PERFORMANCE OF COMMERCIALLY AVAILABLE TECHNOLOGIES OF SECOND GENERATION BT COTTON ON BOLLWORM IN SOUTH CAROLINA

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Abstract

Efficacy trials comparing the performance of Bollgard®, Bollgard II®, and WideStrike® technologies on control of bollworm in cotton were made during 2006-2009 in South Carolina. The effects of heavy bollworm pressure were compared across available Bt technologies, and differences in control and yield were observed. In situations where bollworm caused feeding injury to 100% of bolls in non-Bt cotton, injury reached 13% in varieties of Bollgard II® and about 40% in varieties of both Bollgard® and WideStrike® technology. Under extreme pressure from bollworm all technologies benefited from supplemental control of bollworm with foliar-applied insecticides. Additional educational opportunities exist about the differences between these technologies.

Introduction

In 1996, the introduction of cotton containing genetic material from the naturally occurring bacterium *Bacillus thuringiensis* (Bt) by Monsanto brought with it the ability to reduce reliance on foliar-applied insecticides for major pests such as the tobacco budworm, *Heliothis virescens*, and the bollworm, *Helicoverpa zea*. However, although applications of insecticides were significantly reduced in first-generation Bt cotton (Bollgard®), they were not eliminated entirely for all lepidopteran pests. Transgenic Bt cotton has eliminated 100% of the applications for tobacco budworm, but supplemental control of bollworm has been a routine practice since the first use of single-gene (Cry1Ac) Bt cotton. Because of the need to apply supplemental foliar insecticides for bollworm, treatment thresholds were developed to address "escapes" of bollworm in Bollgard® cotton. Action levels in South Carolina included the incorporation of an egg threshold (75 eggs/100 plants) along with thresholds for larvae. These more aggressive thresholds were adopted by consultants and producers and have served a valuable role in facilitating sustainable/profitable production of cotton in the state; however, varieties with original single-gene Bt technology (Bollgard®) will not be available commercially after 2010.

In 2003, dual-gene (Cry1Ac and Cry2Ab) Bt cotton technology (Bollgard II®) was introduced by Monsanto, offering 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. While varieties with Bollgard II® or WideStrike® technology provide very good control of caterpillar pests, they do not offer 100% control of bollworm. As a result, action thresholds similar to those used for Bollgard® cotton have been recommended for supplemental control of bollworm in second-generation Bt cotton, with the removal of the egg threshold recommendation. Because subtle but measurable differences exist between the two technologies with regard to spectrum of caterpillar control, levels of caterpillars and expressed levels of feeding injury can be very different between the technologies. These differences have not been addressed with threshold refinement from research efforts, so future research should deal with development of action thresholds for bollworm in Bollgard II® and WideStrike® cotton. Extension programs should strive to educate producers and consultants about the potential differences in expressed feeding injury with the two technologies.

Materials and Methods

During 2006-2009, replicated plots 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. 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 per acre at 60psi. To ensure maximum pressure from bollworm, all plots were oversprayed with acephate at 1 lb [AI] per acre during early bloom (ca. early-to-mid July) to decimate beneficial arthropods and potentially flare populations of bollworm. Tests in 2006, 2007, and 2008 were untreated for lepidopterans, but a split-plot design in 2009 provided plots treated for bollworm with a pyrethroid insecticide at recommended thresholds for comparison with an identical untreated plot. Treatment thresholds used in 2009 were those as listed in Greene 2010 (Table 1).

Table 1. Treatment thresholds recommended (2006-2010) for bollworm, *Helicoverpa zea*, in cotton in South Carolina.

Technology	Number per unit
1st generation Bt cotton (Bollgard®)	After 1st bloom: 75 eggs, 30 small (<0.25 inch) or 3 larger (>0.25 inch) larvae per 100 plants, or 5% damaged bolls
2nd generation Bt cotton (Bollgard II® and WideStrike®)	No threshold using eggs or small larvae; after 1st bloom: 3 or more larger (>0.25 inch) larvae per 100 plants or 5% damaged bolls
Non-Bt cotton (all non-Bt varieties)	After 1st bloom: 20 or more eggs or 3 small (<0.25 inch) larvae per 100 plants or 5% damaged squares

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. Populations of bollworm moths were monitored several times per week using pheromone-baited Hartstack-type (Hartstack et al. 1979) traps.

