MISSISSIPPI SOYBEAN PROMOTION BOARD
PROJECT NO. 58-2016 (YEAR 4)
2016 FINAL REPORT

TITLE: Impact of Planting Date and Maturity Group on Management Strategies for Insect Pests in Soybean

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EXECUTIVE SUMMARY

The objectives of studies conducted for this project were to: 1) determine pest complex densities in the Hills and Delta regions of Miss. in early and late planted soybeans in producer fields; 2) evaluate the benefits of season-long control of caterpillars in producer fields in the Hills and Delta regions of Miss. in early and late plantings; 3) evaluate the potential of Bt soybean across multiple planting dates; 4) further evaluate the potential of Bt soybean on the most susceptible planting dates for caterpillar pests; and 5) evaluate findings from small plot studies on large-plot farm studies to determine the value of Bt soybean compared to standard grower practices.

Throughout the small plot studies that were conducted from 2013-2016, the only insect pests that reached action threshold were stink bugs, soybean looper, and bean leaf beetle. Stink bugs reached action threshold more often than soybean looper or bean leaf beetle.

Yield was maximized for plantings made on 20 April. A significant increase in yield of 0.51 bu/acre/day was calculated for plantings made before 20 April. A significant decrease of 0.39 bu/acre/day was calculated for plantings made after 20 April.

Late plantings of soybean were more vulnerable to high populations of insect pests late in the growing season, and generally required 1 to 1.5 insecticide applications.

No insect management strategy significantly affected yield until the mid-May planting.

Yield for all insect management strategies increased from the late March through the mid-April plantings before decreasing through the plantings made in mid-July.

Through the 4 years of evaluating the potential of Bt soybean, it was determined that soybean planted from mid- to late May will benefit the most from Bt soybean.

In all cases except the late-March planting, the simulated Bt insect management strategy had an average of $21.30/acre greater economic returns than the threshold-based insect management strategy.

Keeping soybean caterpillar-free was more profitable than caterpillar pest control using a threshold-based system.

In the absence of caterpillar pests, there was no benefit from Bt soybean.

The simulated Bt soybean insect management strategy never yielded statistically different from the threshold insect management strategy during the 2013-2014 studies. In 2015-2016, there was a decrease in control of soybean looper with the automatic applications of Prevathon to simulate Bt soybean. With increased difficulty to control soybean looper, these results suggest that a Bt soybean could be a useful tool in combating this yield-limiting pest.

BACKGROUND AND OBJECTIVES

Graduate Student PhD Project:

Objective One: Determine pest complex densities in Hills and Delta region in early and late planted soybeans in producer fields.

Activities: Field data currently being collected

Objective Two: Evaluate the benefits of season-long control of caterpillars in producer fields in the Hills and Delta region of Mississippi at an early and late planting date.

Activities: Field data currently being collected

Background

The current soybean planting window in Mississippi spans from early-April through mid-July. There are multiple factors leading to this wide planting window, including harvest management, weather, and other crops needing to be planted. The later soybean is planted, the more susceptible they are to late-season insect damage from pests like stink bugs and soybean looper. Control of pests such as soybean looper with traditional chemical means is becoming increasingly harder; thus, new control tactics need to be evaluated.

Multiple studies were conducted in the Hills (R.R. Foil Research Station, Starkville MS) and Delta (Delta Research and Extension Center, Stoneville MS) regions of Mississippi from 2013-2016. These studies evaluated the effects of planting date and maturity group on insect pest occurrence in soybean. Studies conducted during 2013 and 2014 consisted of seven planting dates spanning from late-March through mid-July spaced approximately two weeks apart.

Two maturity groups—MG IV (Asgrow 4632) and MG V (Asgrow 5332)—were evaluated. Within each planting and maturity group, multiple insect management strategies were implemented. Insect management strategies consisted of a simulated Bt insect management strategy, a threshold insect management strategy, a bug-only insect management strategy, and an untreated insect control (Table 1).

Based on results from studies conducted in 2013 and 2014, a study was conducted to further evaluate the potential of Bt soybean in late plantings in 2015 and 2016. Plantings of MG V Asgrow 5332 soybean were made on 1 June, 15 June, and 1 July. These planting dates were chosen because they were the only plantings to reach action thresholds for caterpillar pests in the 2013-2014 studies.

