MISSISSIPPI SOYBEAN PROMOTION BOARD
PROJECT 01-2018 (YEAR 3)
2018 FINAL REPORT

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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EXECUTIVE SUMMARY

Prior to the introduction of 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). 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 insect pests that can impact stand establishment and yield. 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.

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.

With early planting of soybeans, the chances of less than optimal conditions for plant emergence and growth are higher than for later plantings. 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 with reduced stand loss. However, the impact and value of reduced replant risks has been difficult to quantity.

Studies were conducted in 2016-2018 to 1) evaluate at-planting insecticides as possible alternatives to neonicotinoid seed treatments, and 2) 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. Objectives and major findings from these studies follow.

Objective 1. To evaluate at-planting insecticides as possible alternatives to neonicotinoid seed treatments.

Trials were planted 6 May 2016, 21 Apr 2017, 2 May 2017, and 1 May 2018. All seed were treated with the fungicide ApronMaxx RFC.

In a study where insecticides were applied primarily as seed treatments, all of the insecticide treatments except acephate (organophosphate) resulted in significantly greater plant density (at least 70% of the seeding rate) compared to the fungicide-only control (48% of the seeding rate) at the V3 growth stage. Stand densities in these treatments were near or slightly above 80,000 plants/acre. There were no significant differences among treatments for yield.

In a study where insecticides were applied primarily as in-furrow sprays, insecticides in all classes (neonicotinoid, organophosphate, pyrethroid, and diamide) resulted in greater stands at V3 than did the fungicide-only control. Gaucho (neonicotinoid), Brigade (pyrethroid), and Verimark (diamide) insecticide treatments resulted in the greatest plant densities. All of the insecticide treatments except Prevathon (diamide) resulted in greater yield than the fungicide-only control. Plots treated with Brigade (pyrethroid) produced greater yield than plots treated with any of the other insecticides except Gaucho (neonicotinoid).

Objective 2. 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.

Planting dates were early- and mid-April, early- and mid-May, and early June. Seed treatments were Gaucho (neonicotinoid insecticide) + ApronMaxx (fungicide) and ApronMaxx alone. Two early-season plant populations of 129,000 seed-plants/acre (optimal) and 77,000 seeds-plants/acre (sub-optimal) were imposed. The 77,000 seeds-plants/acre is a density that would likely trigger the decision to replant.

In the studies with optimal initial plant density, the insecticide + fungicide seed treatment resulted in greater plant densities at the V3 stage and at harvest than did the fungicide-only seed treatment in the April plantings. Yield was also greater from this treatment in the April plantings. In the May and June plantings, the Gaucho insecticide seed treatment did not significantly affect either plant density at V3 or seed yield.

In the studies with sub-optimal initial plant density, replanting with both fungicide-only treated seed and insecticide- plus fungicide-treated seed resulted in greater plant densities at V3 and V7 compared to the original planting with fungicide-only treated seed in plantings made in mid-April and beyond. Replanting resulted in greater yields compared to retaining the original stand for the late May planting only, while the opposite was observed for the early June planting. The lack of benefit from replanting for the early June planting is likely due to lower yield potential for the replanted plots due to planting date (replant date early July).

- Results from these studies demonstrate the unpredictability of early season/soil insect infestations.
- These studies 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.
- Based on results from these studies, Bifenthrin applied in-furrow appears to be a viable

alternative to neonicotinoid insecticides; however, many growers do not have the capability for in-furrow applications at planting.

- These results demonstrate that management strategies to avoid replanting are in the best interest of the grower. However, replant decisions are not simple. The magnitude of plant loss (number of remaining plants), timing (date the replant decision has to be made), and possibly weather conditions during the remainder of the growing season will determine the economic viability of replanting. Having to replant results not only in higher costs from the extra equipment operations and seed costs, but depending on planting date, may also result in reduced yields (from lower yield potential associated with later planting dates) and gross returns.
- Thus, the use of fungicide + insecticide seed treatments should be considered a risk management tool to avoid losses associated with sub-optimal stands that may result in costly replanting and/or lower yields.

BACKGROUND AND OBJECTIVES

Prior to the introduction of 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 represent 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 stand establishment and yield.

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 being encountered 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 with 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 have been published that demonstrate a positive economic benefit for the use of neonicotinoid insecticide seed treatments in Mid-South 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.

