PERFORMANCE OF NEW AND EXISTING BT COTTON TECHNOLOGIES WHEN INUNDATED WITH HEAVY/NATURAL POPULATIONS OF BOLLWORM IN SC – 2010

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Abstract

Single-gene (Cry1Ac) Bt technology (Bollgard®), available in cotton varieties since 1996 will no longer be available in the USA. Instead, varieties producing multiple proteins toxic to caterpillar pests, such as dual-Bt-gene technologies commercially available now, will be planted. Those technologies include Bollgard II® (Cry1Ac and Cry2Ab – Monsanto, 2003) and WideStrike® (Cry1Ac and Cry1F – Dow AgroSciences, 2005). New constructs of Bt genes, such as those in TwinLink™ technology (Cry1Ab and Cry2Ae – Bayer CropScience) will be available within a couple of years, pending registration and appropriate approvals. While varieties with dual-Bt-gene technology provide very good control of caterpillar pests, they do not offer 100% control of bollworm, *Helicoverpa zea*. Under extreme pressure from bollworm, these technologies display variable control of bollworm and might require supplemental applications of insecticide to avoid yield losses from the species. Reported here are the results of evaluations of existing and promising Bt cotton technologies when inundated by natural infestations of bollworm.

Introduction

Since 1996, commercial cotton varieties containing genetic material from the naturally occurring bacterium *Bacillus thuringiensis* (Bt) have been available, affording the ability to reduce reliance on foliar-applied insecticides for major pests such as the tobacco budworm, *Heliothis virescens*, and the bollworm, *Helicoverpa zea*. Varieties of first-generation Bt cotton (Bollgard® - Cry1Ac) are no longer available, but they provided 100% control of the tobacco budworm and good control of bollworm for 15 years. Foliar insecticides were required for supplemental control of bollworm in Bollgard® cotton, and treatment thresholds were developed to address bollworm "escapes" in first-generation Bt cotton (Sullivan et al. 1998, Greene 2010). In 2003, dual-gene (Cry1Ac and Cry2Ab) Bt cotton technology (Bollgard II®) was introduced that offered enhanced in-plant control of caterpillar pests, particularly bollworm. As a result, applications of foliar-applied insecticides were further reduced, but not totally eliminated. In 2005, an alternate dual-gene (Cry1Ac and Cry1F) Bt cotton technology (WideStrike®) was made available by Dow AgroSciences. Within the next several years, additional varieties of dual-Bt cotton, such as TwinLink™ (Cry1Ab and Cry2Ae – Bayer CropScience), will be available, pending registrations and appropriate approvals. While varieties with Bollgard II® or WideStrike® technology provide very good control of caterpillar pests (Gore et al. 2008), they do not offer 100% control of bollworm (Bacheler et al. 2006, Greene and Robinson 2010). Because measurable differences exist between the two technologies with regard to spectrum of caterpillar control, caterpillar density and expressed levels of feeding injury can be very different between the technologies. Extension programs should strive to educate producers and consultants about the potential differences in expressed feeding injury with the dual-gene technologies under varying conditions. We addressed these potential differences under field conditions of heavy, natural pressure from bollworm.

Materials and Methods

During 2010, replicated trials that included varieties of non-Bt and first- and second-generation Bt cotton were established at the Edisto Research and Education Center near Blackville, SC, in an area with historically high pressure from bollworm (Figure 1). Plot size was 8 rows by 40 ft, and treatments were replicated 4 times. All applications of insecticide to plots were made with a high-clearance sprayer that delivered 10 gal/acre at 60psi. To ensure maximum pressure from bollworm, all plots were oversprayed with acephate at 1 lb [AI]/acre during early bloom (ca. early-to-mid July) to decimate beneficial arthropods and potentially flare populations of bollworm. In the first trial, comparisons were made for the following technologies/varieties: non-Bt (DP174RF), Bollgard® (DP445BR), Bollgard II® (DP1050B2RF), and WideStrike® (PHY565WRF). In the second trial, eight varieties (DP174RF, DP0912B2RF, DP0935B2RF, DP0949B2RF, DP1028B2RF, DP1032B2RF, DP1050B2RF, and PHY565WRF) were compared. In the third trial, TwinLink™ technology was examined.

Figure 1. Aerial view of cotton plots near Blackville, SC, after heavy pressure from bollworm during 2010.

