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SOYBEAN SCIENCE

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UNIVERSITY OF KENTUCKY

2019 SOYBEAN RESEARCH REPORT

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Effect of Soybean Cultivar and Foliar Fungicide Application on Southern Stem Canker of Soybean

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OBJECTIVES

The objective of this research was to evaluate the effect of foliar fungicides on southern stem canker (caused by the fungus *Diaporthe aspalathi*) when applied to soybean cultivars differing in their susceptibility to the disease.

MATERIALS AND METHODS

Field trials were conducted in Caldwell County (at the University of Kentucky Research & Education Center near Princeton, KY) and in Daviess County (on a farmer's field near Owensboro, KY) in 2019. At each location, a soybean cultivar resistant to southern stem canker (Dynagro 44XS68) and susceptible to southern stem canker (Dynagro 43XS27) were planted into fields that had been planted to soybean the previous year. Plots were 4 rows wide (30 inch row spacing) and either 20 ft long (Caldwell Co.) or 25 ft long (Daviess Co.). Plots were arranged in a randomized complete block design with either 4 replications (Caldwell Co.) or 3 replications (Daviess Co.). Different fungicide products were applied at different growth stages with a carbon dioxide-pressurized backpack sprayer calibrated to deliver 20 GPA at 40 PSI pressure (Table 1). When soybean plots were approximately at the R5 growth stage (beginning seed development), incidence (%) of plants affected by southern stem canker was recorded. Plots were harvested with a small plot research combine and grain yields were calculated and adjusted to 13% moisture.

RESULTS

Statistically significant differences were detected among treatments for southern stem canker incidence and yield at both locations (Table 1). By far, the largest differences observed were between soybean cultivars, where the southern stem canker susceptible cultivar (43XS27) had the greatest incidence of southern stem canker and the lowest yield compared to the resistant cultivar (44XS68). Within a cultivar, the only observed differences in southern stem canker incidence relative to the non-treated check was with Quadris applied at V5 and Priaxor applied at R3 on the susceptible cultivar (43XS27). The only observed difference in yield relative to the non-treated check within a cultivar was with Priaxor applied at R3 on the susceptible cultivar (43XS27). The field in Caldwell County, KY had extremely high southern stem canker pressure, which caused major yield reductions on the susceptible cultivar compared to the resistant cultivar.

CONCLUSIONS AND IMPLICATIONS

Southern stem canker has been a re-emerging disease in Kentucky in recent years. Fields that have been planted to continuous soybean and susceptible cultivars have been affected the most. Our research trials showed that, in general, foliar fungicides are relatively ineffective in controlling southern stem canker, and that planting a resistant cultivar will have a much greater impact on southern stem canker.

ACKNOWLEDGEMENTS

This project was funded by the Kentucky Soybean Promotion Board. We thank Fischer CrossCreek Farms for allowing us to conduct research on their farm and Nutrien Ag Solutions for providing the soybean seed. We also thank Clint Hardy, Philip Logsdon, Carrie Ann Followell, Taylor Wendle, and Curt Bradley for their assistance with this project.

Table 1. Effect of soybean cultivars and foliar fungicides on southern stem canker incidence and yield at trials conducted in Caldwell and Daviess Counties, KY in 2019.