Insect management regimes similar to those used in the 2013-2014 studies were used. Insect management strategies consisted of simulated Bt plus threshold, simulated Bt, threshold, and an untreated control (Table 1). Studies on 23 soybean producers' fields were also conducted during 2015-2016. These studies were conducted to evaluate the potential of Bt soybean compared to standard grower practices. Three replications of either a MG IV (Asgrow 4835) or MG V (Asgrow 5335) variety were planted at each location. The grower treated the whole field as they deemed necessary, while one strip in each replication simulated Bt soybean (Table 1). All plots were sampled weekly with a sweep net to monitor insect densities.

Objectives

- **Evaluate the potential of Bt soybean across multiple planting dates**
- **Further evaluate the potential of Bt soybean on the most susceptible planting dates for caterpillar pests**
- **Evaluate findings from small plot studies on large-plot farm studies to determine the value of Bt soybean compared to standard grower practices**

PROGRESS

All studies have been completed and final analysis conducted.

Objective 1: Evaluate the potential of Bt soybean across multiple planting dates.

Maturity group never significantly impacted insect densities or yield during the 2013-2014 planting date studies; therefore, data were pooled for all variables across maturity groups.

To evaluate yield potential of soybean based on planting date alone, a piecewise regression analysis was conducted on the threshold treatment alone for the 2013-2014 planting date study. This analysis gives an exact point at which the slope changes. Yield was maximized for plantings made on 20 April (Figure 1). A significant (t=5.13; df=6; P<0.01) increase in yield of 0.51 (±0.09) bu/acre/day was calculated for plantings made before 20 April (Figure 1). A significant (t=-13.86; df=124; P<0.01) decrease of 0.39 (±0.03) bu/acre/day was calculated for plantings made after 20 April (Figure 1).

Throughout the small plot studies conducted from 2013-2016, the only insect pests that reached action threshold were stink bugs, soybean looper, and bean leaf beetle. Stink bugs reached action threshold more often than soybean looper or bean leaf beetle.

The late-March, early-June, mid-June, early-July, and mid-July plantings all experienced action threshold densities of stink bug at both locations (Figure 2). Only one application was needed for sufficient control of stink bug in most cases, although during the 2016 growing season, multiple applications were made at the Delta location for the mid-June and early-July plantings due to high populations of redbanded stink bug.

Soybean looper only reached action threshold for plantings made in early-June, mid-June, and early-July for both locations (Figure 3). In all cases, only one insecticide application was needed for sufficient control. Bean leaf beetle only reached action threshold at the Delta location. The mid-June, early-July, and mid-July plantings were the only plantings with action threshold levels of bean leaf beetles (Figure 4), and only required one application for sufficient control.

A significant interaction (F=17.57; df=27, 591; P<0.01) between planting date and insect management treatment was measured for soybean looper for the planting date studies conducted in 2013-2014. The simulated Bt insect management strategy significantly decreased soybean looper densities at the mid-June, early July, and mid-July plantings compared to all other treatments (Table 2). This significant reduction in soybean looper densities suggests that soybean in this treatment were effectively simulating Bt soybean.

A significant interaction (F=18.3; df=27, 591; P<0.01) between planting date and insect management strategy was also measured for yield in this study. No insect management strategy significantly affected yield until the mid-May planting (Table 2). Yield for all insect management strategies increased from the late March through the mid-April plantings before decreasing through the rest of the plantings (Table 2).

The simulated Bt insect management strategy yielded significantly more than the bug-only insect management strategy in the mid-May planting (Table 2). The simulated Bt insect management strategy yielded significantly more than the untreated insect management strategy at the early June through mid-July plantings (Table 2). The simulated Bt insect management strategy did not yield significantly different from the threshold insect management strategy in any planting (Table 2).

The potential economic returns of Bt soybean compared to a threshold-based insect management strategy was also conducted. The cost for Bt soybean was determined to be $13/acre (Table 3). The cost for soybean looper, stink bug, and bean leaf beetle control were determined to be $18, $10, and $12, respectively, per application (Table 3). In all cases except the late-March planting, the simulated Bt insect management strategy had greater economic returns than the threshold-based insect management strategy, with an average of $21.30/acre greater return (Table 4).

Objective 2: Further evaluate the potential of Bt soybean on the most susceptible planting dates for caterpillar pests

A significant interaction (F=3.06; df=11,135; P<0.01) between insect management strategy and planting date was measured for soybean looper in the planting date studies conducted in 2015 and 2016. The simulated Bt plus threshold and the simulated Bt treatment significantly decreased soybean looper densities in the early June planting only (Table 5).

