LANDSCAPE LEVEL CONTRIBUTIONS IN CORN, COTTON, AND SOYBEAN IN MIXED PRODUCTION SYSTEMS FOR *HELICOVERPA ZEA* POPULATIONS

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Abstract

Helicoverpa zea (Boddie) is a major pest of corn, cotton, and soybean and is commonly managed through the use of foliar applied insecticides or transgenic crops expressing *Bt* genes. 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 *H. zea*, an experiment was conducted in Mississippi during 2016 and 2017. Treatments consisted of solid non-*Bt*, Trecepta, and VT Double Pro plantings along with refuge blends of 70:30, 80:20, and 90:10. Plots were allowed to be naturally infested with *H. zea*. After the larvae exited the ears and entered the soil for pupation, all corn plants were removed from the plots. Twenty-five moth emergence traps were placed within each plot and monitored weekly for adult emergence. All data were analyzed using SAS 9.4. Additionally, small plot cages were placed over plantings of *Bt* and non-*Bt* soybeans and cotton. Twenty-Five pairs of *H. zea* moths were released two times at peak bloom of both crops. Eggs and larvae were counted in each treatment to determine ovipositional preference and larval survival. Significant differences in moth emergence were observed among treatments. In general, the number of moths decreased as the refuge size decreased. The number of moths emerged from the refuges corresponded closely with the refuge size in 2016, but not in 2017. More moths than expected emerged in 2017.

Introduction

Since the commercialization of genetically modified crops, producers have seen reduced dependence on foliar insecticide 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, during the ear stage, corn earworm mortality is significantly decreased. 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, a field study was 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 refuge
Trecepta (80:20) RIB & RoundUp Ready II	Cry1A.105, Cry2Ab2, VIP3Aa20 20% RRII refuge
Trecepta (90:10) RIB & RoundUp Ready II	Cry1A.105, Cry2Ab2, VIP3Aa20 10% RRII refuge

The corn was allowed to mature to the silk stage where natural infestations of *H. zea* began. Corn silks were checked for 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 and entered the soil to pupate, all corn plants were 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 placed 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 greatest but decreased 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).

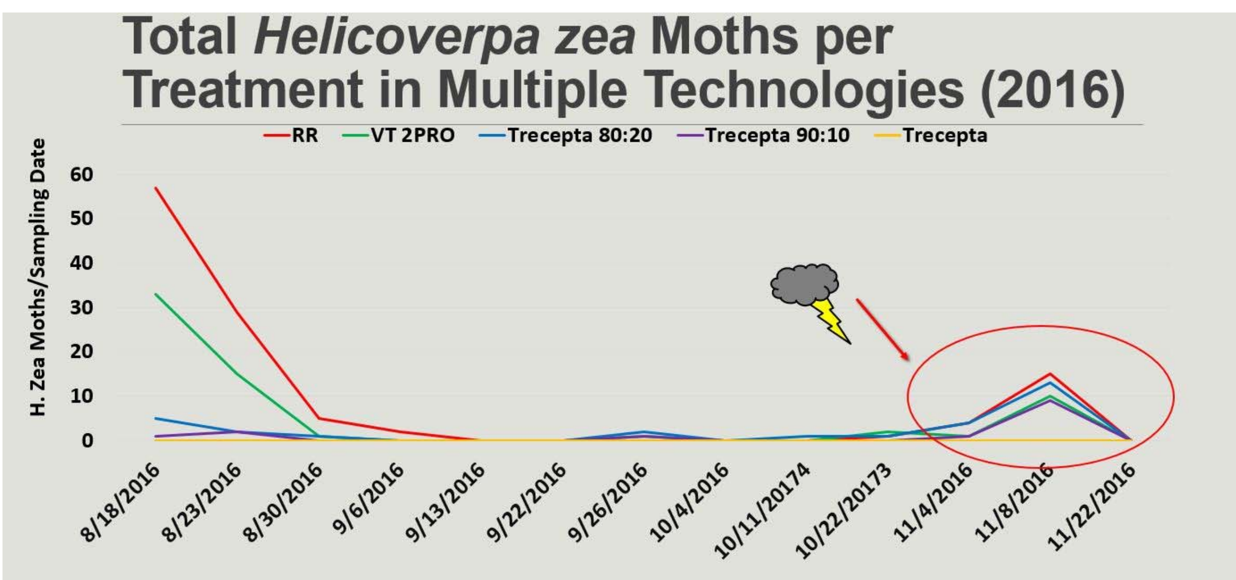

Figure 1. Total *H. zea* adults per treatment across all technologies. (2016)

Data from the 2017 growing season was recorded and is presented below (Figure 2). *H. zea* emergence was similar to that observed 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.