Cultivar	Treatment	Rate (fl oz/A)	Timing	Caldwell County, KY		Daviess County, KY	
				Stem canker incidence (%)	Yield (bu/A)	Stem canker incidence (%)	Yield (bu/A)
43XS27	Nontreated	-	-	98.8	10.8	38.3	52.8
(Susc.)	Priaxor	8	V5	98.8	14.4	16.7	60.5
	TopGuard	14	V5	97.5	11.6	30.0	52.7
	Topsin	20	V5	98.8	11.6	43.3	49.4
	Quadris	15.5	V5	75.0	14.2	30.0	53.2
	Priaxor	8	R1	98.8	13.0	26.7	59.0
	TopGuard	14	R1	96.3	11.8	46.7	55.7
	Topsin	20	R1	98.8	9.2	26.7	55.8
	Quadris	15.5	R1	97.5	7.7	33.3	54.2
	Priaxor	8	R3	73.8	26.7	26.7	59.6
	TopGuard	14	R3	98.8	9.1	36.7	53.3
	Topsin	20	R3	98.8	12.4	18.3	59.5
	Quadris	15.5	R3	97.5	7.2	38.3	52.1
44XS68	Nontreated	-	-	0.0	76.6	0.0	70.3
(Res.)	Priaxor	8	V5	0.0	57.2	0.0	68.1
	TopGuard	14	V5	0.0	75.3	0.0	68.4
	Topsin	20	V5	1.3	74.9	0.0	71.3
	Quadris	15.5	V5	0.0	73.3	0.0	71.6
	Priaxor	8	R1	0.0	73.3	0.0	69.0
	TopGuard	14	R1	0.0	76.7	1.7	72.6
	Topsin	20	R1	0.0	75.4	0.0	68.3
	Quadris	15.5	R1	0.0	78.3	0.0	62.9
	Priaxor	8	R3	0.0	77.0	0.0	70.6
	TopGuard	14	R3	0.0	84.3	1.7	69.5
	Topsin	20	R3	1.3	80.0	0.0	69.8
	Quadris	15.5	R3	0.0	76.7	0.0	67.3
			LSD[z]	**22.6**	**14.1**	**22.7**	**9.6**

[z]Least significant difference (LSD) used to compare values within a column (95% confidence).

Efficacy of Foliar Fungicides for Management of Target Spot of Soybean

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OBJECTIVES

The objective of this research was to determine the efficacy of foliar fungicides for control of target spot of soybean (caused by the fungus *Corynespora cassiicola*).

MATERIALS AND METHODS

A field trial was conducted at the University of Kentucky Research & Education Center near Princeton, KY in 2019. The soybean cultivar 'Credenz 4748' was planted in late May 2019. Plots were 4 rows wide (30 inch row spacing) and 20 ft long. Plots were arranged in a randomized complete block statistical design with 4 replications. When soybean plants reached the R3 growth stage (beginning pod development), foliar fungicide treatments were applied with a carbon dioxide-pressurized backpack sprayer calibrated to deliver 20 GPA at 40 PSI pressure. Approximately 4 weeks following treatment applications, plots were rated for target spot severity by estimating the % of the soybean leaf area affected by target spot lesions. Plots were harvested with a small plot research combine and grain yields were calculated and adjusted to 13% moisture.

RESULTS

Statistically significant differences were detected among treatments for target spot severity, but not for yield (Table 1). All treatments except Acropolis, Veltyma, RevyTek, and Excalia (both rates) had statistically significant lower target spot severity ratings than the nontreated control. The lowest target spot severity rating was achieved with the experimental treatment A23120, which was not statistically different than Priaxor + Tilt (both rates), Lucento, Topguard EQ, and Miravis Top.

CONCLUSIONS AND IMPLICATIONS

Target spot is an emerging disease of soybean that has been increasing its presence in the southern U.S. in recent years. Results from our trial indicate that some fungicide products are able to provide some efficacy against target spot. In general, fungicides that contain an active ingredient in the succinate dehydrogenase inhibitor (SDHI) fungicide class tended to provide the best control of target spot. In our trial, Headline fungicide, which contains only a quinone outside inhibitor (QoI; also known as strobilurin) active ingredient provided control of target spot; however, it is important to note that resistance to QoI fungicides in the target spot fungus was recently reported in Alabama (Nunes Rondon and Lawrence 2019). Therefore, it is important to use a fungicide product that contains active ingredients from at least two efficacious fungicide groups or to tank mix fungicides from at least two groups to help slow down the development of fungicide resistance in the target spot fungus in Kentucky.

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REFERENCE

Nunes Rondon, M., and Lawrence, K. S. 2019. *Corynespora cassiicola* isolates from soybean in Alabama detected with G143a mutation in the *cytochrome b* gene. Plant Health Progress 20:247-249.

Table 1. Effect of foliar fungicides applied at the R3 growth stage on target spot severity and soybean yield near Princeton, KY in 2019.

