EFFECT OF BT EXPRESSION ON BOLLWORM DISTRIBUTION IN THE COTTON CANOPY

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Abstract

Both the level of Bt expression and the nutritional content of various Bt cotton tissues may influence the feeding preferences of *Helicoverpa zea* [Bodie] (Lepidoptera: Noctuidae) larvae. Therefore, Bt expressed in cotton plant tissues may impact both the vertical distribution and the feeding site distribution of larvae within the cotton canopy. This could potentially impact the efficacy of foliar insecticide treatments in addition to improving scouting methods to be trait or site specific. Random plants were selected from plots containing either non-Bt, WideStrike, or Bollgard II cotton and sampled from the top of the plant to the bottom for presence of larvae and damage. Results suggest that despite the possible development of resistance, Bt may still be inhibiting the growth of larvae. One possible implication from this may be a resulting impact on the efficacy of insecticidal foliar treatments. Vertical distribution of larvae and damage within the canopy suggest that most activity occurs in the middle canopy (nodes 6-9). Thus, scouting in the middle canopy may be the best indicator of the presence of *H. zea* larvae. However, more data is needed to support this conclusion and further trials need to be conducted to determine how an insecticide treatment may affect the larvae and damage distribution in the cotton canopy.

Introduction

The state of Tennessee produces an annual average of 200,000 to 300,000 acres of cotton, which is primarily grown in the western portion of the state. More than 98 percent of the cotton planted in the state is genetically modified for herbicide-resistant and with *Bacillus thuringiensis* (Bt) for protection from lepidopteran pests. *Helicoverpa zea* [Bodie], commonly called bollworm, is an important pest of cotton capable of causing significant yield losses if left unmanaged (Adkisson et al. 1964). Early in the growing season this pest poses a lesser threat to yield, but after first bloom, management of this insect can be critical (Luttrell 1994). Both insecticides and transgenic Bt cotton varieties are implemented to manage *H. zea*, however, practical resistance to both Cry1Ac and Cry2Ab has been detected in the United States (Tabashnik and Carrière 2017). Therefore, foliar insecticides may be necessary for adequate management of *H. zea* in Bt cotton. Bollworm larvae have exhibited a preference for feeding on flowers and small bolls with bloom tags in conventional cotton (Farrar and Bradley 1985). The nutritional content and the level of Bt expression in various cotton structures may influence the feeding preferences of larvae on Bt cotton (Orpet et al. 2015). Feeding preferences may impact the vertical distribution of larvae within the cotton canopy and among various fruiting structures. This may limit the efficacy of insecticide treatments if larvae have a tendency to feed in locations where foliar insecticides can be avoided. The application of a foliar insecticide may also influence the distribution of larvae within the canopy, resulting in surviving larvae with tendency to feed in more protected locations of the plant. Additionally, scouting methods may be made more site- or trait- specific if the feeding tendencies of *H. zea* larvae are determined in different Bt technologies in different locations.

Materials and Methods

A split-plot design with four replications of eight row whole plots and four row sub-plots was utilized in this experiment. Plots were planted on 12 June 2018 at the West Tennessee Research and Experiment Station in Jackson, TN. Whole plots consisted of either Non-Bt (PHY 425 RF), WideStrike® (PHY 444 WRF), or Bollgard II® (DP 1646 BXF) cotton varieties. Sub-plots were either treated with 16 oz/ac of chlorantraniliprole (Prevathon®, FMC Corporation, Princeton, NJ) on 21 August or non-treated. The test was rated on 26 August when cotton was at 5-6 NAWF. Plants were randomly selected, and each fruiting structure was sampled from the terminal to the bottom of the plant for the presence of *H.* zea larvae or their damage. Sampling in each plot was performed until either 15 plants were sampled or 25 larvae were found. Additionally, sampling was terminated if ten plants were sampled consecutively with no larvae found. Sub-plots treated with chlorantraniliprole were determined to have inadequate larvae numbers, therefore, treated sub-plots were not sampled for this experiment. This resulted in the study being more similar to a randomized complete block design rather than a split-plot design. Larvae were categorized as small (1^{st} and 2^{nd} instar), medium (3^{rd} and 4^{th} instar), or large (5^{th} instar+). Plant structures were categorized as squares (squares + candled squares), flowers (white flowers + pink flowers + small bolls with bloom tags), and bolls (small bolls + large bolls) for analyses. The cotton canopy was categorized as top (nodes 1-5), middle (nodes 6-9), and bottom (nodes 9+) to allow for adequate sample size in each category. Analyses were conducted using the PROC FREQ command in SAS (Version 9.4, SAS Institute, Cary, NC) to conduct a chi-square analysis (±= .05).