Results and Discussion

Pheromone Trap Captures

Populations of bollworm (BW) and tobacco budworm (TBW) moths were variable from year to year (Figure 1), but numbers of BW were consistently high from 2007 to 2009. Only captures of BW in 2006 were characterized as "low".

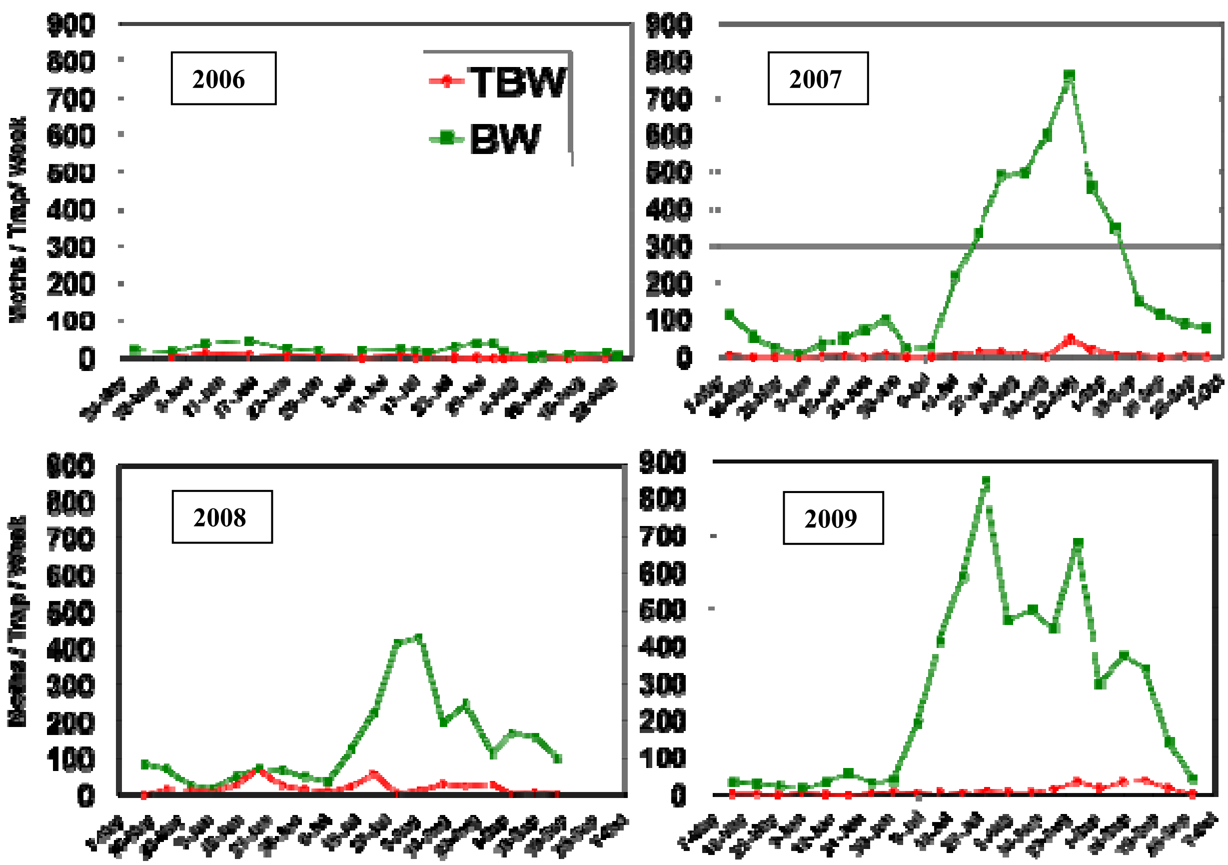

Figure 1. Captures of bollworm (BW), *Helicoverpa zea*, and tobacco budworm (TBW), *Heliothis virescens*, in pheromone-baited traps near Blackville, SC, during 2006-2009.

