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Title: Evaluation of Alternative Management Tactics for Early Season Insect Pests of Soybeans and Impact of Seed Treatments on Stand Establishment and Replant Prevention

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BACKGROUND AND OBJECTIVES

Prior to the introduction of the neonicotinoid seed treatments, there was very little, if any, use of at-planting insecticides in Mississippi soybean production. Most of the products that were available required an in-furrow application (granular or liquid), with acephate being the exception.

Neonicotinoid insecticides are used in soybean production as foliar applications and as seed treatments, which represents most, if not all, of the insecticide seed treatment usage in Mississippi soybean production since 2007. The use of neonicotinoid seed treatments has steadily increased since their introduction, with the most current estimate (2014) of 90% adoption by Mississippi soybean growers. These are an important tool for managing early season pests that can impact yield and stand establishment. Yield responses to neonicotinoid seed treatments in Mississippi have averaged 2.5 bu/acre with a positive economic benefit in ca. 70% of the studies.

The early soybean production system has many advantages; however, with early planting the chances of less than optimal conditions for plant growth are higher than at later planting dates. Slower plant growth can result in greater susceptibility to insect injury or result in larger impacts from insect injury than would be observed on more vigorous plants. With increased input costs for soybeans, especially at-planting costs including seed, replanting is a major economic decision for growers. The consensus among growers, consultants, and entomologists is that the use of these products has reduced the risk of having to replant in many situations through reduced stand loss. However, the impact and value of reduced replant risks has been difficult to quantity.

The U.S. Environmental Protection Agency issued a preliminary report during 2014 stating that neonicotinoid seed treatments provided no benefits to soybean production. Data from the mid-Southern states has been published that shows a positive economic benefit when neonicotinoid insecticide seed treatments have been used in Midsouth soybean production. In spite of this demonstrated benefit and other research findings that indicate that neonicotinoid insecticides applied as seed treatments to soybeans are not present in soybean floral structures, the use of neonicotinoid insecticides could be restricted or prohibited in the future.

Currently growers have very few, if any, alternatives to neonicotinoid seed treatments if the uses of these products are restricted or prohibited. The loss of these products, assuming no replacements, would result in a ca. $30,000,000 loss to Mississippi soybean growers based on 90% seed treatment adoption on 2.33 million acres (2015 estimate), $6.56/acre seed treatment costs, and $8.50/bu soybean selling price. Preliminary studies conducted during 2015 indicated that several treatments including bifenthrin, chlorantraniliprole, and cyantraniliprole performed equal to a neonicotinoid seed treatment.

Objectives.

- To evaluate at-planting insecticides as possible alternatives to neonicotinoid seed treatments.
- To evaluate the impact of neonicotinoid seed treatments on stand establishment and estimate the value of seed treatments with regard to minimizing risk of having to replant.

.REPORT OF PROGRESS/ACTIVITY

Objective 1.

Three studies were conducted to evaluate non-neonicotinoid at-planting insecticide use on soybeans. In the first study, insect infestations were low and no significant differences among treatments were observed for plant density at 26 days after emergence (DAE) or yield (Table 1). In the second study, all of the insecticide treatments resulted in significantly greater plant density at 26 DAE compared to the non-treated control (Table 2). All of the non-neonicotinoid insecticides, except Dermacor at 0.25 mg ai/seed and acephate, resulted in similar plant density compared to the neonicotinoid insecticide Gaucho. Although the non-treated plots had lower plant density, these plants were able to compensate and no significant differences in yield were observed. In the third study, all of the insecticide treatments except Sivanto (4.0 oz/acre) resulted in significantly greater plant density at 26 DAE compared to the non-treated control (Table 3). All of the non-neonicotinoid insecticides, except acephate and Sivanto, resulted in similar plant density compared to the neonicotinoid insecticide Gaucho. No significant differences in yield were observed, but there were trends for higher yields with the use of an at-planting insecticide.

Objective 2.

One study was conducted to evaluate the impact of neonicotinoid seed treatments on soybean stand establishment and their role in minimizing the risk of having to replant. This study included five planting dates (early Apr, mid Apr, early May, mid May, and early Jun) and two levels of insecticide seed treatment (Gaucho 1.6 fl oz/cwt plus Apron Maxx RFC and Apron Maxx RFC alone). Another factor in the study was early-season plant population to simulate early-season plant loss and included two early-season plant population targets (optimal 129,000 seed-plants/acre and sub-optimal 77,000 seed-plants/acre). Based on conversations with soybean agronomists, 77,000 plants/acre would be in the range in which the decision to replant would be difficult for growers. All plots were planted at a rate of 129,000 seed/acre. For the 77,000 seed-plants/acre (sub-optimal target) plots, the equivalent number of Roundup Ready soybean seed (Asgrow 4632) for a seeding rate of 77,000 seed/acre was blended with the equivalent of 52,000 Liberty Link soybean seed/acre to yield a total seeding rate of 129,000 seed/acre. At the V1 growth stage, plots were treated with glyphosate to eliminate the Liberty Link soybean plants to simulate plant loss from early-season insect pests and other factors that can reduce plant density.