All plots were oversprayed with dicrotophos (Bidrin® at 8 oz/acre) for control of bugs during the season. Sampling began when small bolls were present in all varieties and plots. Boll damage was estimated weekly by visually examining 25 bolls per plot (*in situ*) for feeding injury from bollworm. Bolls were considered "damaged" when at least one site on a boll wall was compromised or penetrated by lepidopteran feeding injury (Figure 2). As an additional monitoring tool for bollworm pressure, populations of bollworm moths were monitored several times per week using pheromone-baited Hartstack-type (Hartstack et al. 1979) traps.

Figure 2. Symptoms of boll damage caused by bollworm.

Results and Discussion

Pheromone Trap Captures

Populations of bollworm (BW) and tobacco budworm (TBW) moths were significantly higher during 2010 compared with previous years (Figure 3). The maximum number of bollworm moths captured in pheromone traps per week during 2010 was approximately double that captured in 2009 and the highest of the previous five seasons.

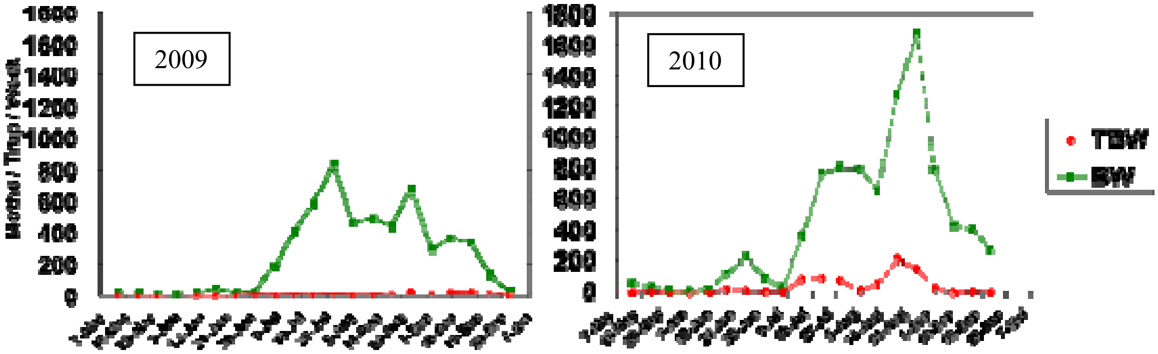

Figure 3. Captures of bollworm (BW), *Helicoverpa zea*, and tobacco budworm (TBW), *Heliothis virescens*, in pheromone-baited traps near Blackville, SC, during 2009 (left) and 2010 (right).

Comparison of Existing Bt Technologies

By the third week in July, damage from bollworm to plots of untreated non-Bt cotton approached 100% (Figure 4A). During the second week in August, damage peaked between 50-60% in plots of untreated Bt cotton (Figure 4B), with seasonal means ranging from 10 to 35% (Figure 4C). Yields of varieties with Bt technology were significantly higher than those observed in non-Bt cotton but were not statistically separated (Figure 4D), despite the differences in damage during July and August (Figure 4A-C). However, numerical differences in yield corresponded with observed damage. In an attempt to contrast technologies and avoid varietal comparisons, yields from identical fully protected varieties in our OVT program were used to calculate a "yield percentage of fully protected" (Figure 4D). Unprotected non-Bt plots in this trial roughly returned about 15% of what was yielded in the fully protected OVT area, while plots of Bollgard II® yielded about the same, regardless of protection from bollworm.