2006

Because captures of bollworm in pheromone traps (Figure 1) were significantly lower in 2006 than in subsequent years, populations in the field were correspondingly characterized as "light" during the initial season. Damage to bolls reached only 52% in non-Bt varieties, and yields (Figure 2) were reflective of the absence of substantial losses due to bollworm.

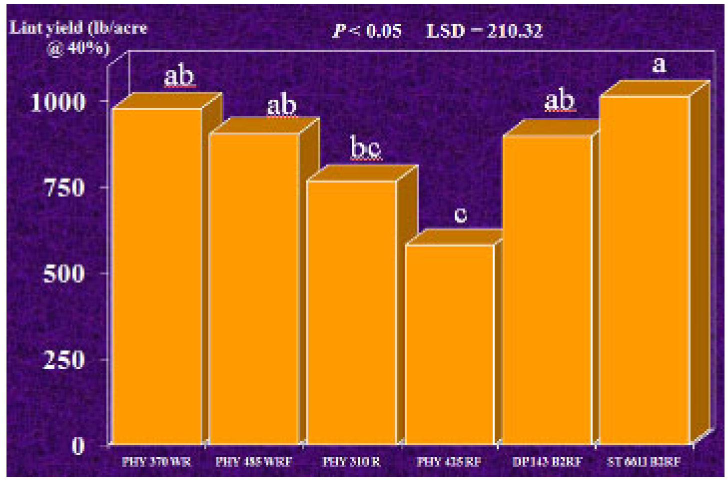

Figure 2. Lint yields (40% turnout) from comparison of Bt cotton technologies in 2006 near Blackville, SC. Columns with letters in common are not statistically different.

2007

Captures of bollworm in pheromone traps (Figure 1) were significantly higher during 2007 than in 2006, and populations of bollworm in the field were correspondingly characterized as "heavy" during the second year. Damage to bolls reached over 90% in non-Bt varieties and exceeded 30% in Phytogen (PHY) 485 WideStrike® cotton during mid-August (Figure 3). Yields of all Bt technologies were comparable, except for PHY485 which produced significantly less yield than a Bollgard II® variety.