Results and Discussion

The middle cotton canopy (nodes 6-9) had the highest pooled frequency of damaged structures and larvae among all the plots that were sampled (Figure 1). The top (nodes 1-5) and bottom (nodes 9+) canopies contained relatively similar pooled frequencies of damaged structures and larvae. However, there was no significant difference in the vertical distribution of the pooled frequency of damaged structures and larvae between different technologies (P= 0.562, Bt vs. non-Bt P= 0.299). This suggests that the middle cotton canopy may be the site of the most larvae activity regardless of the technology being evaluated. Therefore, scouting in the middle canopy may provide the best indicator for the presence of *H. zea* larvae.

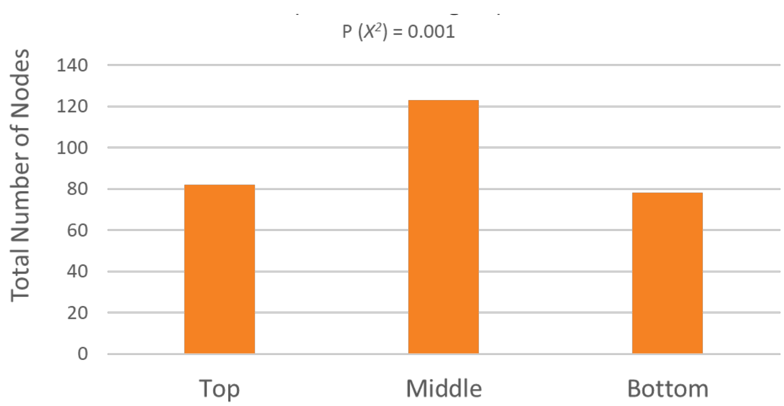

Figure 1. Vertical distribution of larvae and damage pooled across all technologies

Bolls were the most frequently damaged plant structure pooled across all sampled plots (P< .001). Squares were less frequently damaged than bolls, while flowers had the least damage frequency of all the structures evaluated. Non-Bt plots had the highest frequency of damage, followed by WideStrike plots and Bollgard II plots (P < .001). The frequency of larvae sampled from each technology showed similar results to the frequency of damage from each technology. The non-Bt plots had the highest frequency of sampled larvae and the Bollgard II plots had the lowest (P< .001). There was no significant difference between the proportion of damaged structures among technologies (P= .108). However, when the frequencies of damaged structures within the Bt plots were pooled together, the proportion of damaged structures in Bt cotton significantly differs from non-Bt cotton (Figure 2). Analysis showed no significant differences between the proportion of larval sizes among the technologies (P= .056). However, larger sample size may have shown that there was a difference in the larval size proportions between technologies. When the frequencies of larval sizes in the Bt technologies were pooled together, Bt plots had higher proportions of small and medium sized larvae than the Non-Bt plots, which contained a higher proportion of medium and large sized larvae (Figure 3). This indicates that despite the possible development of Bt resistance in the *H. zea* population, the growth of the larvae is likely still inhibited by the Bt toxin being expressed in the cotton tissue. The inhibition of larval growth may also have an influence on the proportion of damaged structure types in Bt cotton plots. This could be explained by the tendency of smaller larvae to feed less on bolls compared to larger larvae (Farrar and Bradley 1985). Furthermore, the presence of proportionally more small and medium sized larvae on Bt cotton and their tendency to feed proportionally less on bolls may result in reduced efficacy of insecticidal foliar applications.