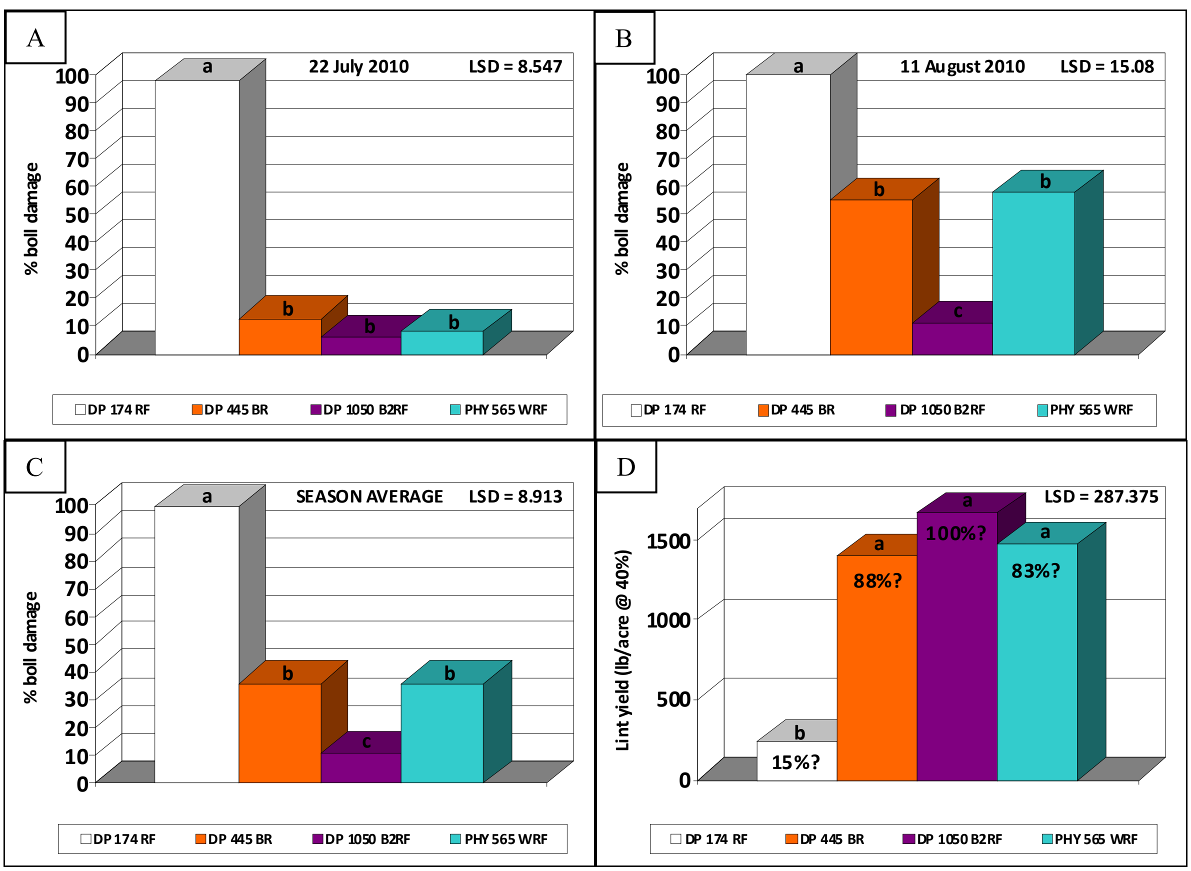

Figure 4. Bollworm damage on 22 July (A), 11 August (B), as a seasonal (6 sample dates) mean (C), and resulting lint yield (D) – percentages within bars indicate percent yield of fully protected variety from OVT program.

Plots of Bollgard® and WideStrike® yielded roughly about 88 and 83%, respectively, of what was observed with fully protected identical varieties in the OVT program. This comparison suggested that Bollgard II® provided better control of bollworm than the other Bt technologies. However, additional trials in the same field that compared Bt technologies, but with different varieties, indicated that yields from protected Bollgard II® and WideStrike® plots were more similar, with an approximate 9-10% increase in yield over unprotected plots. Extremely high pressure from bollworm resulted in visible differences in impact to cotton yield (Figure 5).