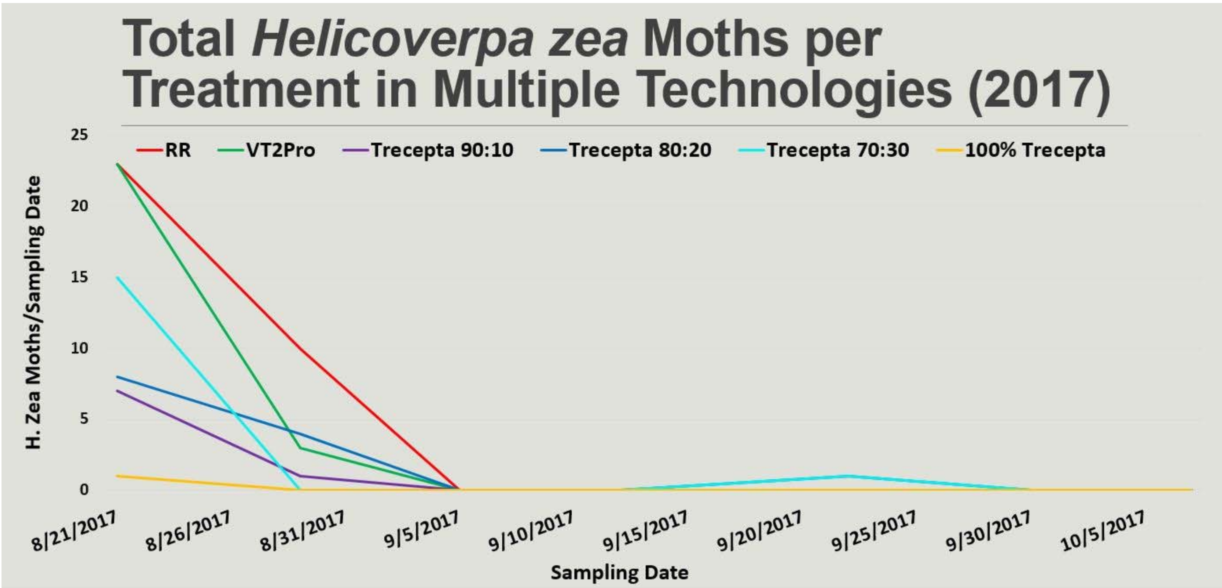

Figure 2. Total *H. zea* adults per treatment across all technologies. (2017).

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). The Trecepta including the 10% RIB blend produced approximately 12% of the adults that the non-*Bt* RoundUp Ready II produced (Figure 3).