Two studies were conducted during 2016 to 2018 to evaluate non-neonicotinoid at-planting insecticides. In one study insecticides were applied primarily as seed treatments. A randomized complete block design with four replications was used. Plot size was four 40-in.-wide rows that were 40 ft. long. Soybean variety Asgrow 4835 was used during 2016, and Asgrow 4362 was used during 2017 and 2018. All seed were treated with Apron Maxx RFC fungicide at a rate of 1.5 oz. product per cwt. The seeding rate for all trials was 117,612 seeds per acre. Trials were planted 6 May 2016, 21 Apr 2017, 2 May 2017, and 1 May 2018. Plant density was determined by counting all plants within a randomly selected 10-ft.-long section of the center two rows of each plot at 7 to 10 DAE (days after emergence) (VC) and 19 to 21 DAE (V3). At the first sampling the randomly selected sections were flagged so that the subsequent sample could be collected from the same area. Plots were harvested with a small plot combine and yield was corrected to 13% seed moisture content. Data were subjected to analysis of variance procedures and means separated according to Fisher's Protected LSD.

At the VC and V3 growth stage, all of the insecticide treatments except acephate (organophosphate) resulted in significantly greater plant density compared to the fungicide-treated control (**Table 1**). There were no significant differences among treatments for yield.

A second study was conducted where insecticides were applied primarily as in-furrow sprays. A randomized complete block design with four replications was used. Plot size was four 40-in.-wide rows that were 40 ft. long. Soybean variety Asgrow 4835 was used during 2016, and Asgrow 4362 was used during 2017 and 2018. All seed were treated with Apron Maxx RFC fungicide at a rate of 1.5 oz. product per cwt. The seeding rate for all trials was 117,612 seed per acre. Trials were planted 7 May 2016, 21 Apr 2017, and 1 May 2018. In-furrow spray treatments were applied with a CO_2-charged spray system through 2501 nozzles (1/row) mounted in front of the press wheels. The spray tips were turned to spray across the furrow and calibrated to deliver 5 gpa total volume. Plant density was determined by counting all plants within a randomly selected 10 ft.-long section of row of rows two and three of each plot at 7 to 10 DAE (days after emergence) (VC) and 20 to 22 DAE (V3). At the first sampling the randomly selected sections were flagged so that the subsequent sample could be collected from the same area. Plots were harvested with a small plot combine and yield was corrected to 13% seed moisture content. Data were subjected to analysis of variance procedures and means separated according to Fisher's Protected LSD.

At the VC growth stage, Gaucho (neonicotinoid), Acephate (organophosphate), Brigade (pyrethroid), Acephate (organophosphate) plus Prevathon (diamide), and Verimark (diamide) resulted in greater plant density than the fungicide-treated control (**Table 2**). Also, plots treated with Gaucho (neonicotinoid) or Brigade (pyrethroid) had greater plant density than plots treated with Acephate (organophosphate) or Acephate (organophosphate) plus Prevathon (diamide). At the V3 growth stage, Gaucho (neonicotinoid), Acephate (organophosphate), Brigade (pyrethroid), Acephate (organophosphate) plus Prevathon (diamide), and Verimark (diamide) resulted in greater plant density than the fungicide-treated control. Also, plots treated with Brigade (pyrethroid) had greater plant density than plots treated with Acephate (organophosphate) or Acephate (organophosphate) plus Prevathon (diamide). All of the insecticide treatments except Prevathon (diamide) resulted in greater yield than the fungicide-treated control. Also, plots treated with Brigade (pyrethroid) had greater yield than plots treated with any of the other insecticides except Gaucho (neonicotinoid).

Objective 2.

Studies were conducted during 2016 to 2018 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 April, mid-April, early May, mid-May, and early June) each year. Two levels of insecticide seed treatment (Gaucho 1.6 fl oz/cwt plus Apron Maxx RFC and Apron Maxx RFC alone) were also included. 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 seeds/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 seeds/acre was blended with the equivalent of 52,000 Liberty Link soybean seeds/acre to yield a total seeding rate of 129,000 seeds/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 seeds per 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. Plant density was determined at V3 and R7 by counting all plants on the center two rows of each plot. Plots were harvested by planting date when plots within a planting date had reached a harvestable grain moisture with a small plot combine. Grain yield was correct to 13% seed moisture content. Data for optimal and suboptimal initial plant densities were analyzed separately and by planting date. Data were subjected to analysis of variance procedures and means separated according to Fisher's Protected LSD.