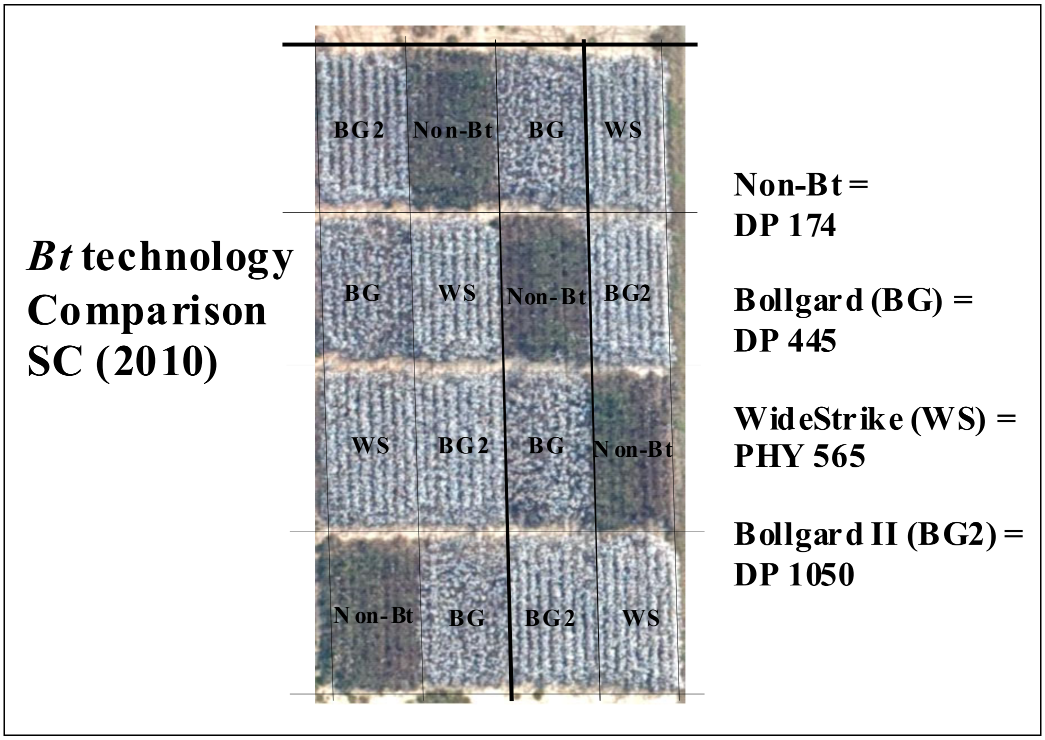

Figure 5. Aerial view of replicated plots of non-Bt, Bollgard®, Bollgard II®, and WideStrike® cotton prior to harvest but following heavy natural pressure from bollworm near Blackville, SC, during 2010.

In another trial with protected and unprotected pairs of varieties, damage from bollworm was similar in plots of non-Bt cotton, Bollgard II® and WideStrike® (Figure 6). Damage reached 100% in plots of unprotected non-Bt cotton (Figure 6A), and, in most varieties with Bollgard II® or WideStrike®, damage reached between 10 and 20% on 28 July (Figure 6B). By the first week in August, damage in plots of WideStrike® technology exceeded 40% (Figure 6C). Aggressive, selective protection from bollworm resulted in significant improvements in yield across almost all varieties when compared with yields from paired, untreated plots (Figure 6D). Yields were similar across all varieties of Bollgard II® and WideStrike® within protected or unprotected groupings.

New Bt Technology

In 2013, TwinLink™ Bt technology will be available (pending registration and appropriate approvals), offering an alternative to existing Bt technologies. The different assemblage of genes/proteins offered another dual-Bt-gene product for evaluation in 2010 under natural, heavy infestations of bollworm. During the third week in July, plots of non-Bt cotton (Glytol) sustained 100% boll damage from bollworm (Figure 7A). On the same date, plots of protected TwinLink™ technology sustained less than 10% damage to bolls, while bollworm caused about 15% boll damage in unprotected TwinLink™ plots. By the end of July, boll damage increased to between 20 and 30% in unprotected plots of TwinLink™ cotton and between 10 and 20% in protected plots (Figure 7B). Average seasonal boll damage (6 dates) was less than 10 and 20% in protected and unprotected plots of TwinLink™ cotton, respectively (Figure 7C). Yields from protected and unprotected plots of TwinLink™ cotton were similar, indicating that performance was minimally increased with supplemental control of bollworm (Figure 7D).

