EFFICACY AND FIELD PERFORMANCE OF BT COTTON IN LOUISIANA

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Abstract

Since the introduction of Bt cotton in the United States, bollworm, *Helicoverpa zea,* management has become less challenging in Midsouth cotton production systems. However, over the past three years all commercially available 2nd and 3rd generation Bt cottons experienced field control failures related to bollworms. In 2018, large and small plot Bt sentinel plots were planted in the major cotton growing regions of Louisiana. Our data demonstrates that all currently available Bt cotton technologies may suffer unexpected bollworm injury. TwinLink, Widestrike and Bollgard 2 experienced the highest level of injury in sentinel and small plot research plots, while varieties containing the Vip3a protein provided the greatest protection. However, two locations in Central Louisiana resulted in unacceptable injury in Widestrike 3 and Bollgard 3. TwinLink Plus performed the best out of all commercially available Bt technologies against bollworms in 2018.

Introduction

The bollworm (BW), *Helicoverpa zea* (Boddie), is one of the most economically important insect pests of Midsouth cotton. In 1996, the first Bt cotton containing the Cry1Ac protein was commercialized for control of fruit and foliage feeding worms. Currently, Bt proteins used in transgenic cotton are categorized into three groups: Cry1, which contains Cry1Ab, Cry1Ac, and Cry1F; Cry2, which includes Cry2Ab and Cry2Ae; and Vip3a. The corresponding cotton varieties include: Bollgard 1 (Cry1Ac), Bollgard 2 (Cry1Ac + Cry2Ab), Widestrike (Cry1Ac + Cry1F), Twinlink (Cry1Ab + Cry2Ae), Widestrike 3 (Cry1Ac + Cry1F + Vip3a), Bollgard 3 (Cry1Ac + Cry2Ab + Vip3a) and Twinlink Plus (Cry1Ab + Cry2Ae + Vip3a). However, extensive and constant exposure of BW to these Bt proteins not only in transgenic cotton, but also in corn, appears to have resulted in a shift towards a reduction in susceptibility in cotton. In 2018, all commercially available cotton technologies experienced field control failures in various cotton growing regions in Louisiana. Failure of the Bt technologies, to control BW, resulted in costly applications of diamide insecticides to control larvae and broad-spectrum insecticides to control ovipositing adult moths. Complicating this issue is resistance selection of BW through transgenic field corn. As a general rule, BW infesting cotton originate from field corn. Thus, selection of Bt resistant worms takes place one or possibly two insect generations before encountering Bt cotton. Corn is a much more suitable host for BW often generating larger, more fecund female moths that migrate to the next host which is often cotton.

The objective of this project was to evaluate the efficacy of second and third generation Bt cotton for efficacy against BW in different Louisiana geographies.

Materials and Methods

Tests were conducted at four locations in Louisiana to determine the efficacy of commercially available 2nd and 3rd generation Bt technologies. The Bt cotton technologies evaluated included ST 494GLT, TwinLink™ (TL; Cry1Ab, Cry2Ae), DP 1646 B2XF, Bollgard II® (BG2; Cry1Ac, Cry2Ab), PHY 333WRF, WideStrike® (WS; Cry1Ac, Cry1F), PHY 330WRF3, WideStrike 3® (WS3; Cry1Ac, Cry1F, Vip3A). ST 5575GLTP, TwinLink Plus™ (TL+; Cry1Ab, Cry2Ae, Vip3A) and DP 1835 B3XF (BG3; Cry1Ac, Cry2Ab, Vip3A).

All tests were non-randomized strip trials planted in either a four or 6 row arrangement on 40 inch centers. Test locations included the LSU AgCenter Red River Research Station in Bossier City, LA, Northeast Research Station in St. Joseph, LA, Macon Ridge Research Station in Winnsboro, LA and Finkey Farms in Rapides Parish, LA. Insect densities and square, bloom and boll injury were determined weekly once moth flights had initiated at each location. Sampling initiated the first week of July and terminated the first week of August at all locations. Two

hundred fruiting structures were randomly pulled from the top 4-5 nodes of each technology and larvae were classified as small, medium or large. No yields were recorded for any location.

