BT-COTTON IN MISSISSIPPI: THE FIRST YEAR

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Abstract

Approximately 42% of Mississippi's cotton crop was planted to transgenic Bt-varieties in 1996, the first year of commercial availability of this technology. Despite unusually low populations of tobacco budworm, Heliothis virescens, the primary target pest of this control tool, overall performance of Bt-cotton was positive. Overall yields were slightly better than conventional varieties and insect control costs were similar. Some Bt-cotton required supplemental foliar treatments to control unusually high populations of bollworms, Helicoverpa zea. However, based on an end of season survey, the number of bollworm/budworm treatments required per field of Bt-cotton (0.33 treatments/field) was considerably less than for conventional cotton (3.05 treatments/field).

Discussion

During the early 1990s high levels of insecticide resistance in tobacco budworm, Heliothis virescense, and other cotton pests caused sharp increases in costs of cotton insect control on most Mississippi farms. This adversely affected profitability and increased the risk of an insect related crop disaster. This risk became a reality for producers in the Hill portion of the state in 1995 when a severe outbreak of resistant tobacco budworms, in combination with other pests, caused an estimated average of 30% yield loss, despite average insect control costs of $118 per acre (Williams, 1996). Many individual fields were totally destroyed by tobacco budworms due to inability to obtain control with currently available insecticides (Layton, et. al. 1996; Williams and Layton, 1996).

When transgenic Bt-cotton was commercially introduced in 1996 it represented not only a novel method of insect control, but also the first new tool to become available for use against tobacco budworm in over 17 years. Consequently Bt-cotton, primarily the Nucotton 33 variety, was well received by Mississippi growers in 1996 and was planted on approximately 42% of the state's 1.03 million acres of cotton. Bt-cotton was distributed throughout the state, but a relatively higher portion was planted in the Hill region of the state as a result of the severe tobacco budworm outbreak that occurred there the previous year.

Several factors affected the overall performance of Bt-cotton in 1996. However, the most significant factor was the unusually low populations of tobacco budworm present in 1996. Although a few areas of the state experienced significant infestations of tobacco budworms during June, mid and late season infestations were low to non-existent over most of the state. Because tobacco budworm is the primary target pest of Bt-cotton, the relative absence of this pest would serve to reduce the overall benefit of utilizing this technology.

Bt-cotton provided excellent control of those infestations of tobacco budworm that occurred during early season. It is likely that a combination of several factors was responsible for the unusually low populations of tobacco budworm experienced in 1996. However, the dilution effect provided by having approximately 42% of the state's cotton acreage planted to Bt varieties, combined with the "trap crop effect" resulting from growers' tendency to preferentially plant the Bt-cotton on fields known to have a history of heavy budworm pressure, must not be over looked as one of these factors.

Another factor that adversely affected the performance of Bt-cotton was the unusually heavy populations of bollworms, Helicoverpa zea, experienced in 1996. Although, Bt-cotton is also active against bollworm, the level of activity is known to be considerably less than against tobacco budworm (Lambert, et. al. 1996; Mahaffey, et. al., 1995), and growers were cautioned that high populations of bollworms in Bt-cotton may require supplemental treatment (Layton, 1996A & 1996B). A drastic increase in corn acreage, from 275,000 acres in 1995 to 610,000 acres in 1996, was the primary cause for the unusually heavy bollworm pressure experienced in cotton during July and August. However, it is noteworthy that unusually high numbers of bollworm moths were observed in pheromone trap captures during early spring (Layton, 1996C), before the insects had an opportunity to complete 2 generations in corn.

Pre-bloom infestations of bollworms in Bt-cotton were relatively uncommon, primarily because of the preference for corn at this time. However, as corn began to senesce after producing two generations of bollworms, nearby cotton acreage experienced extremely heavy bollworm infestations, especially in areas with high corn acreage.

Overall, Bt-cotton provided good control of the unusually heavy populations of bollworms that occurred during July and August. However, supplemental treatment was required on some acreage. Across the different regions of the state there was great variability in the portion of Bt-cotton receiving one or more supplemental treatments for bollworm, ranging from near 0% in some areas to as high as 80 to 90%. Table 1 presents results of an end of season survey comparing number of bollworm foliar treatments and "worm damaged bolls" from 24 pairs of Bt cotton fields and adjacent non-Bt fields.

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Practically all situations in which Bt-cotton received treatment for bollworms were due to survival of larvae occurring in blooms and lower bolls. In most cases, excellent control was obtained against larvae feeding in the terminal area, but survival was greatly increased for larvae feeding on pollen in blooms and then moving into bolls. Damaged boll counts as high as 16 to 24% were observed in some fields of Bt-cotton, however, these were the extremes and overall performance was considerably better than this.

The fact that % worm damaged bolls was considerably lower in the Bt-cotton than in non-bt, 2.7% vs 4.9%, strongly suggests that Bt-cotton in combination with current guidelines on supplemental control was providing adequate protection against excessive damage by bollworms. When supplemental foliar treatments were required, synthetic pyrethroids were the materials of choice. These materials provided excellent control of bollworms, even in situations where high portions of larvae were feeding in relatively protected sites, such as under dried stuck blooms.