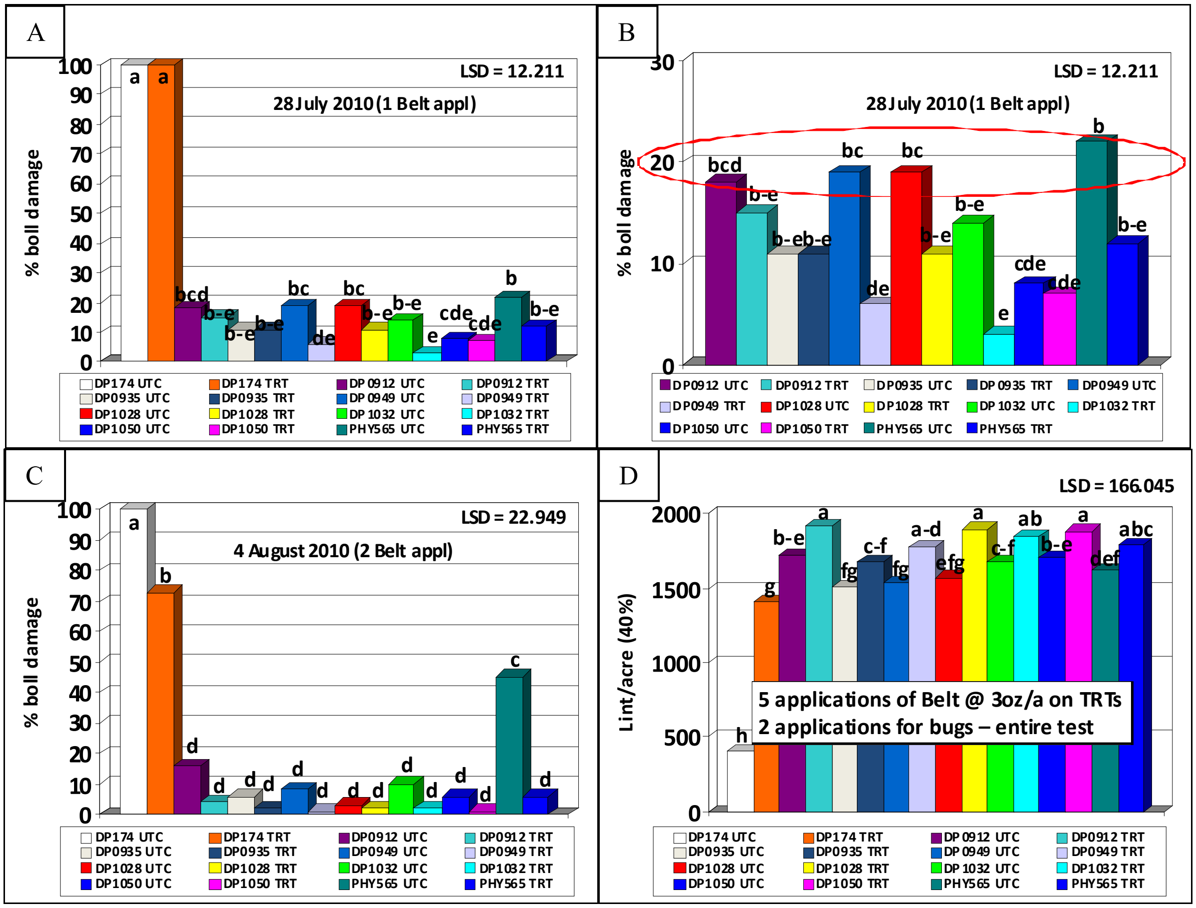

Figure 6. Bollworm damage on 28 July (A,B) and 4 August (C) and resulting lint yield (D) from pairs of unprotected and aggressively protected varieties near Blackville, SC, during 2010.

Summary

In many cotton-growing areas of the Southeast and Mid-South, last season (2010) can be characterized as a "heavy-pressure" year with regard to bollworm numbers, particularly in areas where research specifically addressed Bt cotton performance and comparisons. Captures of bollworm in pheromone traps during 2010 were the highest observed near Blackville, SC, within the last 5 seasons. Because single-Bt-gene cotton (Bollgard®) is no longer available, our efforts focused on performance of available and promising dual-Bt-gene cotton technologies (Bollgard II®, WideStrike®, and TwinLink™). When these technologies were tested under extreme, natural pressure from bollworm, differences in incurred injury were expressed. In the same test area, peak boll damage levels approached 20, 60, and 30% in unprotected varieties with Bollgard II®, WideStrike®, and TwinLink™ traits, respectively. As a comparison, damage levels in original Bollgard® technology reached 60% at the peak of bollworm pressure and damage. In one trial comparing varieties of Bollgard II® and WideStrike®, damage levels in aggressively protected paired plots were significantly less than those in unprotected plots, and most yields were significantly more than those from untreated plots, indicating that bollworm was causing some yield loss at the level of pressure experienced. However, sufficient rainfall and optimal growing conditions late in the season, following the interval of heavy feeding injury from bollworm, allowed tremendous yield compensation in other trials. In particular, WideStrike® was able to compensate for much of the damage caused by bollworm, and yields in plots of unprotected TwinLink™ cotton were very similar to those in protected plots. Research is underway to develop treatment thresholds tailored for multiple-Bt-gene technologies as they become available. Educational challenges still exist about the varying expression of injury symptoms among these technologies and how to scout and manage for bollworm when encountered at high levels.