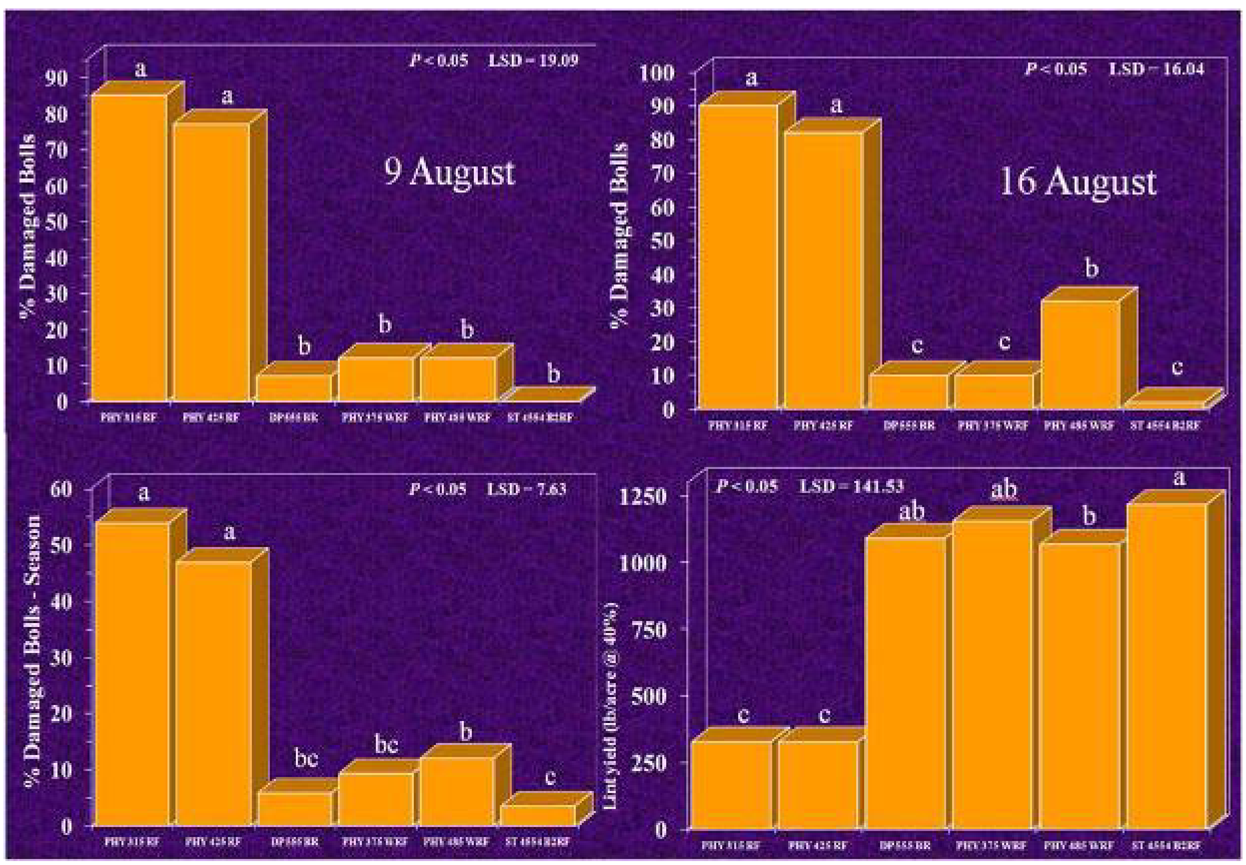

Figure 3. Boll damage from bollworm and lint yields (40% turnout) from comparison of Bt cotton technologies in 2007 near Blackville, SC. Columns with letters in common are not statistically different.

2008

Captures of bollworm in pheromone traps (Figure 1) were lower during 2008 than in 2007, but populations of bollworm in the field were again characterized as "heavy" during the third year. Damage to bolls reached 98% in non-Bt varieties, 40% in Delta Pine (DP) 555 (Bollgard®), and exceeded 30% in PHY485 WideStrike® cotton during mid-August (Figure 4). Yields of DP555 and both PHY375 and PHY485 were comparable. Yields were highest in DP164 (Bollgard II®), and yields of two Stoneville (ST) varieties were intermediate.

