EVALUATING THE MANAGEMENT OF BOLLWORM IN COTTON

Cade Francis
Jeff Gore
Don Cook
Whitney Crow
Mississippi State University
Delta Research and Extension Center
Stoneville, MS
Angus Catchot
Mississippi State University
Starkville, MS

Abstract

The bollworm, *Helicoverpa zea* (Boddie), is an important pest of cotton in the U.S. An experiment was conducted at two locations in Mississippi to determine if the current thresholds for bollworm in cotton are the most economical in current cotton technologies. The objective of this research was to compare and validate bollworm action thresholds currently published in the Mississippi State University Insect Control Guide. Studies were conducted in Stoneville, MS and Clarksdale, MS, during 2019 and 2020 using a 3x3 factorial within a randomized complete block design with treatments replicated four times. Factors included cotton variety and threshold. Plots were scouted weekly for eggs. Once eggs were found, each plot was scouted for damage, eggs, and live larvae on ten plants per plot using a modified whole plant search. Bollworm populations were lower than expected overall at both locations throughout 2019 but populations persisted over several weeks. Populations in 2020 were higher which provided better damage numbers. Damage to non-Bt cotton was greater than that of Bollgard II and Bollgard 3 cottons. For all technologies and across both years, damage thresholds were sprayed more often than the egg thresholds.

Introduction

Bollgard cotton was introduced for commercial production in 1996. Bollgard cotton varieties were transformed to express the Cry1Ac protein from *Bacillus thuringiensis var. kurstaki* for control of tobacco budworm, *Chloridea virescens* (F); bollworm, *Helicoverpa zea* (Boddie); and pink bollworm, *Pectinophora gossypiella* (Saunders) (Gore et al. 2003). Bollgard cotton provided good control of tobacco budworm and pink bollworm, but was less effective against high populations of bollworm (Gore et al. 2002, Gould 1998, Luttrell et al. 1999). Bollgard II was introduced in 2003 to provide better control of bollworm. Bollgard II produces the Cry1Ac protein from Bollgard, plus the Cry2Ab protein to increase overall toxin levels. Recently, bollworm populations became increasingly resistant to both of these Bt proteins. Bollgard 3 cotton was introduced during the 2018-2019 growing season. This new technology uses the Cry1Ac and Cry2Ab proteins found in Bollgard II, but adds a third protein, Vip3A which provides a different mode of action to control bollworms (Bommireddy et. al. 2011).

The current threshold for bollworms in Non-Bt and two gene cotton varieties is 8 or more larvae per 100 plants or 6% fruit injury before bloom and 20 eggs per 100 plants or 6% fruit damage after bloom. In 3 gene cotton varieties the threshold is 8 or more larvae per 100 plants or 6% fruit injury pre-bloom and 4 or more larvae at least 1/8-inch long per 100 plants or 6% fruit injury. Currently, no research has been done to validate these thresholds, especially since resistance to multiple Bt proteins has developed.

Materials and Methods

Experiments were conducted in Stoneville, MS and Clarksdale, MS during 2019 and 2020 to evaluate current action thresholds. The experiment was established as a 3X3 factorial treatment arrangement in a RCB design with four replications. The factors included variety and threshold. Varieties included Deltapine 1822 XF (Non-Bt), Deltapine 1646 B2XF (Bollgard II), and Deltapine 1845 B3XF (Bollgard III). Threshold treatments included an untreated control, 20% egg threshold, and 6% damage threshold. The entire test area was sampled weekly for the presence of bollworm eggs. Once eggs were found, each plot was sampled weekly for damage, eggs, and live larvae. Ten plants per plot were examined using a modified whole plant search which involves checking the terminal, 2-3 squares, and 2-3 bolls on each plant. The mean number for each treatment among all four reps was used to determine if a spray was needed for the corresponding threshold. At the end of each season, the center two rows of each plot were harvested

and seedcotton weights were recorded. Seedcotton weights were converted to lbs lint per acre based on the average of 40% lint. All data were analyzed with Analysis of Variance (PROC GLIMMIX, SAS Institute, Cary, NC). Means were separated using Fishers protected LSD. Means were separated between location and year because of a site year by treatment interaction. Differences were considered significant at α=0.05.

