PLANTING DATE AND ITS EFFECT ON MANAGEMENT STRATEGIES IN MISSISSIPPI SOYBEAN

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Abstract

Multiple field experiments were conducted to evaluate the potential of a soybean expressing a Bt protein. In 2013 and 2014, seven planting dates of soybean were planted from late March through mid-July, and chlorantraniliprole was used to simulate Bt soybean. A threshold treatment was also used where plots were only treated when pests reached action thresholds. Only plantings after early June yielded significantly different from the untreated control. Simulated Bt treatment never yielded significantly different from the threshold treatment. In 2015 and 2016, a similar study was conducted with only three late planting dates (early June, mid-June, and mid-July). There was a simulated Bt treatment plus threshold treatment, along with a simulated Bt treatment and threshold treatment. High densities of soybean looper were encountered in all of these planting dates. While the simulated Bt plus threshold treatment did yielded significantly higher than the untreated control at the early June and mid-July plantings, there were no significant differences among treatments at the mid-June planting. This is due to insufficient control of soybean looper with chlorantraniliprole. A statewide evaluation of the potential of Bt soybean was also conducted in 2015 and 2016, at 23 locations. These locations were split equally between the Hills and Delta regions of Mississippi. The simulated Bt significantly out yielded the grower check in these studies.

Introduction

Cotton acreage has decreased over the past ten years in Mississippi (NASS, 2016). With the reduction of the row crop acreage dedicated to cotton, soybean has become the dominate row crop in Mississippi (NASS, 2016). With soybean accounting for approximately sixty percent of acres dedicated to row crop production in Mississippi (NASS, 2016), the planting window of soybean ranges from late March through mid-July. Many insect pests can be yield limiting in soybean throughout the southern U.S., such as corn earworm, *Heliocoverpa zea* (Boddie); soybean looper, *Chrysodexis includens* (Walker); and a complex of stinkbugs (Hemiptera: Pentatomidae) (Carner, et al., 1974, Higley and Boethel, 1994, Baur, et al., 2000, Musser, et al., 2015). These pest usually occur in the highest densities late in the growing season, which leaves late planted soybean most vulnerable to these pests (Carner, et al., 1974, Funderburk, et al., 1999, Baur, et al., 2000). Pests such as soybean looper are known to become resistant to multiple classes of chemistry of insecticides (Felland, et al., 1990, Leonard, et al., 1990, Thomas and Boethel, 1995, Mascarenhas and Boethel, 1997). With the loss of many chemical control options and it is not feasible to plant all the soybean acreage early enough to avoid soybean looper, growers are left needing new options for control. A potential method for control of soybean looper would be soybean expressing a Bt protein. This has been shown to be effective in both Georgia (Walker, et al., 2000, Macrae, et al., 2005, McPherson and MacRae, 2009a, McPherson and Macrae, 2009b) and Illinois (Miklos, et al., 2007). The objective of this study is to evaluate the potential of Bt soybean based on planting date for the Mississippi agricultural landscape.

Materials and Methods

Small Plot Planting Date Study

Field experiments were conducted in 2013 and 2014, in both the Hills region (Starkville, MS) and the Delta region (Stoneville, MS) of Mississippi. Soybean were planted at seven planting dates, spanning from late March through mid-July with approximately fifteen days in between plantings. An indeterminate maturity group IV (Asgrow® 4632, Monsanto Company, St. Louis, MO) and an indeterminate maturity group V (Asgrow® 5332, Monsanto Company, St. Louis, MO) were used. Four treatments were applied to each planting. A simulated Bt treatment was applied using chlorantraniliprole. Chlorantraniliprole was applied preventatively at 20 oz per acre, every two weeks from first flower through first brown pod. The simulated Bt treatment was used to evaluate the value of a soybean expressing a Bt gene across multiple planting dates. A bug only treatment of dimethoate at 16 oz per acre, was applied at the R1, R3, and R5 growth stages. A threshold treatment was also applied, where plots were treated based on action thresholds and with recommended insecticides, from the Mississippi State Insect Control Guide for Agronomic Crops (Catchot, et al., 2016). The fourth treatment consisted of an untreated control, where no insecticides were applied throughout the growing season. Plots were arranged as a split-split-block within a randomized complete block. Plots were sampled weekly from the R1 through R7 growth stages, conducting 25 sweeps per plot with a standard 15 inch diameter sweep net.