Treatment	Rate (fl oz/A)	Target spot severity (%)	Yield (bu/A)
Nontreated	-	21.3 A[z]	68.2 A[z]
Headline	6	10.4 D	75.5 A
Acropolis	20	18.4 AB	66.2 A
Froghorn	20	17.5 BC	71.3 A
Topsin 4.5 L	20	16.7 BC	68.8 A
Aproach Prima	6.8	14.6 C	72.0 A
Veltyma	7	18.3 AB	76.4 A
RevyTek	8	18.8 AB	69.1 A
Priaxor + Tilt	4 + 4	8.9 DE	63.8 A
Priaxor + Tilt	5 + 5	7.6 DE	65.2 A
Lucento	5	6.8 E	67.0 A
Topguard EQ	5	8.2 DE	72.3 A
Miravis Top	13.7	7.7 DE	72.4 A
A23120	13.7	6.7 E	71.2 A
Delaro	8	14.2 C	68.2 A
Stratego YLD	4.65	17.5 BC	73.1 A
Excalia	3	19.2 A	67.4 A
Excalia	2	18.4 AB	65.5 A
Equus	36	17.5 BC	62.2 A
Trivapro	13.7	14.6 C	69.3 A

[z]Target spot severity values or yields followed by the same letter are not significantly different according to the statistical analysis (95% confidence).

Evaluating Soybean Response to Sulfur in Kentucky

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Soybean has high demands for nitrogen (N) and sulfur (S) since they are essential in making proteins that accumulate in the seed. While the symbiotic relationship between soybean and *Bradyrhizobium japonicum* often supplies enough N for the soybean plant, the soybean crop relies on available S in the soil for plant needs. Organic matter contains reservoir S not available to plants. However, as organic matter decomposes from microbial activity some S is converted into sulfate, which is available to the plants. Sulfate behaves in the soil much like nitrate and is subject to similar loss mechanisms as nitrate. Soil organic matter and its decomposition is the primary source of S for soybean.

The most common conditions for a lack of S release from the soil in Kentucky include eroded soils, sideslopes, and reduced or no-tillage conditions. In other regions, sandy soils and low organic matter are the most common reasons for low S availability in the fields. Cooler soils reduce microbial activity, which slows the release of sulfate from the organic matter as well. Thus, S deficiency is more common early in the spring than later in the summer.

Farmers are interested in applying S to soybean for higher yields. This study was conducted to determine the effect of S fertilizer at planting on soybean yield.

METHODS

Field sites were established at Princeton, KY on a Crider silt loam soil and at Lexington, KY on a Bluegrass Maury silt loam soil. Sulfur was applied at planting in the forms of ammonium sulfate (21-0-0-24S), calcium sulfate (gypsum, 0-0-0-17S), and ammonium thiosulfate (12-0-0-26S) at Princeton. Urea ammonium nitrate was included to bring all treatments to the same N rate. At Lexington, ammonium sulfate and gypsum were applied. Urea ammonium nitrate was used as a separate set of treatments to serve as a check against the ammonium sulfate treatments. At all locations, sulfur rates were 10, 20 and 30 lb S/acre. At Princeton, one soybean variety was used. At Lexington, two soybean varieties were used.

At both locations, all other soil parameters such as pH, phosphorus and potassium were kept constant across the study. Weed control was employed aggressively to prevent weed interference.

Princeton was not irrigated. Lexington was irrigated as needed, and irrigation events occurred in July and August when the dry weather occurred. The study collected tissue samples and soil samples during the study. This report will focus only on soybean yield.

YIELDS

At Princeton, yields ranged from 60 to 71 bushels per acre (Figure 1). However, all yields were within the margin of error ($p=0.2614$), meaning that no fertilizer treatment resulted in a statistically significant yield. Note: In this trial, a p value below 0.1000 is required for significant differences to occur. Since $p=0.2614$ is greater than 0.1000, none of these treatments resulted in a significant difference in yield.

Remembering that all yields are within the margin of error for this trial, the four lowest yields were for the 0 Check (no S fertilizer), Ammoinum Sulfate at the 30 lb S/acre rate, Ammonium Thiosulfate at the 20 lb S/acre rate and Gypsum at the 20 lb S/acre rate.