Results and Discussion

Overall, data collected during these experiments was highly variable throughout both locations as well as between years. In 2019 and 2020 at both locations, the Vip3A protein found in the Bollgard 3 variety, provided good control of bollworm without the need for additional foliar sprays, even during 2020 in Stoneville, where pressures were high. With the Bollgard 3 variety, no differences were observed in yield across thresholds, even in the untreated plots. With Bollgard II, there was evidence of resistance, especially in Stoneville (Fig. 1 & 2). In Clarksdale across both years, there was no difference in yields across thresholds (Fig. 3 & 4). For Stoneville in 2019, there was no difference in Bollgard II yields, likely due to the low bollworm numbers that year. In 2020, differences in yield were observed between the untreated plots and the two thresholds for Bollgard II. This showed that there was a benefit to applying an insecticide, regardless of which threshold was used. Both the egg and damage thresholds yielded better than the untreated plots, but the damage threshold yielded better than the egg threshold both years. This is likely because the damage thresholds triggered more often and were sprayed more than the egg thresholds. When comparing spray numbers across each variety and threshold, more sprays were applied to the non-Bt variety. Four sprays were made on the non-Bt damage thresholds and only one was made on the egg threshold in 2019, compared to four damage threshold sprays and two egg threshold sprays in 2020. For Bollgard II, two total sprays were made in 2019, on the damage threshold, compared to three damage threshold sprays and two egg threshold sprays in 2020. For Bollgard 3 in 2019, only one application was made and it was on the damage threshold. In 2020, five total sprays were made in Bollgard III cotton, three on the damage threshold, and two on the egg threshold. (Table. 1).

Figures and Tables

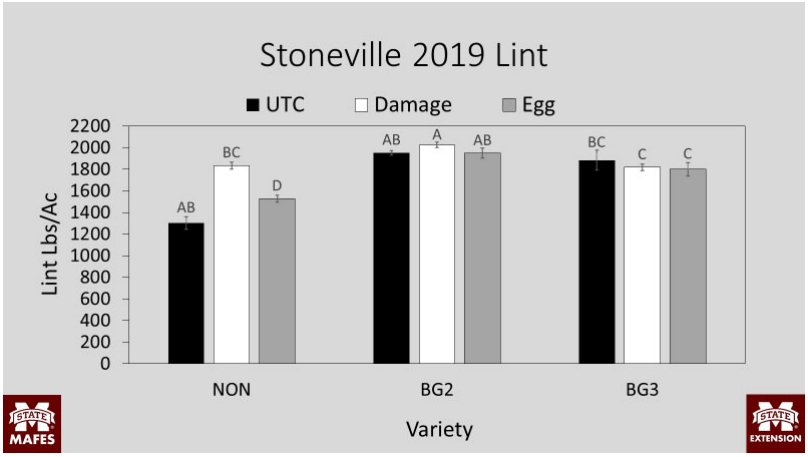

Figure 1. The interaction between cotton variety and treatment thresholds for mean ± SEM cotton lint yields in Stoneville, MS in 2019. Treatments containing the same letter are not significantly different according to Fishers Protected LSD (α=.05).

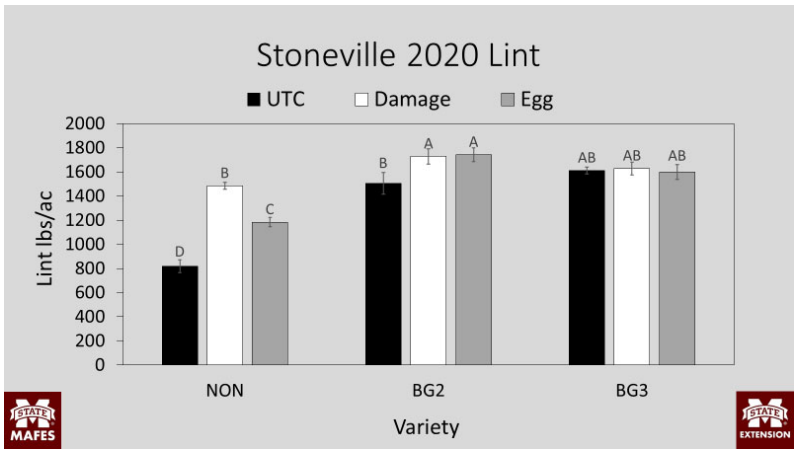

Figure 2. The interaction between cotton variety and treatment thresholds for mean ± SEM cotton lint yields in Stoneville, MS in 2020. Treatments containing the same letter are not significantly different according to Fishers Protected LSD (α=.05).

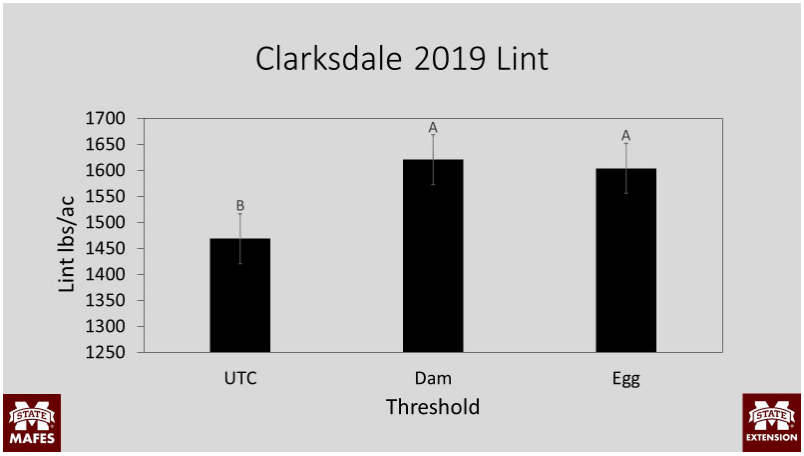

Figure 3. The effects across treatment thresholds for mean ± SEM cotton lint yields in Clarksdale, MS in 2019. Treatments containing the same letter are not significantly different according to Fishers Protected LSD (α=.05).