Results and Discussion

Across all locations fruit damage was highest at the Rapides Parish location for BG2 and BG3 during the week of July 24. (Figures 1,2). Bollgard 2 injury averaged 69% across all fruiting structures with squares and bolls comprising the largest amount of injury. Bollgard 3 injury averaged 18% across all fruiting structures with squares and flowers comprising the greatest amount of injury. Due to a miscommunication all other Bt cotton varieties, at the Rapides Parish location, were prematurely terminated before the sampling could be initiated.

At the Red River location, the WS variety exhibited that largest amount of injury with weekly fruit injury averaging 22% for squares and 16% for bolls (Figure 3). Flowers were not recorded in this study. Following WS, the TwinLink variety experienced 12% average injury in squares and 8% injury in bolls (Figure 3). Bollgard 2 performed the best of the 2nd generation Bt technology with squares experiencing 8% injury and 10% injury in bolls respectively (Figure 3). Of the third generation Bt technologies, TL+ performed the best with no injury documented throughout the trial followed by BG3 (2% injury in squares and bolls) followed by WS3 (4% injury in squares and 6% in bolls).

The Macon Ridge location WS and TL resulted in the largest amount of injury in the 2nd generation Bt cottons. WS received average weekly fruit injury totaling 14% across squares blooms and bolls. (Figure 4). TL received average weekly injury totaling 13.5% across all fruiting forms. BG2 experienced the lowest injury of the 2nd generation Bt cottons with 7% total average injury occurring throughout the sampling period. Of the 3rd generation Bt cottons, WS3 experienced the most total average injury (6%) followed by BG3 (5.5%) and TL+ (4%) (Figure 4). The Macon Ridge location was the only site to have a non-bt check. The Northeast location experienced an insignificant amount of bollworm injury across all technologies (<2%).

These studies illustrate that bollworm injury is common throughout Louisiana's cotton growing regions and most likely due high bollworm pressure and resistance to the Cry Bt proteins. Bt technologies still have exceptional value against tobacco budworm, *Chloridea virescen,* and other lepidopteran pests in Louisiana; however, activity against BW has greatly diminished. Based on field and bioassay results it appears that the Widestrike technology is almost completely ineffective against bollworms in Louisiana (Yang et al. 2018) Widestrike technology is comprised of Cry1F and Cry1Ac. Cry1F is ineffective towards bollworms and high levels of resistance to Cry1Ac are present in Louisiana and Midsouth populations. Furthermore, resistance to Cry2A is becoming increasingly more common in Louisiana and may only provide satisfactory control of BW under light pressure. Vip cotton varieties appear to provide the greatest level of BW control; however, Louisiana experienced control failures with Vip cotton varieties in 2018. With resistance to Cry1A and Cry2A, Vip has become a single gene toxin that is experiencing tremendous selection pressure and the longevity of this protein is uncertain.

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References

Yang, F., D. Kerns, J. Gore, A. Catchot, D. Cook, F. Musser, G. Lorenz, N. Seiter, S. Stewart and S. Brown. 2018. Continuous monitoring of susceptibility of Helicoverpa zea in the Southern U.S. to different Bt proteins. In Proc. Beltwide Cotton Conf., National Cotton Council, Memphis, TN, In Press.

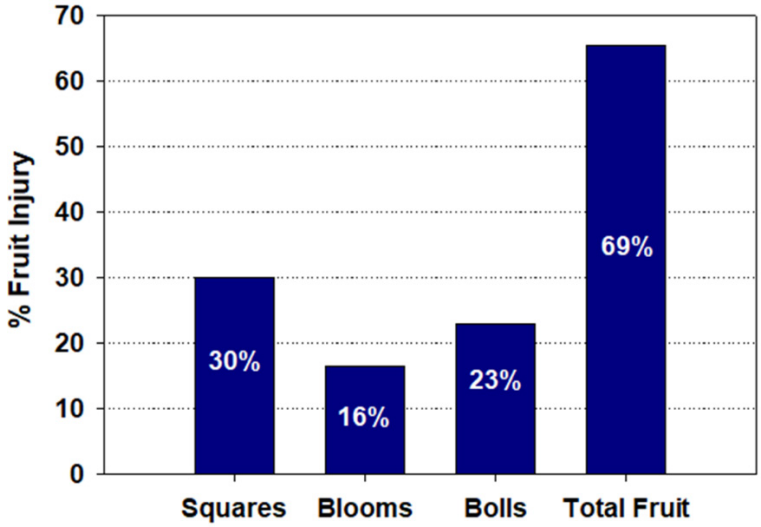

Figure 1. Percent fruit injury of BG2 technology at the Rapides Parish location in 2018.