An additional factor was included within the sub-optimal plant population target, and included keeping the sub-optimal plant population or destroying the current stand and replanting at the optimal planting rate. To accomplish this, plots designated for replanting were treated with paraquat at V3 growth stage to destroy existing soybeans and were replanted at a seeding rate of 129,000 seed/acre. The V3 stage was chosen because it is generally when maximum damage (plant loss) from early-season and soil insect infestations is visually detectable based upon observations from other experiments and grower fields. The glyphosate application timing (V1) was chosen so that death of the Liberty Link plants would occur by the V3 growth stage.

In this study, substantial insect damage (primarily southern corn rootworm) was observed in several of the plantings. For soybean with optimal initial plant density, the insecticide- plus fungicide-treated plots had significantly greater plant density at the V3 growth stage than the fungicide-treated plots for the 6 Apr and 21 Apr plantings (Table 4). Substantial seedling mortality was observed for all plantings with the most severe observed in the 11 May planting. There were no significant differences among insecticide treatments for plant density at R7 for any of the plantings, except the 11 May planting.

Significant differences in yield were observed among insecticide treatments for two of the plantings, with trends observed in a third. Plots planted with insecticide- and fungicide-treated seed produced significantly more yield than plots planted with fungicide-treated seed for the 21 Apr and 6 Jun plantings. For soybean with suboptimal initial plant density, replanting with insecticide- and fungicide-treated seed resulted in significantly higher plant density at the V3 growth stage compared to keeping the original stand (with or without an insecticide seed treatment) for two of the plantings (Table 5). Replanting, regardless of seed treatment, resulted in significantly higher plant density compared to keeping the original stand for three of the plantings. Similar results were observed for plant density at the R7 growth stage.

The use of an insecticide plus fungicide seed treatment resulted in significantly higher yields compared to a fungicide-only seed treatment when the original stand was kept for three of the five plantings. For the first planting, replanting with insecticide- plus fungicide-treated seed or fungicide-only treated seed resulted in significantly higher yields compared to keeping the original stand that received a fungicide seed treatment. When an insecticide plus fungicide seed treatment was used with the initial planting, no yield benefit of replanting was observed.

For the second and fifth plantings, keeping the original stand that received an insecticide plus fungicide seed treatment resulted in significantly higher yields than keeping the original stand that received a fungicide-only seed treatment, or replanting (regardless of seed treatment). For the third planting, early-season plant loss in the original plantings was severe and replanting with insecticide- plus fungicide-treated seed resulted in significantly higher yields compared to keeping the original stand regardless of seed treatment (15 - 27 bushel per acre difference). Replanting with fungicide-treated seed did not result in significantly greater yield compared to keeping the original stand that received an insecticide seed treatment.

Although replanting resulted in greater plant density at the V3 and R7 growth stages, keeping stands as low as ca. 41,000 plants/acre at V3 regardless of planting date resulted in similar or greater yields compared to replanting. There was only one instance (third planting, plant density <15,000 plants/acre) where replanting resulted in significantly higher yields compared to keeping the original stand that received an insecticide seed treatment. In this case plant densities for the original plantings were very low regardless of insecticide seed treatment. This planting experienced considerable insect infestations and the Gaucho seed treatment rate used in this study was the lowest labeled rate (1.6 oz/cwt seed) which is commonly used. This rate may not be sufficient to manage severe insect infestations.

Impacts and Benefits to Mississippi Soybean Producers

Results from these studies demonstrate the unpredictability of early-season/soil insect infestations. These studies also demonstrate the value of at-planting insecticide treatments as risk management tools, because there are no reactive/rescue treatments for many early-season/soil insect pests.

Substantial insect infestations were observed in the planting date - replant trial, and the data demonstrate that management strategies to avoid replanting are in the best interest of the grower. Retaining stands as low as 41,000 plants/acre at the V3 growth stage resulted in similar or greater yield as replanting. Having to replant results not only in higher costs for seed and the extra equipment operations, but depending on planting date, may also result in reduced yields (from lower yield potential associated with later planting dates) and gross returns.