The simulated Bt and simulated Bt plus threshold treatments were highly variable in controlling soybean looper, and did not effectively simulate Bt soybean (Table 5). This lack of simulation was also measured for yield (Table 5).

There was a significant interaction (F=12.61; df=11, 135; P<0.01) between insect management strategy and planting date for yield in this study (Table 3). The simulated Bt plus threshold treatment yielded significantly more than the untreated insect management strategy in the early-June and early-July plantings (Table 5). No other treatments yielded significantly different from one another at any planting (Table 5).

Objective 3: Evaluate findings from small plot studies on large plot on farm studies to determine the value of Bt soybean compared to standard growing practices

All insect pests were recorded for studies conducted in 2015 and 2016 on grower fields, but significant relationships with insect management strategies were only measured for soybean looper. A significant interaction (F=8.49; df=1, 90; P<0.01) between region and insect management strategy was measured for soybean looper (Figure 5). More soybean looper were observed in the Hills region than in the Delta region for the grower check insect management strategy (Figure 5).

There was no significant interaction between region and insect management strategy for yield (F=0.56; df=1, 77; P<0.01). The effect of both region (F=5.28; df=1, 77; P<0.01) and insect management strategy (F=9.05; df=1, 77; P<0.01) was significant for yield. The soybean planting at the Delta locations (57.8±4.0 bu/acre) yielded significantly more than plantings at the Hills locations (45.1±3.8 bu/a). This is most likely due to increased management that occurs with irrigation, fertility, and pest management practices in the Delta region compared to the Hills region.

The simulated Bt insect management strategy resulted in significantly greater soybean yields than the grower check insect management strategy (Figure 6). Throughout the 2 years of this study, soybeans at the Delta locations required an average of about one and one-half insecticide applications compared to the average one application at the Hills locations. These applications were primarily for pests such as soybean looper and the stink bug complex. Even with applications being made based on thresholds for multiple pest species, additional yield benefits were measured from season-long caterpillar control.

IMPACTS AND BENEFITS TO MISSISSIPPI SOYBEAN PRODUCERS

This project will help growers make planting date decisions that will benefit their insect pest management. It was observed that late plantings of soybean were more vulnerable to high populations of insect pests late in the growing season. The main focus of this project was to determine when and where a Bt soybean will fit in the Mississippi agricultural landscape. Through the 4 years of evaluating the potential of Bt soybean, it was determined that soybean planted from mid- to late May will benefit the most from Bt soybean. It was also observed that keeping soybean caterpillar-free was more profitable than control using a threshold-based system. It was also observed that, in the absence of caterpillar pests, there was no benefit from Bt soybean.

The simulated Bt soybean insect management strategy never yielded statistically different from the threshold insect management strategy during the 2013-2014 studies. In 2015-2016, there was a decrease in control of soybean looper with the automatic applications of Prevathon to simulate Bt soybean. With increased difficulty to control soybean looper, these data suggest that a Bt soybean could be a useful tool in combating this yield-limiting pest.

END PRODUCTS

These results have been presented over 50 times at local, state, national, and international conferences. One publication covering the agronomics of soybean based on planting date has been accepted to Crop, Forage, and Turf Grass Management. Another six publications are currently being prepared for submission to Journal of Economic Entomology and Environmental Entomology. These data will be presented to companies before Bt soybean come to the US market to help determine the price point for Bt soybean.

Table 1. Insect management strategy descriptions for small plot studies conducted in Mississippi to evaluate the potential of Bt soybean—2013 to 2016.

Insect Management Strategy	Application Description
	2013-2014 Planting Date Study
Simulated Bt	Automatic applications of Prevathon at 20 oz/acre every 2 weeks during reproductive growth stages
Threshold	Insecticide applications were made for any insect pest exceeding action threshold based on Mississippi State recommendations
Bug Only	Automatic applications of Dimethoate at 16 oz/acre at the R1, R3, and R5 growth stages
Untreated	No Insecticide applications were made
	2015-2016 Late Planting Study
Simulated Bt	Automatic applications of Prevathon at 20 oz/acre every 2 weeks during reproductive growth stages
Threshold	Insecticide applications were made for any insect pest exceeding action threshold based on Mississippi State recommendations
Simulated Bt + Threshold	A combination of the simulated Bt and threshold treatments
Untreated	No Insecticide applications were made

Table 2. Impact of insect management strategies and planting date on soybean looper and yield for planting date studies conducted in 2013 and 2014 in Mississippi.

