LANDSCAPE LEVEL CONTRIBUTIONS IN MISSISSIPPI CORN FOR *HELICOVERPA ZEA* POPULATIONS

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Abstract

Helicoverpa zea is a major pest of corn, cotton, and soybean and is commonly controlled through the use of foliar applied insecticides or transgenic crops expressing the *Bt* gene. To prevent the selection of resistant populations, refuge systems have been implemented into the agroecosystem. To test the efficacy of these traits and efficiency of various refuge systems on *Helicoverpa zea*, an experiment will be conducted at the Monsanto Learning Center in Scott, Mississippi (2016) and The Delta Research and Extension Center in Stoneville, Mississippi (2017). A field trial containing two refuge blend scenarios and three solid planting scenarios in field corn will be established in the 2016. The trial will be initiated again in 2017, this time adding another RIB treatment. Treatments consist of solid non-*Bt*, Trecepta, and VT Double Pro plantings. The refuge blends to be planted in 2016 are 80:20, and 90:10. These blends will be tested again in 2017 with the addition of 70:30. Plots will be allowed to be naturally infested with *Helicoverpa zea*. After the immature *zea* exit infested ears and enter the soil for pupation, whole corn plants will be removed from the plots. Twenty-five moth emergence traps will be placed within each plot and monitored weekly for adult emergence. This experiment will be replicated four times. All data will be analyzed using SAS 9.4. Additionally, small plot cages will be placed over planting of *Bt* and non-*Bt* soybeans and cotton. Twenty-Five pairs of *H. zea* moths are to be released two times at peak bloom of both crops. Eggs and larvae will be counted in each treatment to determine ovipositional preference and larval survival.

Introduction

Since the commercialization of genetically modified crops, producers have seen reduced dependence on foliar insecticidal applications while improving yield. For example, in cotton, *Bt* crops have successfully controlled species such as tobacco budworm, the pink bollworm, armyworms, and loopers. *Bt* corn controls the borer complex and whorl stage *H. zea* successfully. However, when it comes to the ear stage, controlling the earworm is a more daunting task. During this experiment, three varieties were used to determine *H. zea* adult production from both *Bt* and non-*Bt* field corn. Refuge systems were also integrated to determine efficacy using the "refuge in a bag" (RIB) approach. To determine total contributions of *H. zea* adults, emergence traps were implemented and checked weekly and totaled for adult *H. zea* production. In cotton growing areas, there is a corn refuge requirement of 20% non-*Bt*. RIB is a standard bag of seed, however, a percentage of the bag is filled with non-*Bt* seed, in this case, 20%. The refuge system is based on the idea that in the rare case that a resistant *H. zea* adult emerges from *Bt* corn, it will mate with one of the many susceptible adults from the non-*Bt* refuge, producing a new generation of susceptible offspring. RIB offers the convenience of not having to bulk plant a separate refuge while forcing compliance with the refuge requirement.

Materials and Methods

In 2017 and 2018, field studies were conducted at the Delta Research and Extension Center (DREC), in Stoneville, Mississippi. Three separate traited genotypes of field corn, with and without RIB incorporations, were planted at a rate of 79,040 seeds per hectare. Corn was planted on 101.6 cm rows. The three genotypes, the RIB incorporations, and their incorporated traits are listed in Table 1.

Table 1. Genotypes of corn planted in the 2017 field trial in Stoneville, MS with incorporated trait names.

Trade Names	**Incorporated Traits**
RoundUp Ready II	RRII herbicide resistance trait
VT Double Pro	Cry1A.105, Cry2Ab2
Trecepta	Cry1A.105, Cry2Ab2, VIP3Aa20
Trecepta (70:30) RIB & RoundUp Ready II	Cry1A.105, Cry2Ab2, VIP3Aa20 30% RRII non-*Bt* refuge blend
Trecepta (80:20) RIB & RoundUp Ready II	Cry1A.105, Cry2Ab2, VIP3Aa20 20% RRII non-*Bt* refuge blend
Trecepta (90:10) RIB & RoundUp Ready II	Cry1A.105, Cry2Ab2, VIP3Aa20 10% RRII non-*Bt* refuge blend

The corn was allowed to mature to the silk stage where natural infestations of *H. zea* began. Corn silks were checked for substantial oviposition. Once this had occurred, eggs were allowed to hatch and the larvae were allowed to feed until they began pupation in the soil. Once the larvae had left the ear entered the soil to pupate, corn was cut down and removed from the plot area to make room for emergence traps. Twenty-five emergence traps were placed throughout the entirety of each plot spanning a total of 38.1 sq. meters. Individual trap measurements were 1.5 meters by 1.2 meters. Plastic cups with removable lids were implemented onto the traps to catch *H. zea* adults. Throughout the growing season, adult emergence was quantified by which genotype they had emerged.