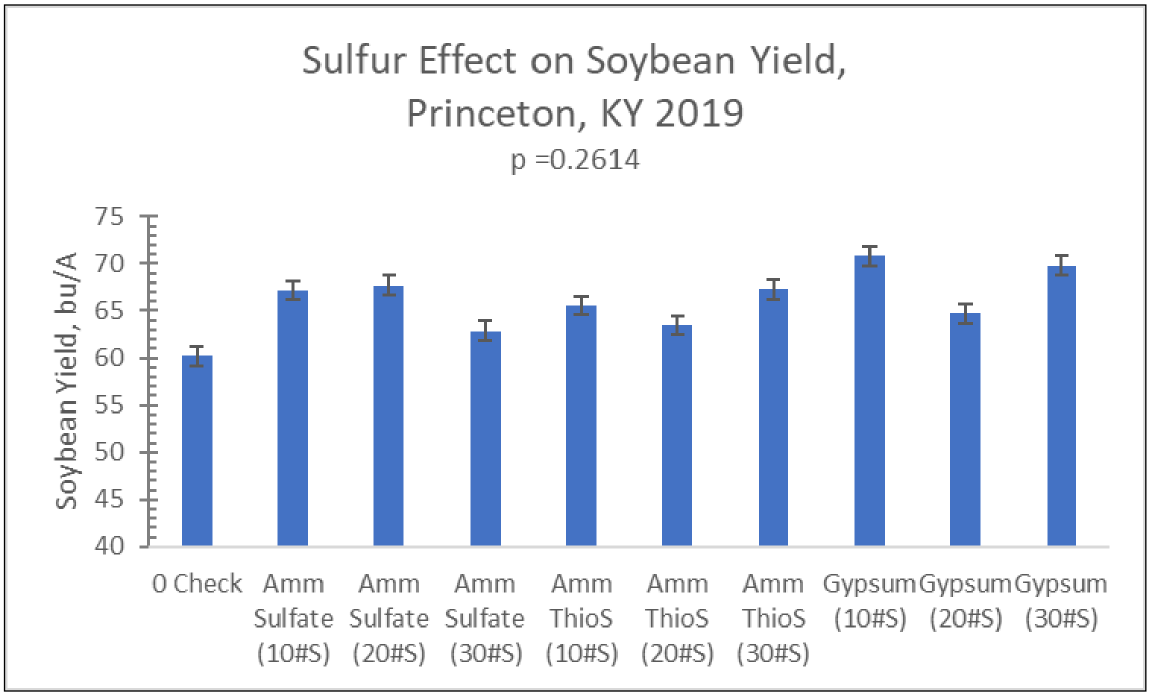

Figure 1. Sulfur effect on soybean yield at Princeton, KY 2020. Standard error bars are included.

At Lexington, yield averaged across both varieties ranged from 70 to 77 bushels per acre. Just like at Princeton, all yields were within the margin of error and there was no significant differences among the yields (p=0.6209). At Lexington, the two highest yields were the Urea at 9 lb N/acre and the 0 Check (no fertilizer added). Two of the lowest yields occurred for the Gypsum at 20 lb S/acre and Urea at 26 lb N/acre.