Planting Date	Interaction Statistics			Insect Management Strategy			
	***F*-Value**	**df**	***P*-Value**	**Simulated Bt**	**Threshold**	**Bug Only**	**Untreated**
				Soybean Looper[1]			
Late March				0.1(0.1) gh	1.1(0.5) gh	1.3(0.4) gh	0.8(0.4) gh
Mid-April				0.3(0.1) h	1.2(0.3) h	0.9(0.2) h	1.1(0.3) h
Mid-May				0.4(0.2) h	3.3(0.9) gh	3.2(1.0) gh	2.7(0.8) gh
Early June	17.57	27, 591	<0.01	1.8(0.9) gh	8.3(1.8) fg	11.2(2.0) ef	7.7(1.0) fg
Mid-June				2.2(0.6) gh	18.2(3.5) cd	15.5(2.1) de	19.8(3.9) bcd
Early July				2.5(0.8) gh	25.3(3.9) b	34.7(5.4) a	25.9(4.0) b
Mid-July				2.0(0.6) h	21.2(3.4) bcd	24.1(4.8) bc	19.6(3.5) cd
				Yield (bu/a)			
Late March				56.0(2.0) cd	55.4(2.0) cde	56.1(2.0) cd	53.9(2.1) cdef
Mid-April				71.5(2.8) a	71.0(2.0) a	71.2(2.9) a	69.2(2.5) ab
Mid-May				64.4(1.9) bc	61.7(1.9) cd	59.6(2.3) def	60.8(2.3) cde
Early June	18.30	27, 591	<0.01	58.0(1.7) defg	55.6(1.6) efgh	54.7(1.7) fgh	52.4(1.5) hi
Mid-June				57.7(2.1) defg	53.6(1.9) gh	52.3(2.5) hi	49.2(2.0) ij
Early July				44.9(1.8) jk	42.5(1.8) kl	41.4(1.9) l	40.2(1.7) l
Mid-July				35.6(2.4) m	35.1(2.7) m	32.1(2.4) mn	30.2(2.4) n

[1] Values based on seasonal means (±SEM) per 25 sweeps.
Means with same letters are not significantly different from one another.

Table 3. Number of threshold applications made and the price for one insecticide application for studies conducted in 2013 and 2014 in Mississippi to simulate Bt soybean for the threshold insect management strategy.

	Insect Pest Targeted		
Planting Date	**Soybean Looper**	**Stink Bugs**	**Bean Leaf Beetles**
Late March	---	1	---
Mid-April	---	---	---
Mid-May	---	---	---
Early June	1	1	---
Mid-June	2	2	1
Early July	2	2	1
Mid-July	---	2	3
Cost Per Application	$18	$10	$12

Table 4. Potential economic returns for the simulated Bt and threshold insect management strategies compared to the untreated insect management strategy for studies conducted in Mississippi in 2013 and 2014

	Insect Management Strategy		
Planting Date	**Simulated Bt**	**Threshold**	**Difference**
Late March	$4.40	$5.70	$-1.30
Mid-April	$9.70	$17.70	$9.70
Mid-May	$18.40	$0.10	$18.40
Early June	$43.40	$25.10	$18.30
Mid-June	$71.90	$26.90	$45.00
Early July	$34.10	$6.00	$28.10
Mid-July	$37.90	$29.80	$8.10
Average	$31.40	$10.10	$21.30

Table 5. Impact of insect management strategies and planting date on soybean looper and yield for planting date studies conducted in 2015 and 2016 in Mississippi.

Planting Date	Interaction Statistics			Insect management Strategy			
	F-Value	df	P-Value	Simulated Bt + Threshold	Simulated Bt	Threshold	Untreated
				Soybean Looper[1]			
Early-June				6.6(2.0) de	8.9(2.4) cde	16.3(2.8) abc	17.3(3.8) ab
Mid-June	3.06	11, 135	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
				Yield			
Early-June				49.6(2.7) a	47.5(2.4) ab	46.4(3.0) ab	46.9(2.7) b
Mid-June	12.61	11, 135	<0.01	34.4(2.8) c	36.0(1.9) c	36.6(2.3) c	35.0(2.3) cd
Early-July				30.9(1.7) d	29.5(2.0) de	29.5(1.9) de	27.3(2.0) e

[1] Values based on seasonal means (±SEM) per 25 sweeps

Means with same letters are not significantly different from one another

Figure 1. Piecewise regression for yield across multiple planting dates of soybean in Mississippi. 20 April is the breakpoint at which the slope changes from positive to negative for yield.