Small Plot Late Planting Study

Two field experiments were conducted in 2015 and 2016. The first experiment was a planting date study to further evaluate the potential of Bt soybean. Three planting dates of an indeterminate maturity group V soybean (Asgrow® 5332, Monsanto Company, St. Louis, MO) were planted on 1 June, 15 June, and 1 July. These planting dates were selected based on the field experiments conducted in 2013 and 2014. In 2013 and 2014, these were the only planting dates that reached action thresholds for caterpillar pests. Four treatments were applied, which consisted of the same simulated Bt and threshold treatments that were used in the field experiments conducted in 2013 and 2014. There was also a simulated Bt plus threshold treatment, which had the same preventative applications of chlorantraniliprole from R1 through R7, and was also treated for any insect pests that reached action threshold. The fourth treatment was an untreated control, where no insecticide treatments were applied throughout the growing season. Plots were arranged as a split-block within a randomized complete block design. Plots were sampled weekly from the R1 through the R7 growth stage, conducting 25 sweeps per plot with a standard 15 inch diameter sweep net.

Large Plot Study

Statewide large block studies were conducted throughout the state of Mississippi. These trials were conducted on grower farms, by planting two to three replications of either an indeterminate maturity group IV (Asgrow® 4835, Monsanto Company, St. Louis, MO) or an indeterminate maturity group V (Asgrow® 5335, Monsanto Company, St. Louis, MO) soybean depending on space provided by the grower. These plots were in a randomized complete block design. In 2015 there were eleven locations planted, with eight locations being the maturity group IV variety (3 Delta locations, 5 Hills locations), and three locations being the maturity group V variety (2 Delta locations, 1 Hills location). In 2016 there were 12 locations planted, with 5 locations being the maturity group IV variety (3 Delta locations, 2 Hills locations), and seven locations being the maturity group V variety (2 Delta locations, 5 Hills locations). Plot size varied by location based on growers equipment. Two treatments were applied, which consisted of a grower check and a simulated Bt treatment. The grower check was only treated by the grower as they deemed fit for any pests. When the grower check was treated, the whole test area was treated as well. The simulated Bt treatment used chlorantraniliprole applied preventatively from the R1 through R7 growth stages at 20 oz per acre. Yield was taken using the growers combine, but grain for each replication was weighed independently using a cart equipped with a scale, and moisture samples were taken independently for each replication. Plots were sampled weekly from the R1 through the R7 growth stage, conducting 100 sweeps per plot with a standard 15 inch diameter sweep net. Data for all experiments were analyzed in PROC GLIMMIX (SAS 9.4. SAS Institute, Cary, NC) with an analysis of variance.

Results and Discussion

Small Plot Planting Date Study

There was a significant interaction between treatment and planting date for yield ($df=27, 591$; $F=18.3$; $P<0.01$).Yield decreased for all treatments after the mid-April planting (Table 1). There were no significant differences among treatments inside of a planting date until the mid-May planting (Table 1). The simulated Bt treatment yielded significantly higher than the bug only treatment for the mid-May planting, but was not significantly different from the threshold or untreated control treatments (Table 1). For plantings starting after mid-May the simulated Bt treatment yielded significantly higher than the untreated control (Table 1). At no planting date did the simulated Bt treatment yield significantly different from the threshold treatment, but the simulated Bt did yielded higher than the untreated control in all cases (Table 1). Only at the mid-June and mid-July plantings did the threshold treatment yield significantly different from the untreated control (Table 1). While the simulated Bt treatment did out yield all other treatments at every planting other than the mid-April planting, this was only significant when action threshold levels of soybean looper were present. The early June, mid-June, early July, and mid-July plantings all had high densities of soybean looper.