Results and Discussion

Adult *H. zea* were counted across the span of four months throughout the summer. At emergence initiation, adult production was substantial but decreased substantially after five weeks of data collection (Figure 1). From the middle of September until the beginning of November, very few adults were collected across any of the technologies (Figure 1). It was a very dry fall season until early November, in which Scott, MS received a rainfall event (Figure 1). Following the rainfall, there was a surge in emergence throughout the month until the trial was concluded at the end of November (Figure 1).

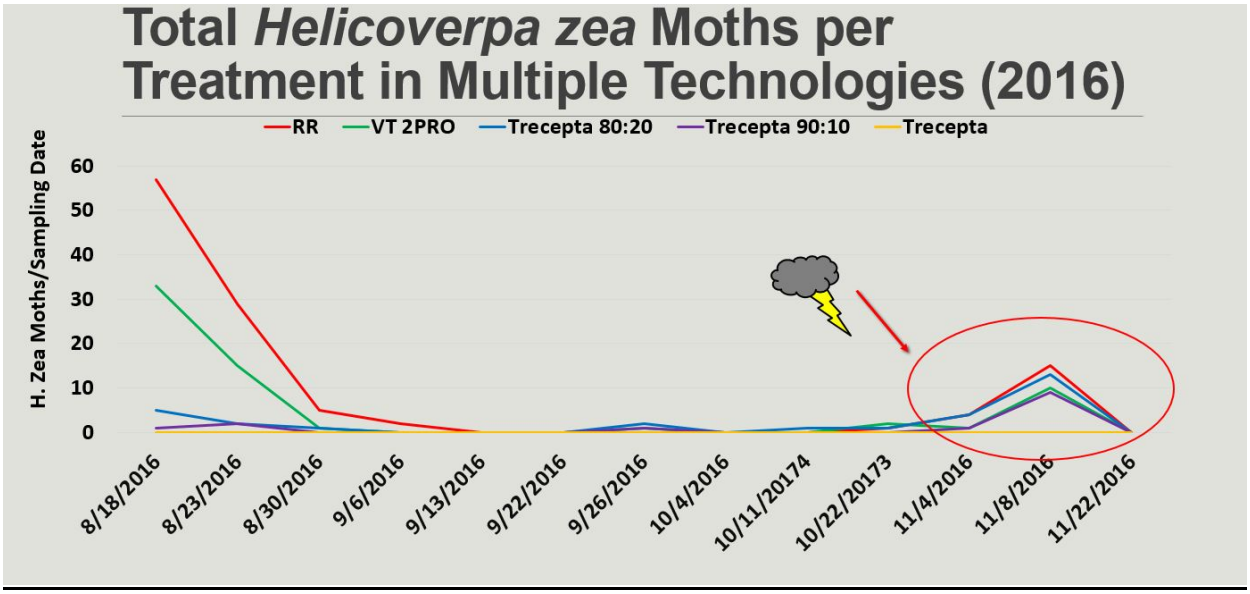

Figure 1. Total *H. zea* adults per treatment across all technologies. (2016)

Data from the 2017 growing season was recorded and is presented below (Figure 2). *H. zea* emergence followed suit as in 2016 with emergence beginning high and leveling out at zero after a few weeks. The number of *H. zea* that emerged this year was much lower than in 2016.