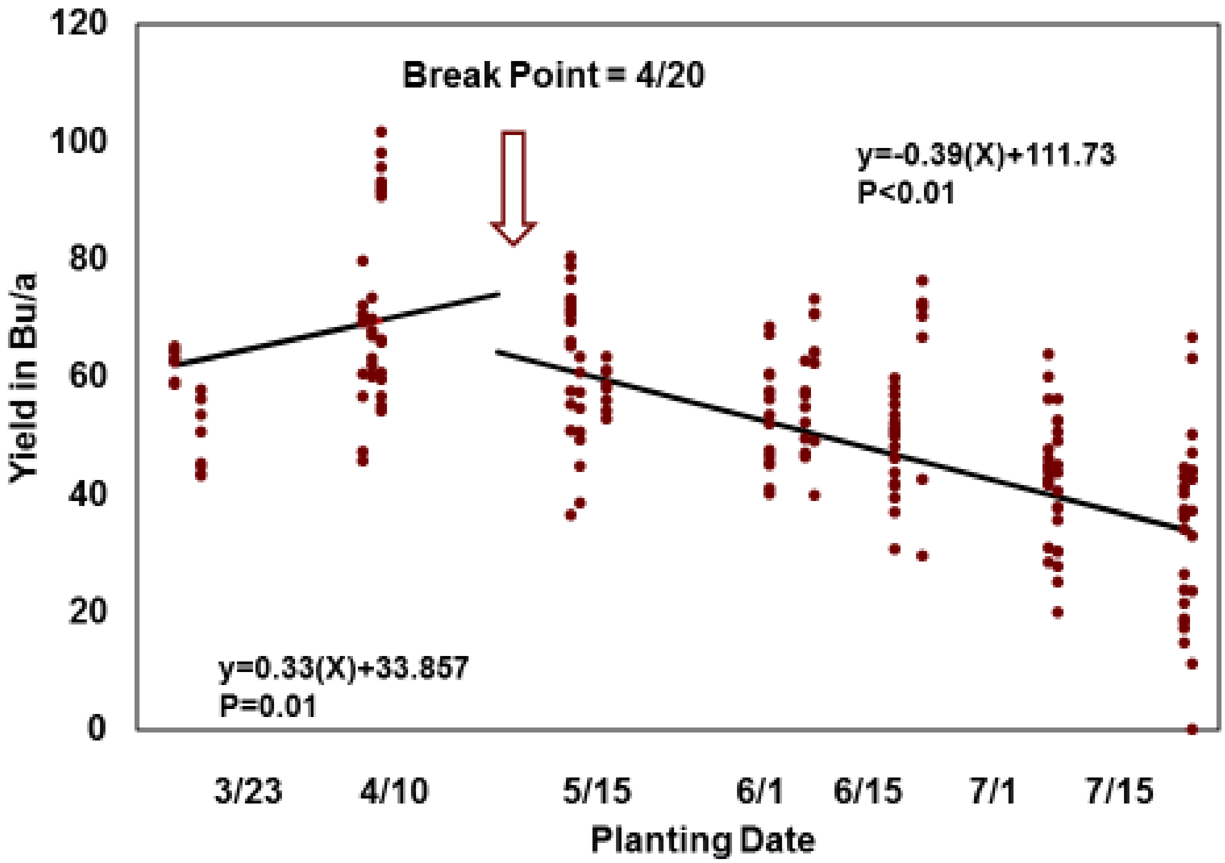

Figure 2. Positive detections and over-threshold detections of stink bugs for planting date studies conducted in Mississippi.