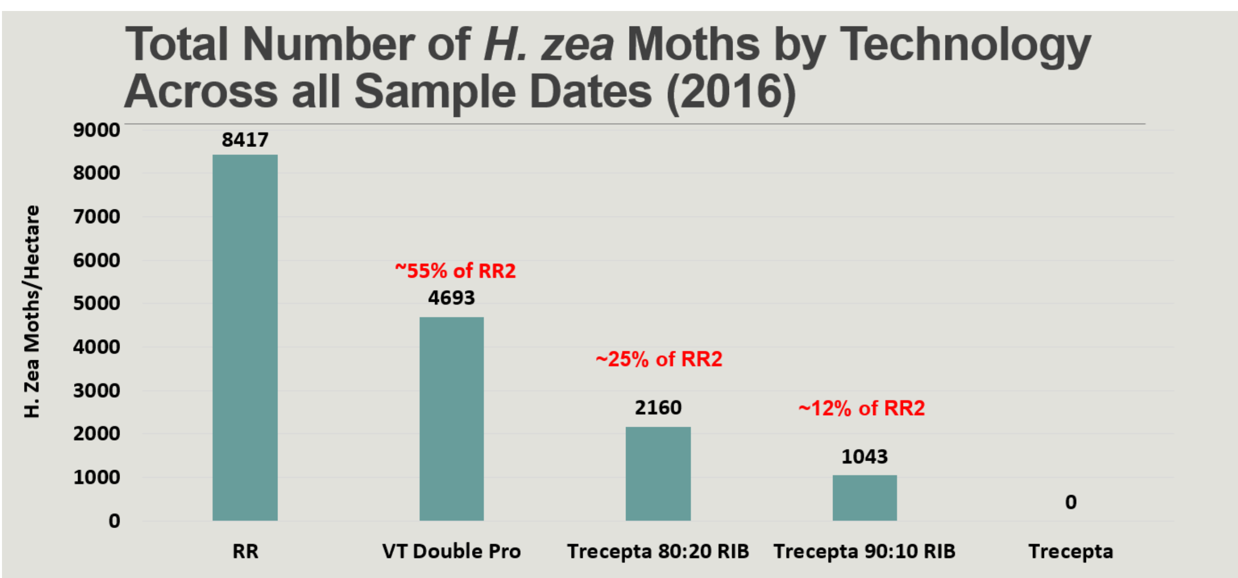

Figure 3. Total number of H. zea adults by technology across all sampling dates per hectare.

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 non-*Bt* RoundUp Ready corn produced (Figure 4). Trecepta produced 75 moths per hectare which was greater than 2017 (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). The Trecepta including the 10% RIB blend produced approximately 24% of the adults that the non-*Bt* RoundUp Ready II produced (Figure 4). All the RIB treatments continued to produce an acceptable amount of susceptible adult *H. zea*.

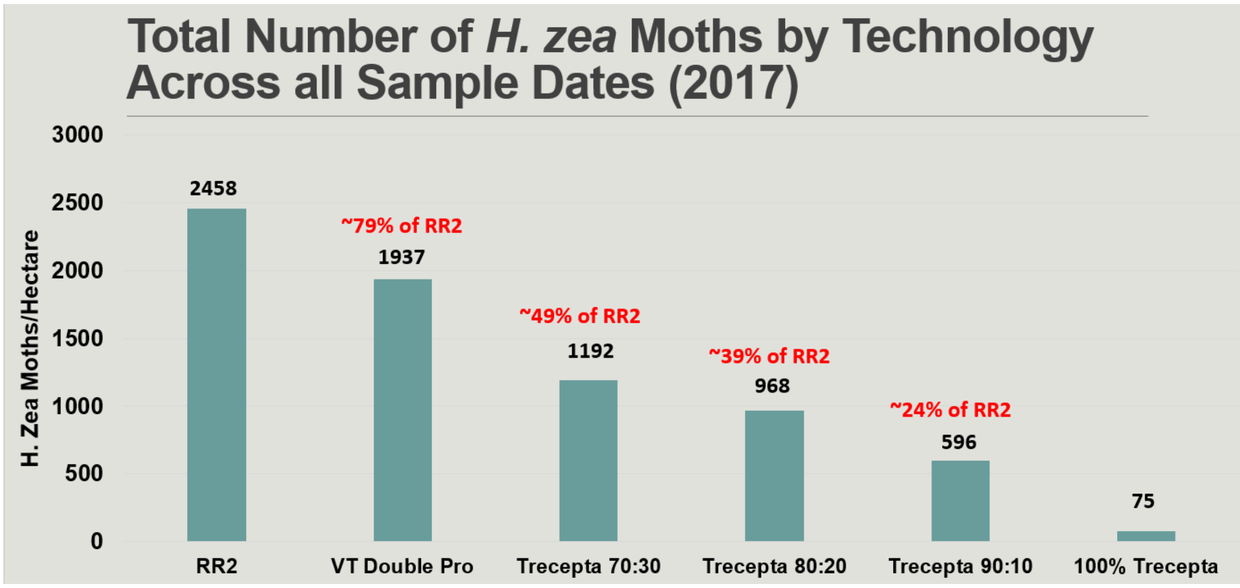

Figure 4. Total number of H. zea adults by technology across all sampling dates per hectare.

Summary

In summary, this experiment provides improved understanding of *H. zea* adult production from the aforementioned corn genotypes. With these 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 shows that the RIB treatments performed similarly to the equivalent non-*Bt* variety as a percentage of the total non-*Bt* blend. The data that were collected in 2017 shows that the RIB treatments performed better than expected. These data can be used to better populate resistance models to evaluate *H. zea* population contributions.