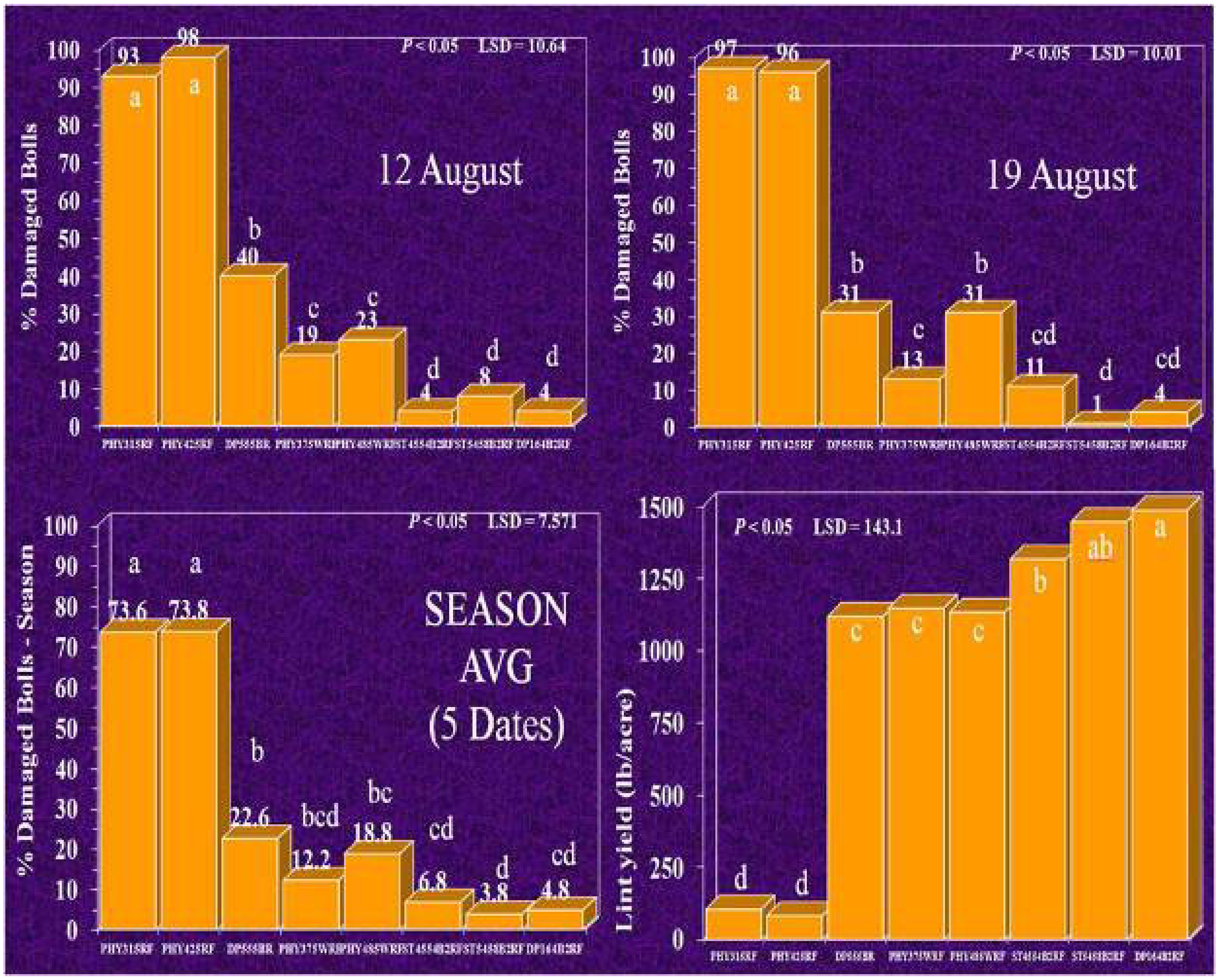

Figure 4. Boll damage from bollworm and lint yields (40% turnout) from comparison of Bt cotton technologies in 2008 near Blackville, SC. Columns with letters in common are not statistically different.

2009

Captures of bollworm in pheromone traps (Figure 1) were highest during 2009, and populations of bollworm in the field were again characterized as "heavy" and sustained during the fourth year. Damage to bolls reached 100% in non-Bt varieties, 23% in DP555 (Bollgard®), and 39% in PHY485 WideStrike® cotton during mid-August (Figure 5). Yields of all Bt technologies were comparable and significantly higher than those of non-Bt varieties. All varieties receiving supplemental insecticide for bollworm yielded higher than matching untreated varieties. Yields were highest in ST5458 and ST4498 (Bollgard II®). When yields from untreated and treated plots were combined, yields from DP555 (Bollgard®) were not significantly less than the highest varieties, but yields in DP0935 (Bollgard II®), DP161 (Bollgard II®), and PHY485 (WideStrike®) were significantly lower than the highest-yielding varieties.