In this study substantial insect damage (primarily southern corn rootworm) was observed in several of the plantings during 2017 and 2018. For soybean with optimal initial plant density, the insecticide-plus fungicide-treated plots had significantly greater plant density at the V3 growth stage and at harvest than the fungicide-treated plots for the early April and mid-April plantings (**Table 3**). Significant differences in yield were observed among insecticide treatments for the mid-April planting with a similar trend observed for the early April planting. For soybean with suboptimal initial plant density, replanting with insecticide- plus fungicide-treated seed resulted in greater plant density at V3 compared to the original planting with fungicide-treated seed at the mid-April planting (**Table 4**). For the mid-May, late May, and early-June plantings, replanting resulted in significantly higher plant density at the V3 growth stage compared to keeping the original stand (with or without an insecticide seed treatment). At the R7 growth stage, retaining the initial planting that received an insecticide plus fungicide seed treatment resulted in greater plant density than retaining the initial planting that received only the fungicide seed treatment for the mid April planting. Replanting resulted in similar plant density to that of the initial planting with an insecticide seed treatment. For the mid-May planting, replanting resulted in greater plant density than the initial planting with only a fungicide seed treatment. For the late May planting, replanting with insecticide- plus fungicide-treated seed resulted in greater plant density than the initial plantings. Replanting resulted in greater plant density at R7 compared to retaining the original plantings for the early June plantings. Replanting resulted in greater yields compared to retaining the original stand for the late May planting, while the opposite was observed for the early June planting. The lack of benefit from replanting for the early June planting is likely due to lower yield potential for the replanted plots due to planting date (replant date early July).

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. However, with severe insect infestations, commonly used insecticide seed treatments may not be adequate to prevent stand loss. Insects must feed on treated seed/plants to be exposed to the insecticide, and with large infestations plant damage can occur before the insects are controlled.

Neonicotinoid seed treatments are commonly used in soybean production. Based on the current studies, Bifenthrin applied in-furrow appears to be a viable alternative, although many growers do not have the capability for in-furrow applications at planting.

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. Replant decisions are not simple. The magnitude of plant loss (number of remaining plants), timing (date the replant decision has to be made), and possibly weather conditions during the remainder of the growing season will determine the economic viability of replanting.

In this study, retaining stands as low as 39,000 plants per acre at the V3 growth stage in a mid-May planting resulted in similar yields as replanting. Replanting of a late May planting resulted in greater yields, but did not an early Jun planting. Having to replant results not only in higher costs from the extra equipment operations and seed costs, 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 presented at >50 grower meetings throughout the state of Mississippi during the winter/spring of 2016-2019.

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

Treatment/Form.	Rate	Application Method	Plant Density/acre VC[5]	Plant Density/acre V3[6]	Yield (bu/acre)
Fungicide Only	-	ST[7]	52,997d	56,713c	48.0
Gaucho 600FS[9]	1.6[1]	ST[7]	76,509a	83,370a	49.1
Acephate 90S[10]	8.0[2]	ST[7]	58,949cd	65,524c	48.8
Dermacor 5.21FS[11]	0.25[3]	ST[7]	69,338ab	79,470ab	49.5
Dermacor 5.21FS[11]	0.5[3]	ST[7]	67,219ab	74,396b	51.4
Gaucho 600FS[9] + Dermacor 5.21FS[11]	1.6[1] + 0.25[3]	ST[7]	71,418ab	82,520ab	48.7
Verimark 1.67SC[12]	0.25[3]	ST[7]	72,834ab	81,461ab	48.4
Verimark 1.67SC[12]	0.5[3]	ST[7]	74,181ab	79,878ab	50.1
Gaucho 600FS[9] + Verimark 1.67SC[12]	1.6[1] +0.25[3]	ST[7]	71,752ab	79,266ab	48.0
Brigade 2EC[13]	2.6[4]	IFS[8]	73,064ab	82,300ab	51.7
Brigade 2EC[13] + Prevathon 0.43SC[11]	2.6[4] + 7.0[4]	IFS[8]	74,262ab	84,097a	49.3
P>F			<0.01	<0.01	0.50

Means within columns followed by a common letter are not significantly different (FPLD *P>F* 0.05).
All seed received the same fungicide seed treatment.
[1]fluid oz product/cwt seed.
[2]oz product (wt.)/cwt seed.
[3]mg ai/seed.
[4]fluid oz product/acre
[5]VC – 7-10 days after emergence.
[6]V3 – 19-21 days after emergence.
[7]Seed Treatment.
[8]In-Furrow Spray.
[9]Active ingredient – Imidacloprid, Class - Neonicotinoid.
[10]Active ingredient – Acephate, Class - Organophosphate.
[11]Active ingredient – Chlorantraniliprole, Class - Diamide.
[12]Active ingredient – Cyantraniliprole, Class - Diamide.
[13]Active ingredient – Bifenthrin, Class - Pyrethroid.