Table 1: Planting date by treatment interaction for yield (KgHa^{-1}) for the small plot planting date study across both years and all sites.

	Interaction Statistics			Treatment			
Planting Date	**df**	**F-Value**	**P-Value**	**Simulated Bt**	**Threshold**	**Bug Only**	**Untreated Control**
Late March				3515.5(127.4) cd	3477.2(125.7) cde	3524.5(126.6) cd	3384.1(129.3) cdef
Mid-April				4486.1(175.1) a	4454.8(172.9) a	4467.9(179.8) a	4343.6(154.1) ab
Mid-May				4039.7(120.6) bc	3870.1(121.0) cd	3738.7(141.4) def	3815.6(143.8) cde
Early June	27,591	18.3	<0.01	3642.1(109.8) defg	3489.9(102.9) efgh	3434.5(104.6) fgh	3288.3(95.9) hi
Mid-June				3620.9(134.3) defg	3363.3(119.7) gh	3284.9(158.9) hi	3088.0(124.8) ij
Early July				2818.8(115.0) jk	2667.8(114.1) kl	2598.7(117.4) l	2523.3(105.3) l
Mid-July				2231.9(149.7) m	2201.7(167.5) m	2013.8(148.4) mn	1898.0(150.7) n

*Means followed by the same letter do not differ significantly at the 0.05 level of probability.

Small Plot Late Planting Study

There was a significant interaction between planting date and treatment for yield (df=11, 135; F=12.61; P<0.01). Yield for all treatments decreased as planting date was delayed (Table 2). The simulated Bt plus threshold treatment yielded significantly higher than the untreated control at the early June and early July plantings (Table 2). The simulated Bt and the threshold treatments never yielded significantly different from the untreated control (Table 2). There were no significant differences among treatments for the mid-June planting (Table 2). This was due to poor control for chlorantraniliprole for soybean looper (Table 2). For the early June and early July plantings where the simulated Bt plus threshold treatment did yield significantly higher than the untreated control, soybean looper control was adequate (Table 2).

Table 2: Planting date by treatment interaction for yield (KgHa^{-1}) and soybean looper for the small plot late planting study across both years and all sites.

	Interaction Statistics			Treatment			
	Yield						
Planting Date	**df**	**F-Value**	**P-Value**	**Simulated Bt Plus Threshold**	**Simulated Bt**	**Threshold**	**Untreated Control**
Early June				3112.5(167.5) a	2980.7(150.4) ab	2914.6(188.1) ab	2941.6(168.5) b
Mid-June	11, 135	12.61	<0.01	2158.8(174.3) c	2258.1(116.4) c	2297.6(142.4) c	2196.8(146.8) cd
Early July				1939.9(109.6) d	1849.0(126.2) de	1852.6(121.4) de	1713.9(128.6) e
	Soybean Looper						
Early June				6.6(2.0) de	8.9(2.4) cde	16.3(2.8) abc	17.3(3.8) ab
Mid-June	11, 135	3.06	0.02	16.8(4.5) ab	11.8(2.1) abcde	14.0(3.0) abcd	18.3(3.7) a
Early July				6.8(2.1) de	5.1(1.5) e	7.6(2.0) de	10.6(2.6) bcde

*Means followed by the same letter do not differ significantly at the 0.05 level of probability.

