn borers in 116 Bollgard vs. 116 conventional cotton fields in 1996 vs. 1985-1995 historical average in North Carolina.

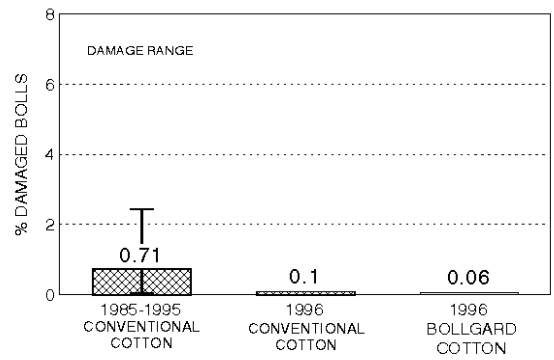

Figure 3. Boll damage by fall armyworms in 116 Bollgard vs. 116 conventional cotton fields in 1996 vs. 1988-1995 historical average in North Carolina.

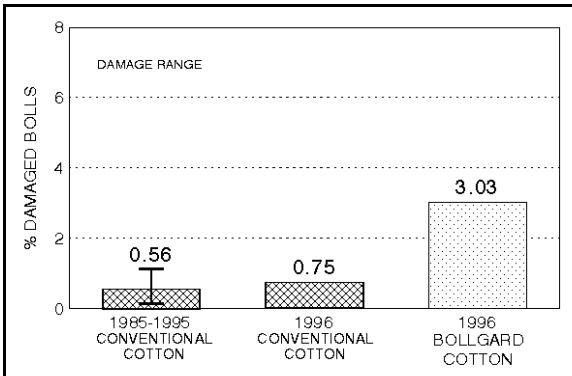

Figure 4. Boll damage by stink bugs in 116 Bollgard vs. 116 conventional cotton fields in 1996 vs. 1989-1995 historical average in North Carolina.

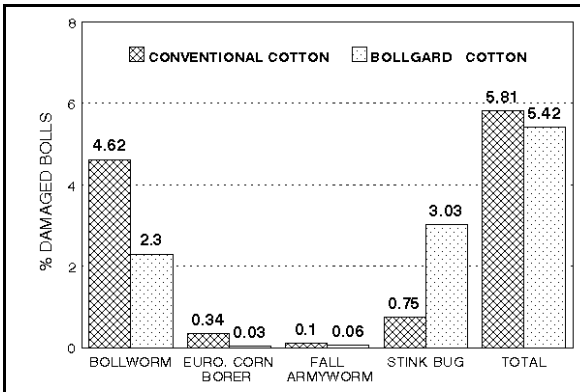

Figure 5. Boll damage by late season insects in 116 Bollgard vs. 116 conventional cotton fields in North Carolina, 1996.

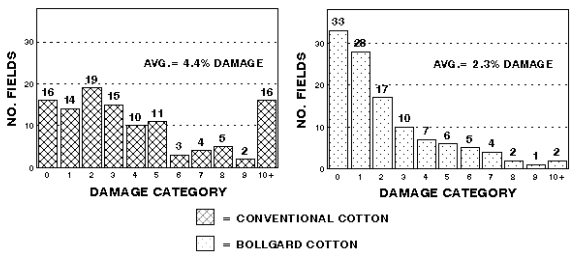

Figure 6. Distribution of boll damage categories by bollworms in 116 Bollgard vs. 116 conventional cotton fields in North Carolina in 1996.

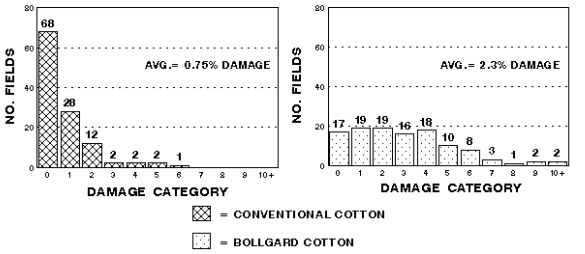

Figure 7. Distribution of boll damage categories by stink bugs in 166 Bollgard vs. 116 conventional cotton fields in North Carolina in 1996.