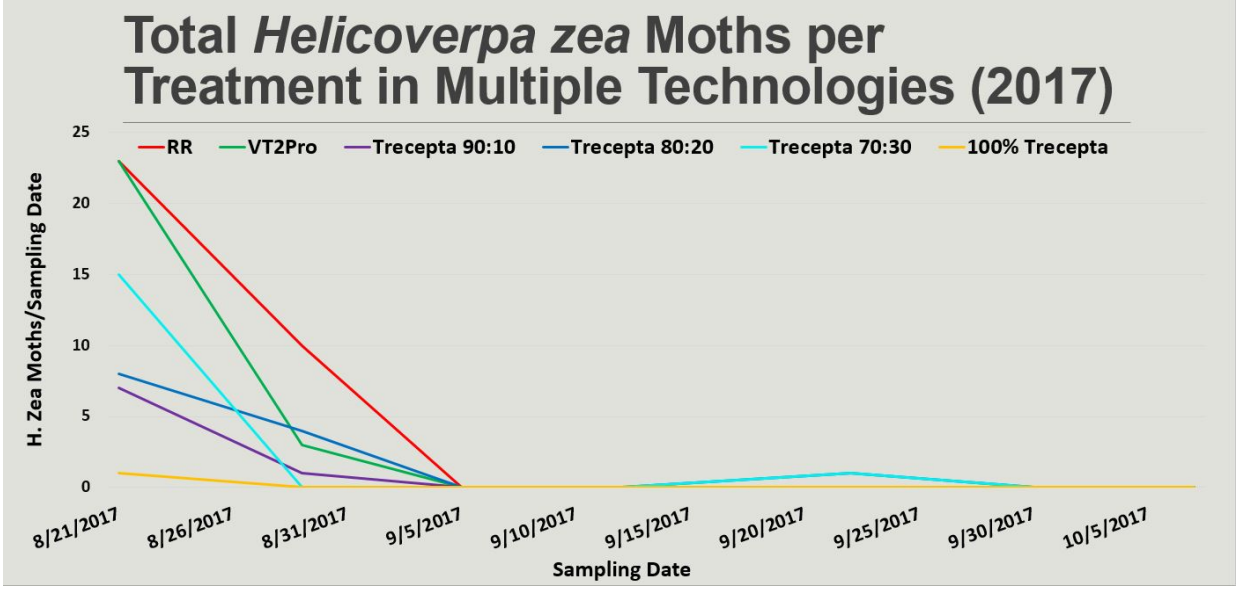

Figure 2. Total *H. zea* adults per treatment across all technologies. (2017)

For total production numbers, the non-*Bt*, RoundUp Ready II corn produced approximately 8,500 adults per hectare (Figure 3). The VT Double Pro produced 45% of the adult *H. zea* that the completely non-*Bt* RoundUp Ready corn produced (Figure 3). Trecepta produced zero adults across all sampling dates (Figure 3). The Trecepta including the 20% RIB blend produced approximately 25% adults of the non-*Bt* RoundUp Ready II corn (Figure 3). While the Trecepta including the 10% RIB blend produced approximately 12% of the adults that the non-*Bt* RoundUp Ready II produced (Figure 3).

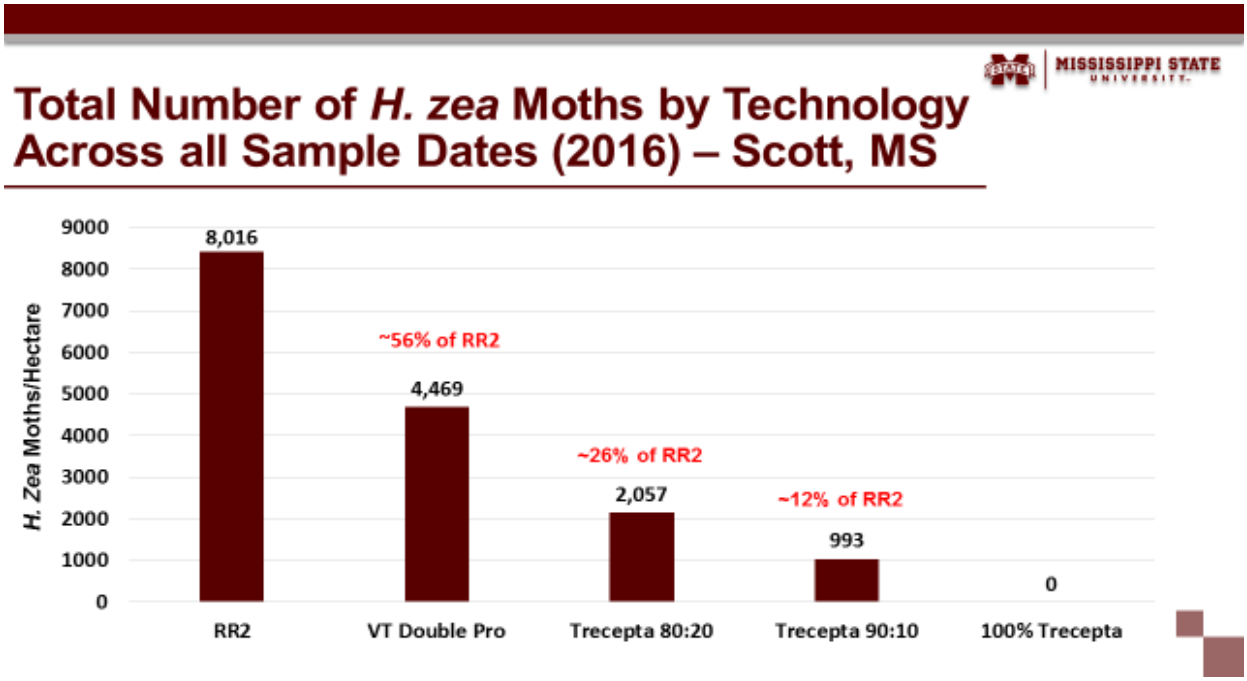

Figure 3. Total number of *H. zea* adults by technology across all sampling dates per hectare. (2016)