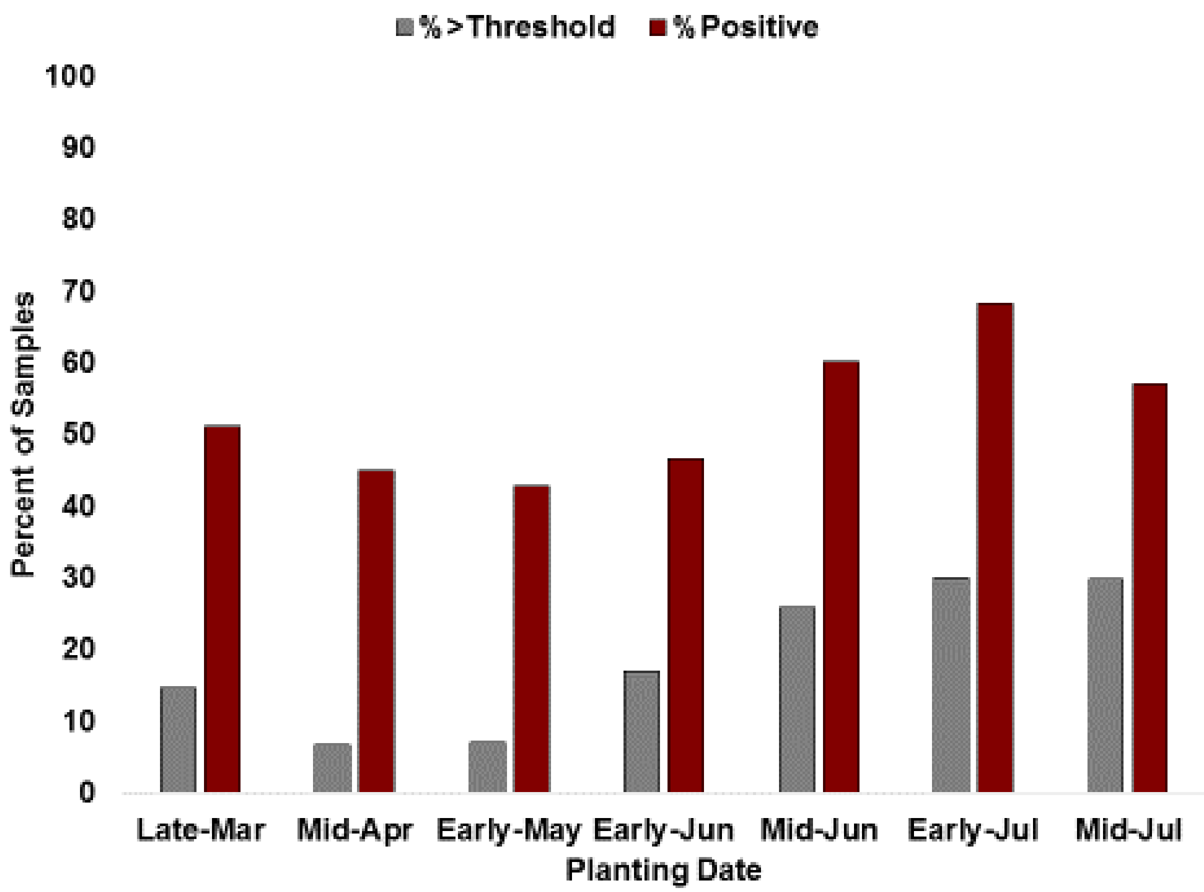

Figure 3. Positive detections and over-threshold detections of soybean looper for planting date studies conducted in Mississippi.