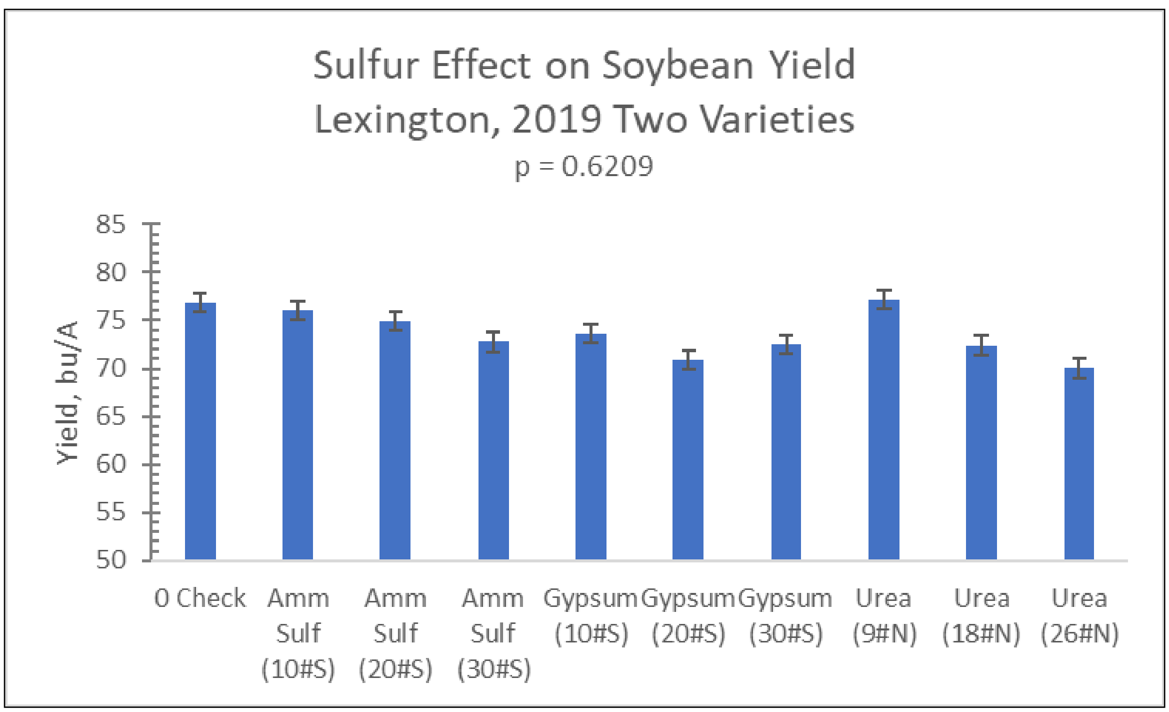

Figure 2. Sulfur effect on soybean yield at Lexington, 2020. The yields are averaged across two soybean varieties. Standard error bars are included.

TISSUE SAMPLES

At Princeton, tissue samples taken at R2-R3 growth stages did not identify any significant differences in N concentration in the plants. However, Gypsum at the 30 lb S/acre rate resulted in the highest %S in the trial and the 0 Check (no fertilizer) and Ammonium Sulfate at 10 lb S/acre resulted in the least %S in the trial.

Table 1. Tissue samples from soybean at the R2-R3 growth stage at Princeton, KY 2019.

Fertilizer	Tissue Sample at R2/3		
Treatment	**% N**	**% S**	
0 Check	5.32	0.27	d‡
AMS: Ammonium Sulfate (10#S)	5.32	0.27	d
AMS: Ammonium Sulfate (20#S)	5.46	0.28	cd
AMS: Ammonium Sulfate (30#S)	5.39	0.29	ab
ATS: Ammonium Thiosulfate (10#S)	5.55	0.29	bcd
ATS: Ammonium Thiosulfate (20#S)	5.67	0.29	abc
ATS: Ammonium Thiosulfate (30#S)	5.37	0.29	bcd
Gypsum (10#S)	5.42	0.28	bcd
Gypsum (20#S)	5.33	0.29	bcd
Gypsum (30#S)	5.71	0.30	a
LSD (0.10)	ns†	0.01	
p value	0.6776	0.0394	

† ns = not significant

‡ Letters in the same column represent significant differences among treatments. Means separation was based on values with 4 digits after the decimal.

CONCLUSIONS

The fertilizer sulfur was applied at planting, yet elevated sulfur concentrations were detected when soybeans were at full boom and beginning pod stages. However, these elevated sulfur values did not result in significant yield increases in 2019. The irrigated soybeans at Lexington yielded greater than the rainfed soybeans at Princeton. Perhaps the irrigation events allowed for more soil organic release of sulfur at Lexington. At Princeton, all sulfur fertilizer treatments resulted in numerical yields greater than the zero fertilizer check. These results make it tempting to assume that sulfur caused greater yields. However, the statistics indicate that these observations are not repeatable or predictable.