There were also several factors that had an overall positive effect on the relative performance of Bt-cotton in 1996. Perhaps the most significant of these was that the 1996 season generally was favorable to the production of an early maturing crop. The two varieties in which the Bt gene was initially introduced are relatively late maturing varieties and this could potentially have caused problems for producers in the northern portion of the state, especially during an adverse growing season conducive to late crop maturity. Fortunately this was not a problem in 1996, and ongoing efforts to have the Bt gene available in earlier maturing varieties for future years should minimize this concern in the future.

Overwintered boll weevil, Anthonomus grandis grandis, numbers were considerably lower than normal during the early portion of the 1996 season, a result of increased winter mortality due to unusually low winter temperatures. This reduction in overwintered boll weevil populations was relatively more favorable to Bt-cotton than to conventional cotton. Because the reduction in foliar sprays targeting budworm/bollworm in Bt-cotton would also reduce coincidental control of boll weevils, it was anticipated that the need to treat specifically to control boll weevils would increase in Bt-cotton (Layton, 1996D). This situation still occurred, with many growers applying 2 to 3 more boll weevil treatments to their Bt-cotton fields than to fields of conventional cotton grown on the same farm. However, it is likely that the difference in number of boll weevil treatments applied to Bt vs. conventional cotton would be even greater in a year with more normal boll weevil and tobacco budworm populations.

By the end of the 1996 season fall boll weevil pheromone trap captures had rebounded to near normal levels. This recovery appeared to be more rapid than has occurred following similar winter kills in the past, presumably a result of Bt-cotton. However, it must be noted that the number of insecticide treatments applied to conventional cotton also was considerably lower than normal in 1996, due to low overall populations of tobacco budworm. Still it was apparent that Bt-cotton will require more intensive management to control boll weevils during mid and late season. As a result, it is anticipated that widespread adoption of Bt-cotton will serve to increase the cost of completing any boll weevil eradication efforts that are initiated within the state.

As with boll weevil, the reduction in sprays targeting caterpillar pests in Bt-cotton also was anticipated to reduce coincidental control of tarnished plant bug, Lygus lineolaris, (Layton, 1996D), especially during mid and late season. Thus, the fact that pre-bloom plant bug populations ranged from low to moderate across most of the state, also had a favorable impact on the overall performance of Bt-cotton. However, the anticipated build up of mid and late season plant bug populations was still observed in many portions of the state, and many producers, particularly those in the Delta region, reported an increase in the number of foliar treatments required to control this pest in Bt fields during mid and late season.

It is important to note that plant bug populations and management recommendations for Bt-cotton are not expected to change during the pre-bloom portion of the year. However, continued documentation of increases in levels of insecticide resistance in many Delta plant bug populations (Snodgrass and Scott, 1996) makes the potential for increased plant bug populations in Bt-cotton during mid and late season especially significant. Overall yield and performance of Bt-cotton in 1996 would suggest that these mid and late season plant bug infestations had relatively little effect on yield. However, there is an obvious need for additional research to refine plant bug treatment thresholds during mid and late season, particularly on Bt-cotton. Clouded plant bugs, Neurocolpus nubilus, and several species of stink bugs were also observed to be more common in Bt-cotton during 1996, and these pests may also require additional research to refine thresholds and management recommendations.

Several studies were conducted in 1996 to compare yields and insect control costs of Bt-cotton to that of conventional cotton (Reed, pers. comm.; Cook, pers. communication). Preliminary results indicate that, although there were some locations where Bt-varieties did not perform as well, overall yields of Bt-cotton were slightly superior to those of conventional varieties. Including the $32 per acre licensing fee charged for using Bt-cotton in 1996, cost of insect control was similar to that for conventional cotton. The cost comparisons differ from those for previous years in which Bt-cotton was observed to have substantially lower overall insect control costs (Davis, et. al., 1995).

Obviously the relatively low populations of tobacco budworm experienced in 1996 greatly impacted this year's cost comparisons and Bt-cotton would be expected to perform relatively better during a year with normal to high populations of tobacco budworm. However, it is important to note that wide scale planting of Bt-cotton may be at least partially responsible for the reduced populations of tobacco budworms. If this is true, unbiased comparisons of yield and costs between Bt-cotton and conventional cotton can not be made in areas where a significant portion of the acreage is planted to Bt varieties. Any overall reduction in tobacco budworm numbers due to the presence of Bt-cotton would have positive benefits to both yield and insect control costs in conventional varieties that would be difficult or impossible to quantify.

Summary

In summary, the overall performance of Bt-cotton during it's first year of commercial use in Mississippi was positive, despite unusually low populations of tobacco budworm, the primary target pest of this technology, and unusually high populations of bollworm. Bt-cotton has become an important component of cotton IPM, and its continued utilization will provide significant risk management and resistance management benefits.

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Table 1: End of Season Survey Results, Bt-cotton vs non-Bt varieties, 1996

	Non-Bt	Bt-cotton
% treated for 'worms'"	88.9	27.8
# sprays/treated field	3.4	1.2
# sprays/ field	3.05	0.33
% worm damaged bolls	4.9	2.7

Survey of 24 pairs of fields (18 with treatment history)