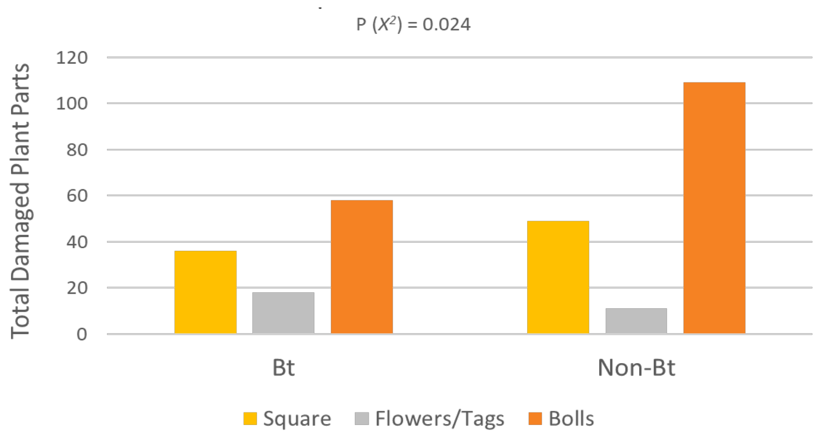

Figure 2. Frequency of different plant structures pooled across all technologies

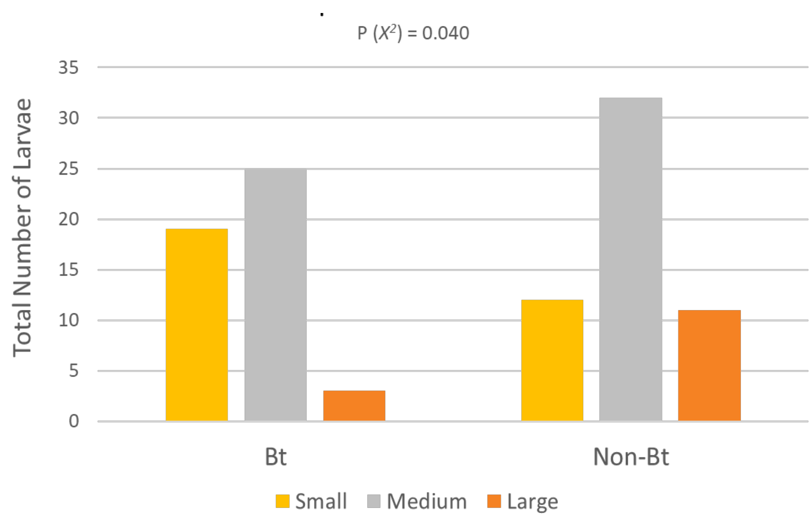

Figure 3. Frequency distribution of larvae sizes in Bt vs. non-Bt cotton

Summary

The use of a Bt technology (WideStrike or Bollgard II) reduced the number of larvae and the amount of injury found on the plant compared to non-Bt cotton. Overall, Bollgard II plots had a lower frequency of larvae and damage than the WideStrike plots. The middle canopy had a higher frequency of larvae and damage than the bottom and top canopies regardless of technology. This suggests that scouting in the middle canopy area of the plant may provide the best indicator of *H. zea* activity. However, more data is needed to further support this and target structures in this area need to be identified to further improve scouting methods. Despite the possible development of resistance, it appears that exposure to Bt toxins still inhibits the growth of larvae, thus impacting where the larvae tend to feed on the plant. The smaller sized larvae in Bt cotton may be more likely to feed on squares and flowers rather than bolls. This could impact the efficacy of a foliar insecticide treatment on Bt cotton. Unfortunately, the chlorantraniliprole treatment yielded plots with inadequate larvae sample sizes and sampling was terminated in treated sub-plots after replications one and two. This trial will need to be repeated in multiple locations to examine how the efficacy of a foliar insecticide may be impacted by Bt cotton and how the use of an insecticide may further alter the distribution of larvae within the canopy. Perhaps a pyrethroid could be utilized rather than chlorantraniliprole so that there is a higher rate of larvae survivorship and adequate sample size.

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