End Products–Completed or Forthcoming

- 2017 Mississippi State Row Crop Short Course. Dec 4-6, 2017. Starkville, MS.
- Results were also presented at >20 grower meetings throughout the state of Mississippi during the winter/spring of 2017-2018.

Table 1. Impact of seed treatment alternatives to neonicotinoids on soybean stand establishment and yield, 1.

Treatment/Form.	Rate	Plant Density 26 DAE[4]	Yield (bu/acre)
Fungicide Only	-	97,193	61.2
Gaucho 600FS[5]	1.6[1]	92,456	62.4
Acephate 90S[6]	8.0[1]	92,701	60.0
Dermacor 5.21FS[7]	0.25[3]	102,257	58.8
Dermacor 5.21FS[7]	0.5[3]	86,576	63.7
Gaucho 600FS[5] + Dermacor 5.21FS[7]	1.6[1] + 0.25[3]	96,458	61.0
Verimark 1.67SC[8]	0.25[3]	94,988	59.9
Verimark 1.67SC[8]	0.5[3]	93,681	61.3
Gaucho 600FS[5] + Verimark 1.67SC[8]	1.6[1] + 0.25[3]	101,522	60.5
P>F		0.49	0.64

Means within columns followed by a common letter are not significantly different (FPLD *P>F* 0.05).
[1] fluid oz product/cwt seed.
[2] oz product (wt.)/cwt seed.
[3] mg ai/seed.
[4] Days after emergence.
[5] Active ingredient – Imidacloprid, Class - Neonicotinoid.
[6] Active ingredient – Acephate, Class - Organophosphate.
[7] Active ingredient – Chlorantraniliprole, Class - Diamide.
[8] Active ingredient – Cyantraniliprole, Class - Diamide.

Table 2. Impact of seed treatment alternatives to neonicotinoids on soybean stand establishment and yield, 2.

Treatment/Form.	Rate	Application Method	Plant Density 26 DAE[5]	Yield (bu/acre)
Fungicide Only	-	ST[6]	50,965e	45.3
Gaucho 600FS[8]	1.6[1]	ST[6]	109,036ab	44.0
Acephate 90S[9]	8.0[2]	ST[6]	88,699d	48.2
Dermacor 5.21FS[10]	0.25[3]	ST[6]	94,090cd	46.4
Dermacor 5.21FS[10]	0.5[3]	ST[6]	98,173bcd	47.6
Gaucho 600FS[8] + Dermacor 5.21FS[10]	1.6[1] + 0.25[3]	ST[6] ST[6]	96,213bcd	48.3
Verimark 1.67SC[11]	0.25[3]	ST[6]	100,787bcd	48.8
Verimark 1.67SC[11]	0.5[3]	ST[6]	96,703bcd	49.1
Gaucho 600FS[8] + Verimark 1.67SC[11]	1.6[1] + 0.25[3]	ST[6] ST[6]	96,948bcd	42.0
Brigade 2EC[12]	2.6[4]	IFS[7]	104,707abc	51.9
Brigade 2EC[12] + Prevathon 0.43SC[10]	2.6[4] + 7.0[4]	IFS[7] IFS[7]	116,959a	49.2
P>F			<0.01	0.26

Means within columns followed by a common letter are not significantly different (FPLD *P>F* 0.05).

[1]fluid oz product/cwt seed.

[2]oz product (wt.)/cwt seed.

[3]mg ai/seed.

[4]fluid oz product/acre

[5]Days after emergence.

[6]Seed Treatment.

[7]In-Furrow Spray.

[8]Active ingredient – Imidacloprid, Class - Neonicotinoid.

[9]Active ingredient – Acephate, Class - Organophosphate.

[10]Active ingredient – Chlorantraniliprole, Class - Diamide.

[11]Active ingredient – Cyantraniliprole, Class - Diamide.

[12]Active ingredient – Bifenthrin, Class - Pyrethroid.

Table 3. Impact of seed treatment alternatives to neonicotinoids on soybean stand establishment and yield, 3.