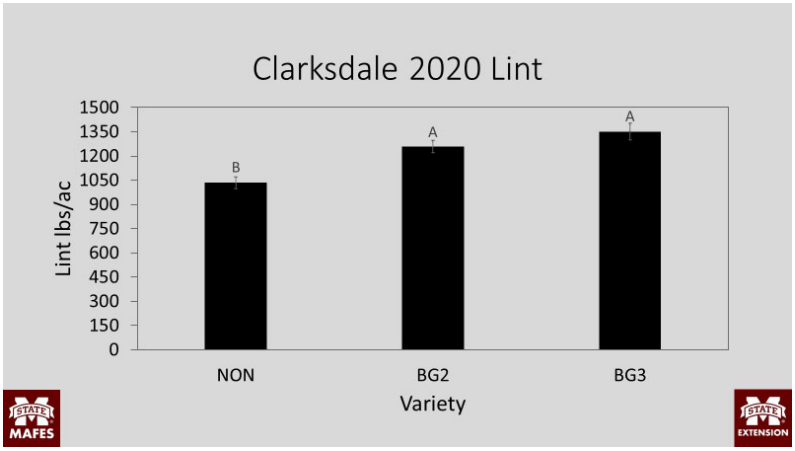

Figure 4. The effects across treatment thresholds for mean ± SEM cotton lint yields in Clarksdale, MS in 2019. Treatments containing the same letter are not significantly different according to Fishers Protected LSD (α=.05).

Table 1. Number of sprays per threshold for each variety during 2019 and 2020.

	2019			2020	
Variety	**Threshold**	**No. Sprays**	**Variety**	**Threshold**	**No. Sprays**
Non-Bt	Egg	1	**Non-Bt**	Egg	2
Non-Bt	Damage	4	**Non-Bt**	Damage	4
BG2	Egg	0	**BG2**	Egg	2
BG2	Damage	2	**BG2**	Damage	3
BG3	Egg	0	**BG3**	Egg	2
BG3	Damage	1	**BG3**	Damage	3

Summary

In general, it was more beneficial to plant a Bt cotton variety over a non-Bt variety because there was less damage without treatment in Bollgard II and Bollgard III varieties. No differences were observed between thresholds in Bollgard III. With Bollgard II, there is a benefit to spraying, but the threshold used did not impact the cotton yields. In non-Bt, using the damage threshold seems to be the better option over the egg threshold, but regardless, an insecticide application yielded better than no application. Now, more research needs to be done to determine if the action thresholds for bollworms in cotton could be updated.

Acknowledgements

I would like to thank my advisors, fellow graduate students, summer workers and full time workers for helping me with this project. I would also like to thank Cotton Incorporated, Mississippi State University, and USDA for this opportunity and funding.

References

Bommireddy, P.L., B.R. Leonard, J. Temple, P. Price, K. Emfinger, D. Cook, and J.T. Hardke. 2011. Field Performance and Seasonal Efficacy of Transgenic Cotton Lines Expressing Vip3A and VipCot Against *Helicoverpa zea* (Boddie) and *Heliothis virescens* (F.). J. Cotton Science. 15: 251-259.

Catchot, A., C. Allen, D. Cook, D. Dodds, J. Gore, T. Irby, E. Larson, B. Layton, N. Little, J. MacGown, F. Musser, S. Myers, and C. Speights. 2019. Insect Control Guide for Agronomic Crops. Mississippi State University. Publication 247.

Gore, J., B.R. Leonard, G.E. Church, and D.R. Cook. 2002. Behavior of Bollworm (Lepidoptera: Noctuidae) Larvae on Genetically Engineered Cotton. J. Econ. Entomol. 95(4): 763–769.

Gore, J., B. R. Leonard, R. H. Gable. 2003. Distribution of Bollworm, *Helicoverpa zea* (Boddie), Injured Reproductive Structures on Genetically Engineered *Bacillus thuringiensis* var. *kurstaki* Berliner Cotton. J. Econ. Entomol. 96(3): 699–705.

Gould, F. 1998. Sustainability of transgenic insecticidal cultivars: integrating pest genetics and ecology. Annual Review of Entomology 43: 701-726.

Luttrell, R. G., L. Wan, and K. Knighten. 1999. Variation in Susceptibility of Noctuid (Lepidoptera) Larvae Attacking Cotton and Soybean to Purified Endotoxin Proteins and Commercial Formulations of Bacillus thuringiensis. Journal of Economic Entomology 92: 21-32.