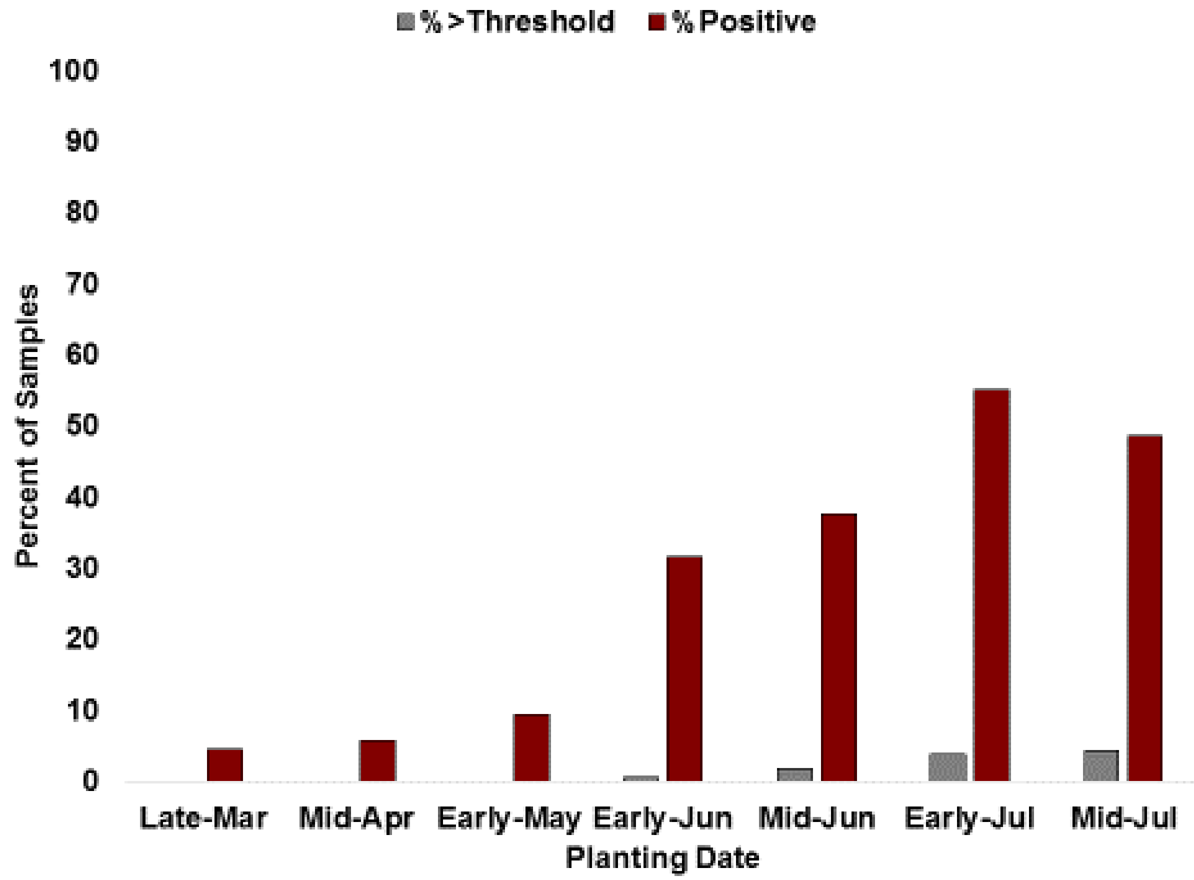

Figure 4. Positive detections and over-threshold detections of bean leaf beetle for planting date studies conducted in Mississippi.