In 2017, the total production numbers of non-*Bt*, RoundUp Ready II corn produced approximately 2,500 *H. zea* adults per hectare (Figure 4). The VT Double Pro produced 79% of the adults that the completely non-*Bt* RoundUp Ready corn produced (Figure 4). Trecepta produced 75 moths per hectare which is up from last year (Figure 4). The Trecepta including the 30% RIB blend produced 49% of the adults of the non-*Bt* RoundUp Ready II (Figure 4). The Trecepta including the 20% RIB blend produced approximately 39% of the adults of the non-*Bt* RoundUp Ready II corn (Figure 4). While the Trecepta including the 10% RIB blend produced approximately 24% of the adults that the non-*Bt* RoundUp Ready II produced (Figure 4). All of the RIB treatments continued to produce an acceptable amount of susceptible adult *H. zea*.

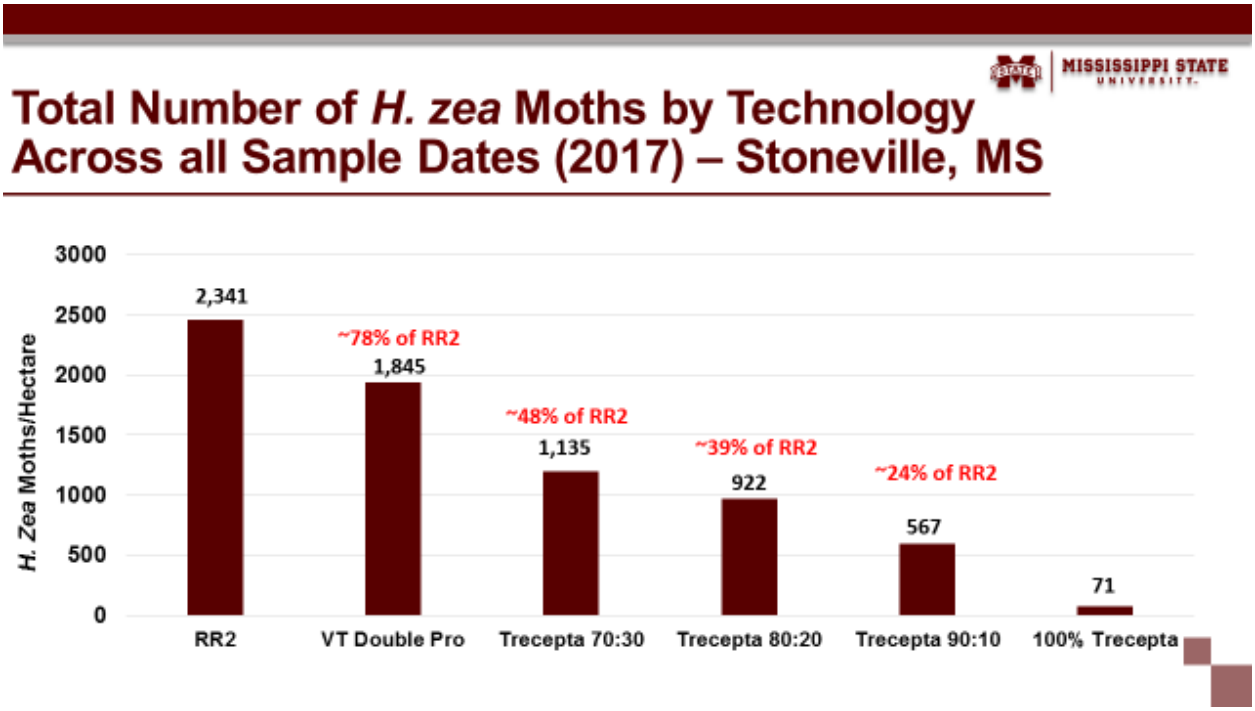

Figure 4. Total number of *H. zea* adults by technology across all sampling dates per hectare. (2017)

In 2018, there was an increase in the amount of *H. zea* adults emerge from the non-*Bt*, RoundUp Ready II corn compared to 2016 & 2017. This could be attributed to the relocation of the trial location to a finer, more suitable soil for pupation to occur. The total production numbers of non-*Bt*, RoundUp Ready II corn produced approximately 13,200 *H. zea* adults per hectare (Figure 5). The VT Double Pro treatment produced 75% of the non-*Bt* RoundUp Ready corn produced. This data is consisted with *H. zea* emergence that was observed in 2017 from the VT Double Pro treatment. The RIB treatments did not produce the expected percentages as they did in 2016 and 2017. The 30%, 20%, and 10% RIB treatments produced 17%, 12%, and 10% respectively. It is unclear as to why emergence was as low as it was in the RIB treatments in 2018. The solid planting of Trecepta did not yield any adult moths.