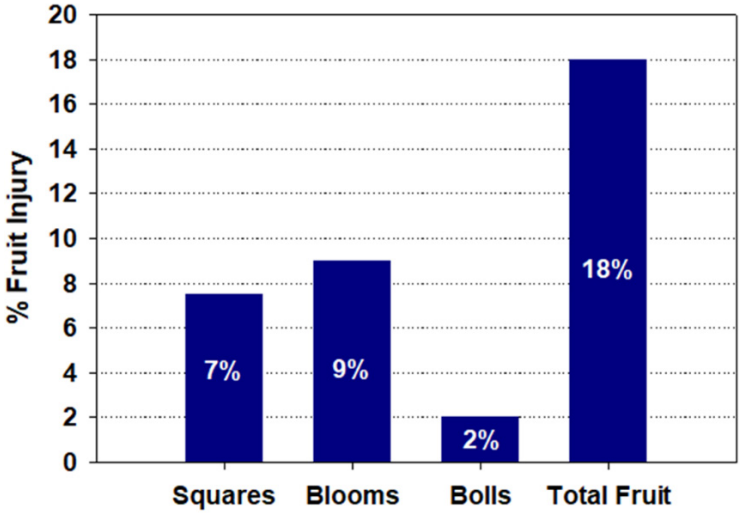

Figure 2. Percent fruit injury of BG3 technology at the Rapides Parish location in 2018.

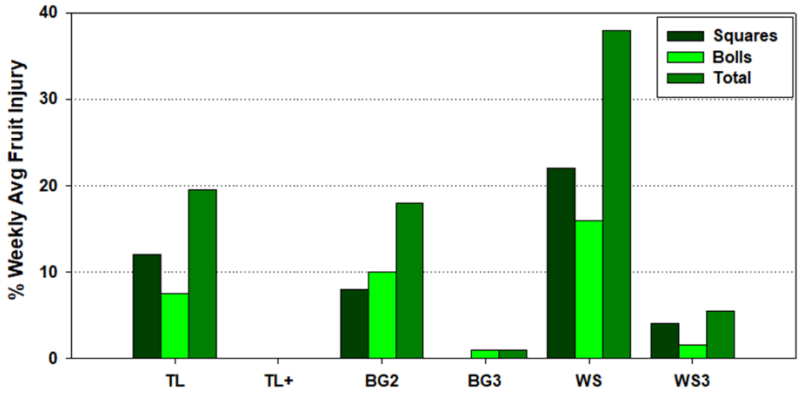

Figure 3. Average percent injury of squares and bolls at the Red River location in 2018.

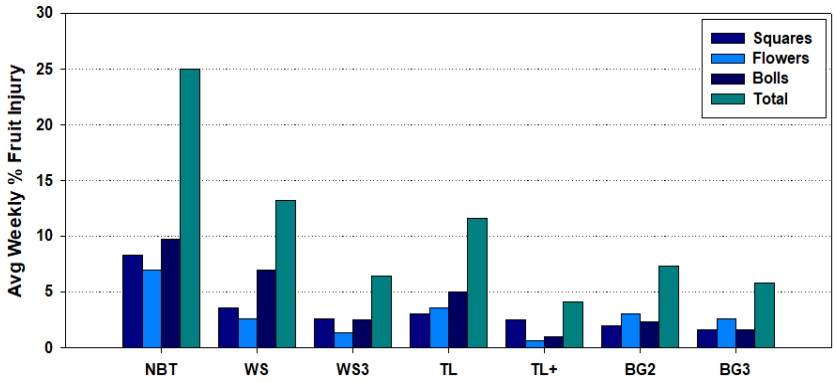

Figure 4. Average percent injury of squares and bolls at the Macon Ridge location in 2018.