Treatment/Form.	Rate	Application Method	Plant Density 26 DAE[4]	Yield (bu/acre)
Fungicide Only	-	ST[5]	53,007e	47.7
Gaucho 600FS[7]	1.6[1]	ST[5]	96,295ab	55.0
Acephate 90S[8]	17.8[2]	IFS[6]	78,490cd	49.4
Brigade 2EC[9]	2.6[3]	IFS[6]	98,337ab	58.0
Prevathon 0.43SC[10]	14.0[3]	IFS[6]	90,823bc	51.9
Prevathon 0.43SC[10]	20.0[3]	IFS[6]	102,175ab	54.6
Acephate 90S[8] + Prevathon 0.43SC[10]	13.3[3] + 14.0[3]	IFS[6] IFS[6]	91,231bc	51.2
Verimark 1.67SC[11]	6.7[3]	IFS[6]	106,668ab	50.9
Verimark 1.67SC[11]	13.5[3]	IFS[6]	109,363a	52.9
Sivanto 1.67SC[12]	4.0[3]	IFS[6]	66,728de	50.2
Sivanto 1.67SC[12]	7.0[3]	IFS[7]	72,282d	56.9
P>F			<0.01	0.20

Means within columns followed by a common letter are not significantly different (FPLD $P>F$ 0.05).
[1]fluid oz product/cwt seed.
[2]oz product (wt.)/acre.
[3]fluid oz product/acre
[4]Days after emergence.
[5]Seed Treatment.
[6]In-Furrow Spray.
[7]Active ingredient – Imidacloprid, Class - Neonicotinoid.
[8]Active ingredient – Acephate, Class - Organophosphate.
[9]Active ingredient – Bifenthrin, Class - Pyrethroid.
[10]Active ingredient – Chlorantraniliprole, Class - Diamide.
[11]Active ingredient – Cyantraniliprole, Class - Diamide.
[12]Active ingredient – Flupyradifurone, Class - Butenolide.

Table 4. Impact of seed treatments on soybean plant density and yield with optimal initial plant density at different planting dates.

Planting Date	At Planting Insecticide	Plant Density V3	Plant Density Harvest	Yield (bu/acre)
6 Apr	Non-Treated	46,432b	36,795	52.2
6 Apr	Gaucho	67,504a	46,228	54.2
P>F		0.04	0.09	0.60
21 Apr	Non-Treated	47,657b	38,673	60.3b
21 Apr	Gaucho	71,261a	49,699	68.6a
P>F		0.04	0.14	0.04
11 May	Non-Treated	12,292	10,005b	25.3
11 May	Gaucho	21,154	19,929a	44.7
P>F		0.17	0.05	0.08
26 May	Non-Treated	46,636	37,979	48.8
26 May	Gaucho	51,251	39,327	50.3
P>F		0.46	0.40	0.48
6 Jun	Non-Treated	58,602	45,085	46.3b
6 Jun	Gaucho	63,298	41,042	49.3a
P>F		0.12	0.09	0.04

Means within columns within planting dates followed by a common letter are not significantly different (FPLD *P>F* 0.05).

Table 5. Impact of seed treatments on soybean plant density and yield with suboptimal initial plant density at different planting dates.

Planting Date	At Planting Insecticide	Replant	Plant Density / acre V3	Plant Density / acre R7	Yield (bu/acre)
6 Apr	Non-Treated	No	33,283b	27,770c	48.9c
6 Apr	Gaucho	No	43,329b	32,915b	56.2ab
Replant 16 May	Non-Treated	Yes	35,651b	37,448b	54.7b
Replant 16 May	Gaucho	Yes	58,724a	54,926a	60.4a
P>F			<0.01	<0.01	<0.01
21 Apr	Non-Treated	No	32,057c	26,299c	58.7b
21 Apr	Gaucho	No	47,657b	36,141b	63.8a
Replant 26 May	Non-Treated	Yes	65,217a	55,907a	55.8b
Replant 26 May	Gaucho	Yes	70,118a	62,441a	56.2b
P>F			<0.01	<0.01	0.02
11 May	Non-Treated	No	12,619b	11,353b	23.1c
11 May	Gaucho	No	14,865b	13,599b	35.1bc
Replant 9 Jun	Non-Treated	Yes	69,587a	51,700a	46.9ab
Replant 9 Jun	Gaucho	Yes	74,569a	57,622a	50.1a
P>F			<0.01	<0.01	0.01
26 May	Non-Treated	No	38,551b	30,383b	47.9
26 May	Gaucho	No	41,409b	34,304b	48.8
Replant 20 Jun	Non-Treated	Yes	53,701b	48,637ab	38.4
Replant 20 Jun	Gaucho	Yes	82,818a	65,789a	44.9
P>F			<0.01	0.01	0.11
6 Jun	Non-Treated	No	33,732b	25,687b	38.6b
6 Jun	Gaucho	No	42,348b	36,059b	45.8a
Replant 5 Jul	Non-Treated	Yes	88,005a	83,268a	39.5b
Replant Jul	Gaucho	Yes	96,417a	80,736a	40.8b
P>F			<0.01	<0.01	0.02

Means within columns within planting dates followed by a common letter are not significantly different (FPLD *P>F* 0.05).