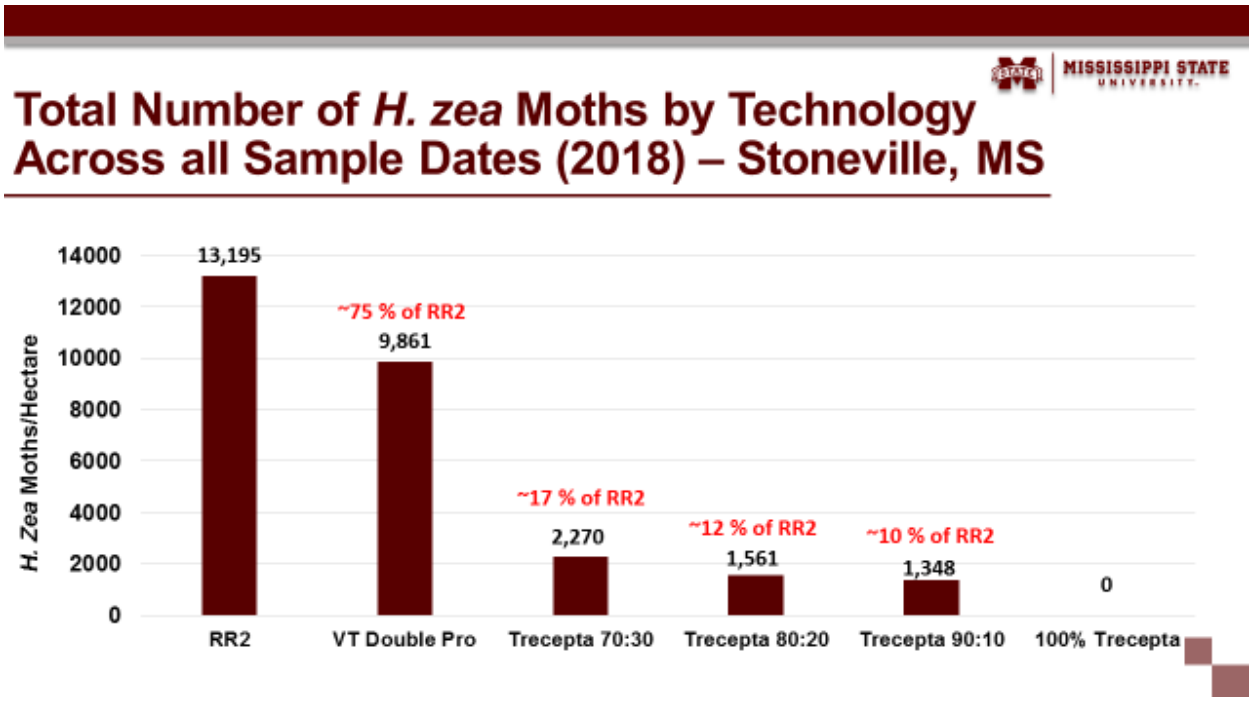

Figure 5. Total number of *H. zea* adults by technology across all sampling dates per hectare. (2018)

Summary

In summary, this experiment provides improved understanding of *H. zea* adult production from the aforementioned corn genotypes. With this data, the efficacy of the RIB refuge strategy approach can be better assessed. The RIB approach is important, not only because it reduces the rate of resistance development, but it forces compliance to the refuge requirements. However, one drawback to RIB is the possibility of cross-pollination of the *Bt* and the non-*Bt* plants. Corn silks that are cross pollinated produce kernels that can express insecticidal properties. In this particular experiment, when it comes to adult *H. zea* production, the data collected in 2016 show that the RIB treatments performed similarly to the equivalent non-*Bt* variety as a percentage of the total non-*Bt* blend. The data that was collected in 2017 show that the RIB treatments performed better than expected. In 2018, data showed that both the 30% RIB and 20% RIB treatments performed less than would be expected at 17% and 12% emergence respectively. The 10% RIB treatment performed at 10% adult emergence. More field work will be completed in 2019 to refine this data and to draw better conclusions. This data can be used to better populate resistance models to evaluate *H. zea* population contributions as well as improve refuge strategies.