Large Plot Study

There was no significant interaction between region and treatment for yield (df=1, 77; F=0.56; *P*=0.46). Treatment (df=1, 77; F=9.05; *P*=<0.01) was significant for yield. The simulated Bt significantly out yielded the grower check (Figure 1). While the overall analysis was significant, only two locations (one delta location, one hills location) were significant for treatment. Over all there was a 64 percent positive yield increase in 2015 and a 58 percent positive yield increase in 2016, with an average of 61 percent positive yield increase across the two years. Throughout the two years of this study the Delta locations averaged approximately one and half insecticide applications and the Hills region averaged one insecticide. These applications were primarily for pest such as soybean looper and the stinkbug complex. In some cases fall armyworm (*Spodoptera frugiperda*) (Smith) were at treatable levels, but this was only at two locations in the Hills region and one location in the Delta region. Even with applications being made based on thresholds for these pests, there was added yield benefits from season long caterpillar control.

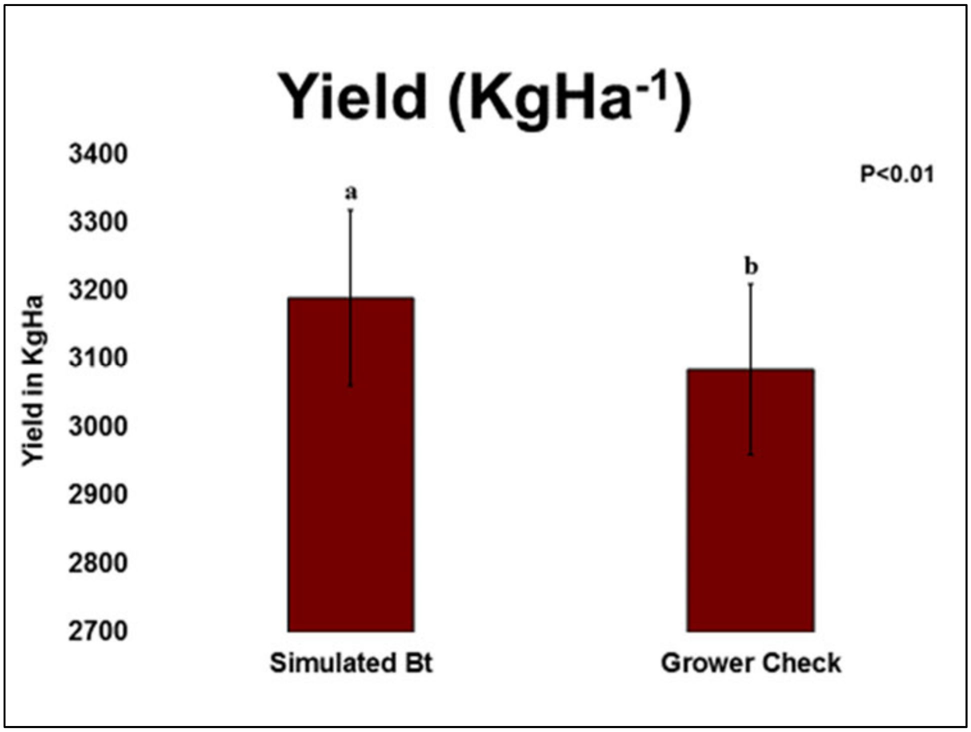

Figure 1. Yield for the large plot study across both years and sites.

Summary

Soybean expressing a Bt protein has high potential in the southern U.S., and has been documented in multiple studies conducted in Georgia (Walker, et al., 2000, Macrae, et al., 2005, McPherson and MacRae, 2009a, McPherson and Macrae, 2009b) as well as in Illinois (Miklos, et al., 2007). In all of these studies, Bt soybean out performed a non-Bt soybean from the same iso-line when defoliating caterpillars were present. With the loss of many control methods for pests such as soybean looper (Felland, et al., 1990, Leonard, et al., 1990, Thomas and Boethel, 1995, Mascarenhas and Boethel, 1997) and the potential loss of the diamide class of chemistry due to resistance, a soybean expressing a Bt protein could potentially give growers another method of control for caterpillar pests. Bt soybean will likely be most beneficial in late planting situations in areas where pests such as soybean looper occur frequently.

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