We intend to repeat this study at least one more season and compare it with similar trials in other states. We hope that the multitude of locations and treatments will help us gain a better understanding when sulfur fertilizer on soybean is repeatable and predictable.

ACKNOWLEDGEMENTS

Thanks to the Kentucky Soybean Promotion Board for partial funding of these projects and to James Dollarhide, Daniel Quinn and Griffin Mobley at Lexington and Conner Raymond, Katherine Rod, Jacob Foote, Gracie Harper, and Hunter Adams at Princeton for helping with the research trials.

Soybean Response to Foliar Products 2019

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Numerous foliar products are marketed to growers to apply to soybeans with the goal of increasing yield. Several products were evaluated in 2019 in Kentucky.

METHODS

Full season soybeans were established at Lexington and Princeton, KY. Soil pH, P, K and Zn were standardized across all treatments at each location. Weeds were controlled aggressively to prevent competition. Soybeans were scouted for disease and insects. At Lexington, foliar fertilizer was applied at R3 (beginning pod) (Table 1). At Princeton, foliar products were applied once at R3 or twice at R1 (beginning bloom) and R3 (Table 2). Plots were harvested with small plot combines and seed samples were analyzed for protein and oil.

RESULTS

The foliar products did not result in significant differences in yield, seed protein or seed oil at Lexington (Table 1). All yields were within the margin of error and averages ranged from 58 to 68 bushels per acre. The Untreated Control (no foliar product applied) was the highest at 67.6 bushels per acre and the Smart B-Mo was the lowest yield of 58.3 bushels per acre.

Table 1. Soybean response to foliar products at Lexington, KY 2019 on a Bluegrass Maury silt loam.

Foliar Product	Rate	Timing	Yield, bu/A	Seed Protein, %	Seed Oil, %
FertiRain	3 gal/A	R3	60.1	38.5	20.3
Maximum NPact K	1.5 gal/A	R3	60.5	38.5	20.5
Smart B-Mo	1 pt/A	R3	58.3	38.6	20.3
Smart Quatro Plus	1 qt/A	R3	61.9	38.4	20.2
SureK	3 gal/A	R3	65.6	38.3	20.2
Untreated Control			67.6	38.2	20.2
LSD (0.1)			ns†	ns	ns
trt p value			0.3171	0.4280	0.1647

† ns = no significant difference

The foliar products at Princeton did not result in significant difference in yield (Table 2). All yields are within the margin of error and ranged from a high of 58 bu/A to a low of 51 bu/A. The two lowest yields were for Maximum NPact K applied twice and Maximum NPact K applied once.

Table 2. Soybean response to foliar products at Princeton, KY 2019 on a Crider silt loam.

Foliar Product	Rate	Timing	Yield, bu/A
FertiRain	3 gal/A + 3 gal/A	R1+R3	55.0
HarvestMoreUreamate	2.5 lb/A + 2.5 lb/A	R1+R3	53.2
Maximum NPact K	1.5 gal/A + 1.5 gal/A	R1+R3	51.0
Smart B-Mo	1 pt/A + 1 pt/A	R1+R3	52.3
Smart Quatro Plus	1 qt/A + 1 qt/A	R1+R3	58.0
SureK	3 gal/A + 3 gal/A	R1+R3	55.4
FertiRain	3 gal/A	R3	57.6
HarvestMoreUreamate	2.5 lb/A	R3	53.6
Maximum NPact K	1.5 gal/A	R3	52.1
Smart B-Mo	1 pt/A	R3	53.4
Smart Quatro Plus	1qt/A	R3	56.0
SureK	3 gal/A	R3	55.4
Untreated Control			56.5
LSD (0.10)			ns†
trt p value			0.6432

†ns = no significant difference

CONCLUSIONS

In 2019, none of the foliar products tested at either location or either timing resulted in significant yield increases. We hope to compare these results with another year of data and to similar trials in some other states.