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

Treatment/Form.	Rate	Application Method	Plant Density/acre VC[4]	Plant Density/acre V3[5]	Yield (bu/acre)
Fungicide Only	-	ST[6]	33,981f	40,974f	41.6e
Gaucho 600FS[8]	1.6[1]	ST[6]	64,224ab	69,779abc	49.2ab
Acephate 90S[9]	17.8[2]	IFS[7]	47,344cd	60,426bcd	45.7b-d
Brigade 2EC[10]	2.6[3]	IFS[7]	67,259a	75,440a	53.3a
Prevathon 0.43SC[11]	14.0[3]	IFS[7]	41,273def	51,755def	44.4cde
Prevathon 0.43SC[11]	20.0[3]	IFS[7]	37,625def	48,406ef	43.9de
Acephate 90S[9] + Prevathon 0.43SC[11]	13.3[3] + 14.0[3]	IFS[7]	47,984cd	59,596cde	44.7b-d
Verimark 1.67SC[12]	6.7[3]	IFS[7]	55,566bc	71,997ab	47.1bcd
Verimark 1.67SC[12]	13.5[3]	IFS[7]	55,825bc	70,567abc	47.5bcd
Sivanto 1.67SC[13]	4.0[3]	IFS[7]	36,781def	46,187f	44.8b-d
Sivanto 1.67SC[13]	7.0[3]	IFS[7]	36,781ef	47,848ef	48.6bc
$P>F$			<0.01	<0.01	<0.01

Means within columns followed by a common letter are not significantly different (FPLD $P>F$ 0.05).
All seed received the same fungicide seed treatment.
[1]fluid oz product/cwt seed.
[2]oz product (wt.)/acre.
[3]fluid oz product/acre
[4]VC – 7-10 days after emergence.
[5]V3 – 19-21 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 – Bifenthrin, Class - Pyrethroid.
[11]Active ingredient – Chlorantraniliprole, Class - Diamide.
[12]Active ingredient – Cyantraniliprole, Class - Diamide.
[13]Active ingredient – Flupyradifurone, Class - Butenolide.

Table 3. Impact of seed treatments on soybean plant density and yield with optimal initial plant density at different planting dates during 2016 to 2018.

Planting Date	At Planting Insecticide	Plant Density/acre V3	Plant Density/acre Harvest	Yield (bu/acre)
Early April	Non-Treated	57,880b	39,599b	48.1
Early April	Gaucho	75,079a	50,293a	53.8
P>F		<0.01	0.04	0.17
Mid-April	Non-Treated	61,523b	43,787b	59.6b
Mid-April	Gaucho	80,300a	55,177a	65.8a
P>F		<0.01	<0.01	0.04
Mid-May	Non-Treated	58,480	46,164	52.0
Mid-May	Gaucho	63,764	48,139	52.5
P>F		0.14	0.55	0.95
Late May	Non-Treated	65,422	46,519	54.7
Late May	Gaucho	60,998	48,134	53.8
P>F		0.11	0.30	0.40
Early June	Non-Treated	72,010	52,644	50.8
Early June	Gaucho	73,943	51,365	51.7
P>F		0.63	0.62	0.53

Means within columns within planting dates followed by a common letter are not significantly different (FPLD *P>F* 0.05).
All seed received the same fungicide seed treatment.

Table 4. Impact of seed treatments on soybean plant density and yield with suboptimal initial plant density at different planting dates, 2016-2018.

Planting Date	At Planting Insecticide	Replant	Plant Density/acre V3	Plant Density/acre R7	Yield (bu/acre)
Early April	Non-Treated	No	53,211	34,902	47.3
Early April	Gaucho	No	53,483	38,510	53.9
Replant Mid-May	Non-Treated	Yes	44,595	37,228	53.8
Replant Mid-May	Gaucho	Yes	66,524	47,006	54.6
P>F			0.07	0.34	0.14
Mid-April	Non-Treated	No	45,074c	30,791b	59.0
Mid-April	Gaucho	No	56,084bc	42,983a	61.0
Replant Late May	Non-Treated	Yes	62,876ab	42,587a	56.5
Replant Late May	Gaucho	Yes	67,681a	50,297a	54.6
P>F			<0.01	0.01	0.07
Mid-May	Non-Treated	No	39,000b	31,290b	49.1
Mid-May	Gaucho	No	42,171b	36,710ab	53.0
Replant Early June	Non-Treated	Yes	78,735a	50,586a	53.1
Replant Early June	Gaucho	Yes	79,715a	52,067a	54.5
P>F			<0.01	0.03	0.63
Late May	Non-Treated	No	47,412b	35,665b	38.7b
Late May	Gaucho	No	49,114b	39,215b	41.0b
Replant Late June	Non-Treated	Yes	64,142a	43,127ab	49.7a
Replant Late June	Gaucho	Yes	73,957a	53,547a	50.7a
P>F			<0.01	0.01	0.04
Early June	Non-Treated	No	47,385b	38,397b	45.6a
Early June	Gaucho	No	49,336b	41,499b	48.1a
Replant Early July	Non-Treated	Yes	77,047a	60,726a	38.3b
Replant Early July	Gaucho	Yes	71,356a	59,401a	40.4b
P>F			<0.01	<0.01	<0.01

Means within columns within planting dates followed by a common letter are not significantly different (FPLD *P>F* 0.05).
All seed received the same fungicide seed treatment.