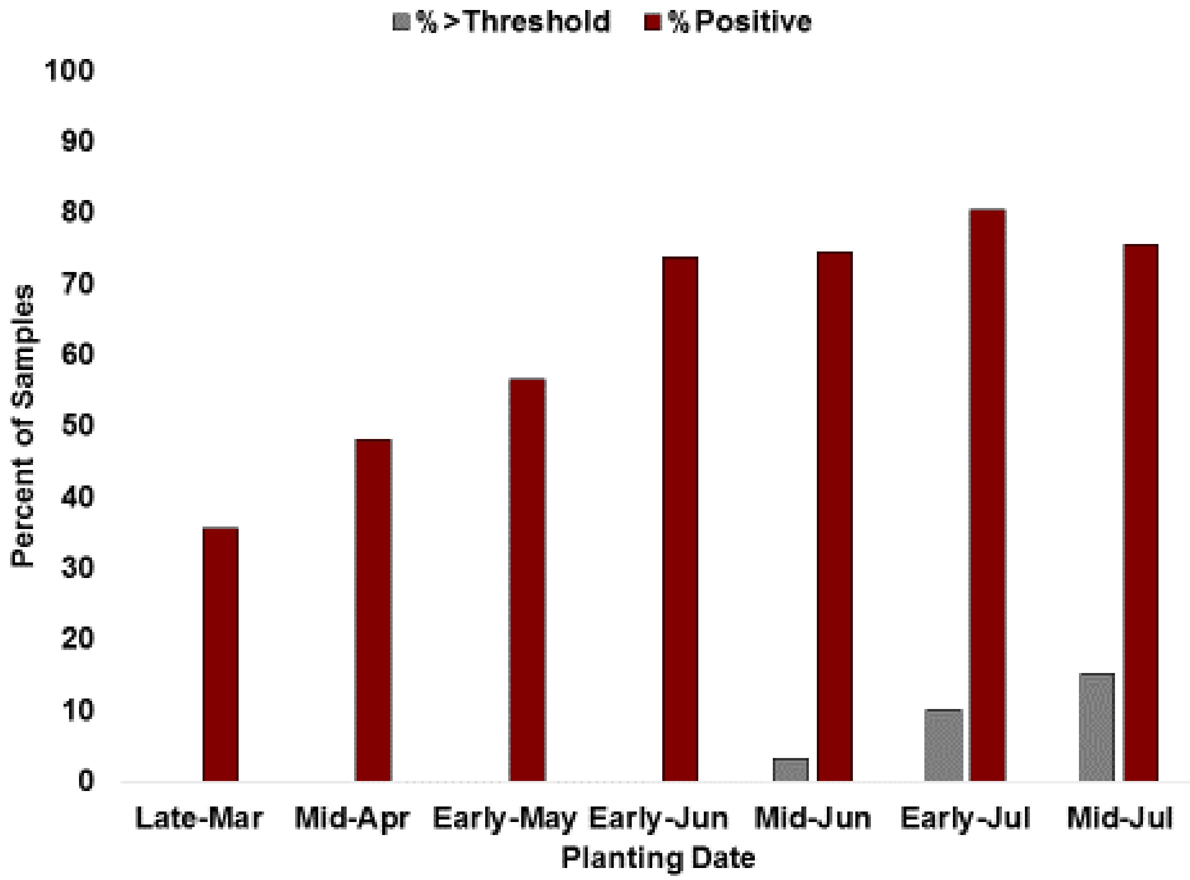

Figure 5. Impact of insect management strategy and region on soybean looper in studies conducted on grower fields throughout Mississippi.

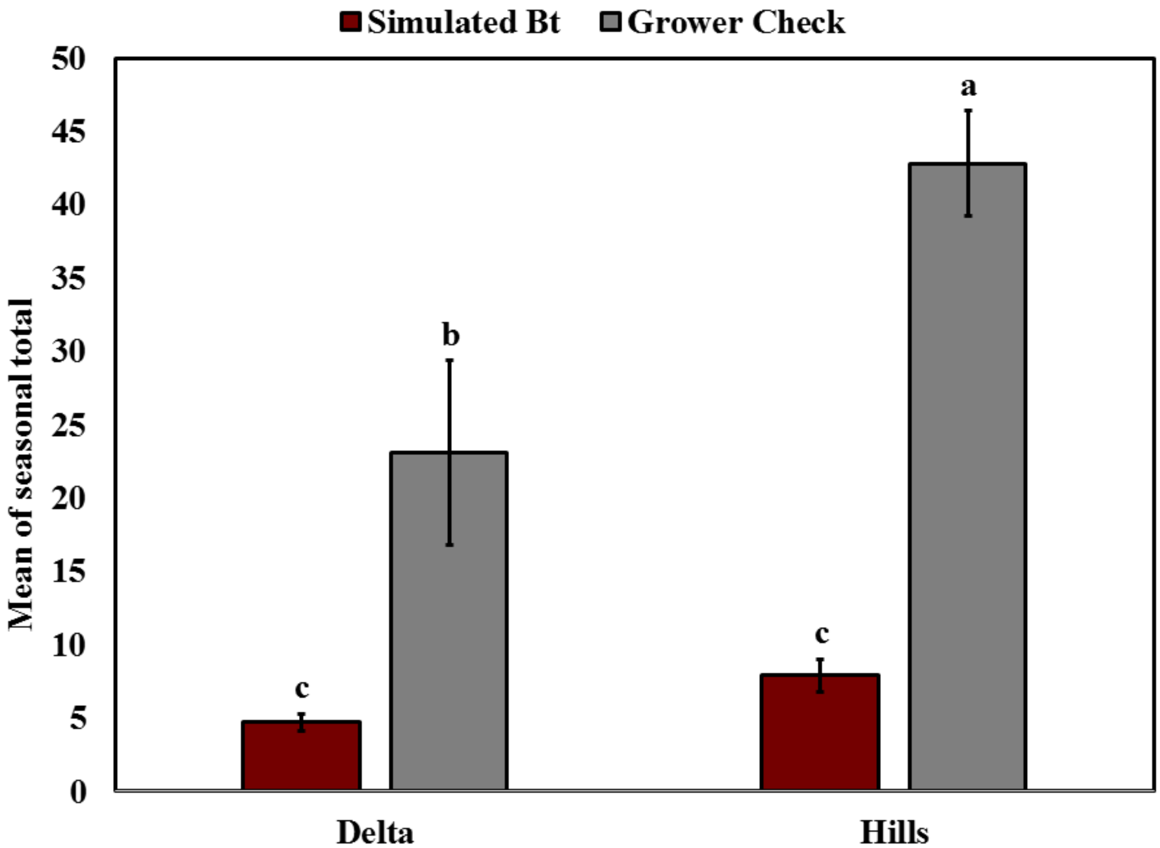

Figure 6. Impact of insect management strategy on yield in studies conducted on grower fields throughout Mississippi.