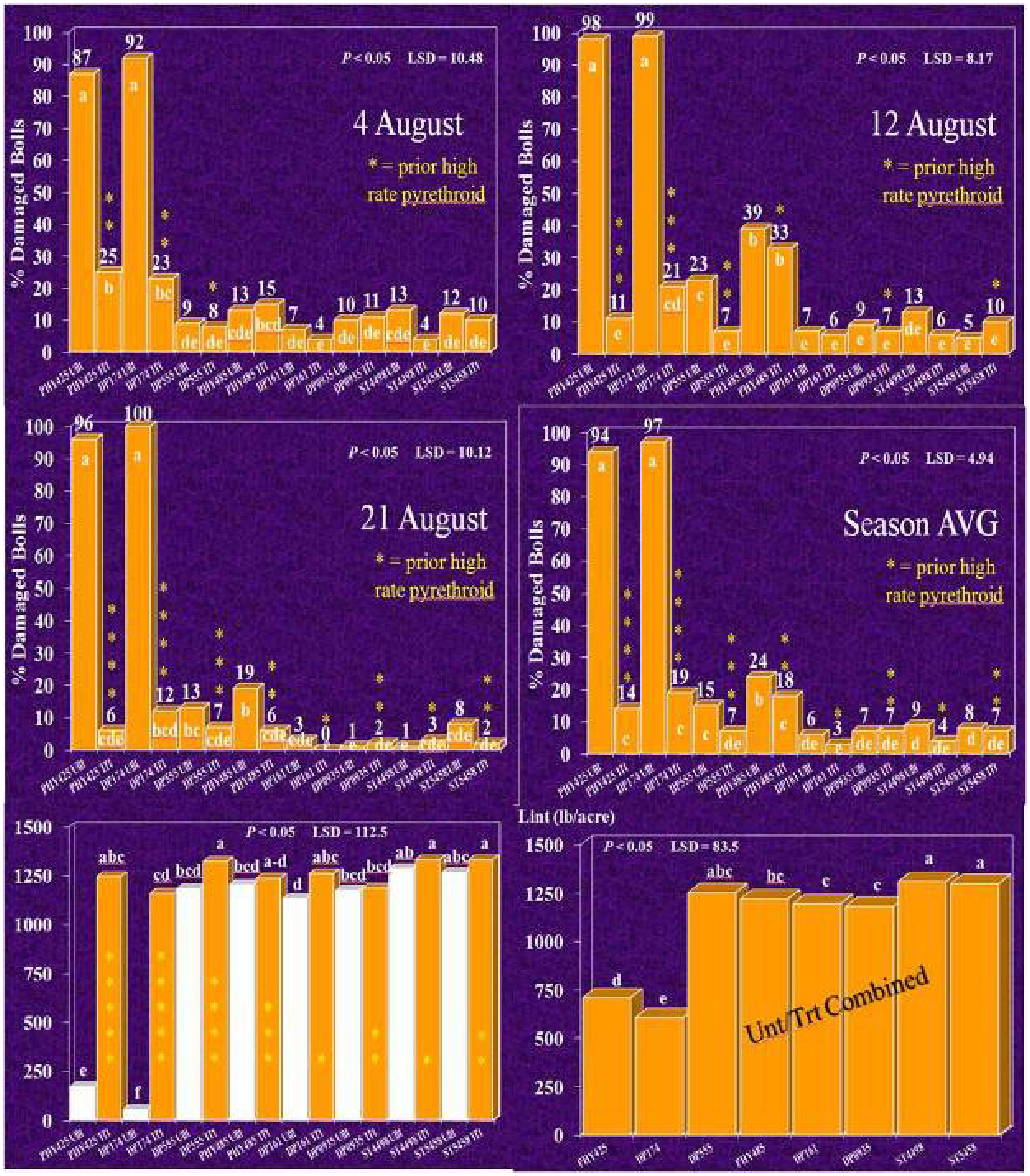

Figure 5. Boll damage from bollworm and lint yields (40% turnout) from comparison of Bt cotton technologies in 2009 near Blackville, SC. Columns with letters in common are not statistically different. *Application to treatment with pyrethroid insecticide before sampling date.

Summary

Second generation (2-gene) Bt cotton (Bollgard II® and WideStrike®) remains 100% effective on tobacco budworm and is considerably better on controlling bollworm than original Bollgard® technology. Bollworm will remain extremely important in cotton for at least another year, until single-gene Bollgard® varieties are phased out after 2010, but will likely continue to require management efforts for bollworm in subsequent technologies of Bt cotton. Varieties of dual-gene Bt cotton are performing better over time in terms of yield potential, and choice of available technologies is beneficial for producers. When these technologies were tested under extreme pressure from bollworm, differences were expressed. Bollgard II® technology afforded very good control of bollworm but gained yield when supplemental applications of insecticide were applied. Also, WideStrike® technology, particularly in a longer-season variety such as PHY485, suffered significant losses to bollworm, often translating into yield reductions. However, if optimal growing conditions were extended following the interval of heavy feeding injury, WideStrike® varieties were able to compensate for the losses caused by bollworm. Research is needed for developing treatment thresholds tailored for each these new technologies as they become available. Educational challenges exist now about the varying expression of injury symptoms among these technologies and how to scout and manage for bollworm when encountered at high levels.

Acknowledgements

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Disclaimer

The mention of trade names in this report is for informational purposes only and does not imply an endorsement.

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