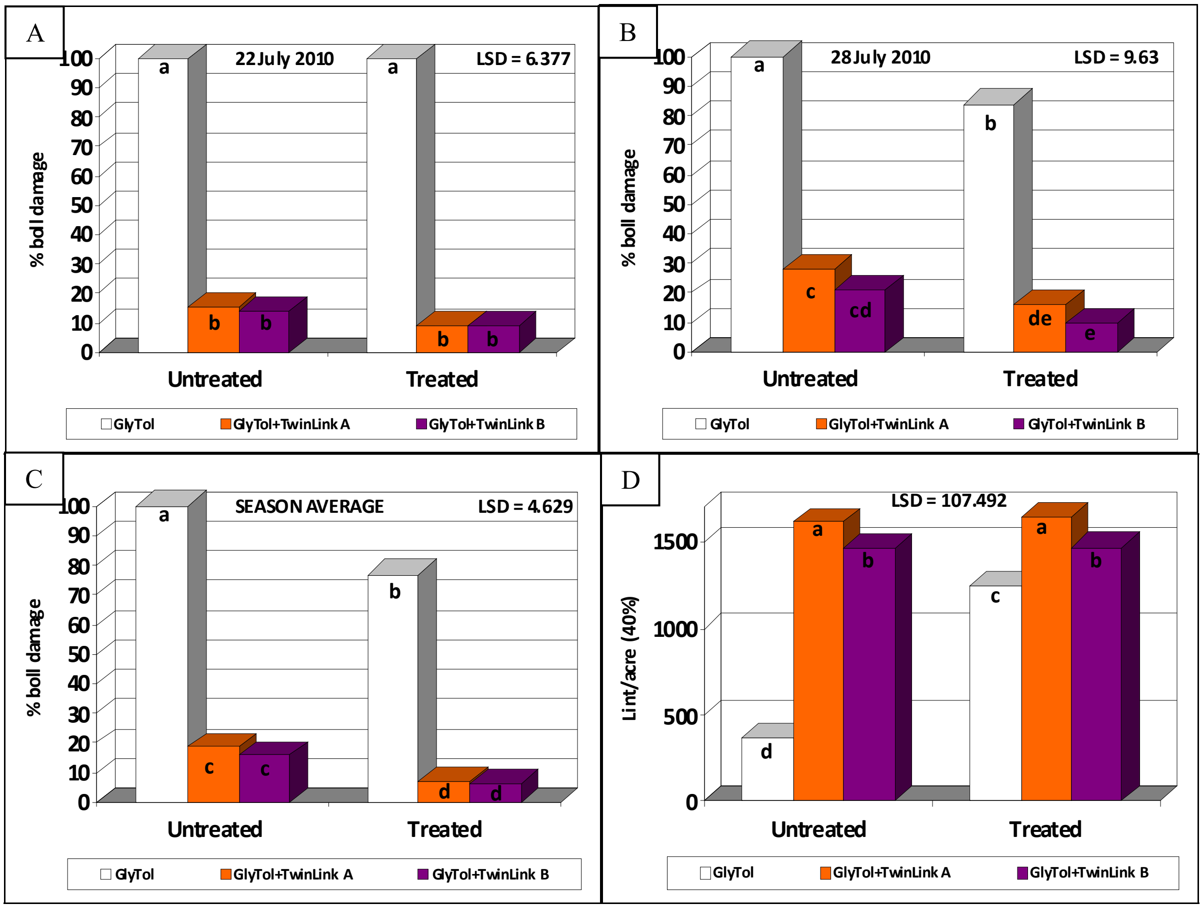

Figure 7. Bollworm damage on 22 July (A), 11 August (B), as a seasonal (6 sample dates) mean (C), and resulting lint yield (D) from unprotected and aggressively protected plots of non-Bt and TwinLink™ cotton near Blackville, SC, during 2010.

Acknowledgements

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