ACKNOWLEDGEMENTS

Thanks to the Kentucky Soybean Promotion Board for partial funding of these projects and to James Dollarhide, Daniel Quinn and Griffin Mobley at Lexington and Conner Raymond, Katherine Rod, Jacob Foote, Gracie Harper, and Hunter Adams at Princeton for helping with the research trials.

Evaluation of Herbicide Programs with a Glyphosate, Glufosinate, and Dicamba-Resistant Soybean Variety for Control of Waterhemp and Palmer Amarnath

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INTRODUCTION

Palmer amaranth and common waterhemp are two *Amaranthus* species that have become notoriously aggressive in Kentucky and other states where corn and soybean are grown. These two Amaranthus species, commonly referred to as "pigweeds", are especially troublesome in soybean. The heavy use of postemergence herbicides to control these two species has led to wide spread resistance and loss of effective use of multiple postemergence herbicide, including glyphosate, ALS-inhibiting herbicides, and PPO-inhibiting type herbicide products in Kentucky.

Farmers who have infestations of these pigweed species with resistance to all three herbicide classes have been forced to rely more on preemergence (soil-applied) herbicides for effective control, as well as seeking alternative soybean resistance events such as glufosinate tolerant soybean varieties (i.e. Liberty Link). The introduction in 2017 of glyphosate and dicamba-resistant soybean (i.e. Roundup Ready 2 Xtend) brought relief to farmers dealing with resistant pigweeds in providing an additional effective postemergence herbicide option.

Control of Palmer amaranth and waterhemp in dicamba-resistant soybean systems has largely been successful for Kentucky growers, although the introduction of this technology has come with many challenges. The ability to apply dicamba postemergence on soybean during the months of June, July, and even August has led to greater amounts of this product being applied. This has subsequently resulted in wide spread injury to extremely sensitive crops such as non-dicamba soybean and tobacco within some areas of Kentucky. The high value of tobacco, which has a zero residue tolerance for dicamba residues, has led to a multiple cases of complete marketing loss of tobacco crops due to dicamba applications on nearby soybean fields.

The introduction of other alternative herbicide tolerance events such as 2,4-D, glyphosate, and glufosinate-resistant soybean (i.e. Enlist E3) can provide some relief on the reliance of dicamba. Some producers have stayed reliant on dicamba-resistant soybean not only for its value for weed control, but also for protection from off-target dicamba movement from neighboring fields. This inherently puts soybean producers who are near tobacco production areas in a conundrum as dicamba is the only postemergence option for control of waterhemp and Palmer in these soybean in many cases.

The pending release of Xtend Flex soybean varieties will provide an additional weed management tool whereby these soybeans express 3-way resistance to glyphosate, dicamba, and glufosinate. University of Kentucky weed science program has been allowed to investigate the Xtend Flex system for control of Palmer amaranth and common waterhemp at three locations in 2019 to further investigate the utility of this new soybean event.

MATERIAL AND METHODS

Experiments were established on grower locations with known infestations of waterhemp in Taylor and Caldwell County, and a population of Palmer amaranth located in Fulton County, KY. Sites were planted to a Xtend Flex soybean variety at 140,000 seeds per acre on May 22, May 24, and June 4, 2019 at the Taylor, Caldwell, and Fulton County sites, respectively.

The experimental design was a factorial design with two factors: Preemergence herbicide and Postemergence herbicide. Preemergence herbicide treatments consisted of Zidua (pyroxasulfone [15]), Fierce XLT (chlorimuron [2], flumioxazin [14], and pyroxasulfone [15]), and Intimidator (metribuzin [5], fomesafen [14], and S-metolachlor [15]), as well as an untreated or no-preemergence herbicide treatment. Each of the preemergence herbicides was followed by four postemergence programs: Xtendimax (dicamba [4]) plus Roundup PowerMax (glyphosate [9]), Liberty (glufosinate [10]), Liberty plus Roundup Powermax, and Xtendimax plus Roundup PowerMax early postemergence followed by Liberty. The Xtendimax plus glyphosate, Liberty, and Liberty plus Roundup PowerMax were all planned two pass postemergence programs with a second application applied as needed and allowed by label growth stage cutoffs.

Treatments were evaluated for percent waterhemp or Palmer amaranth control 14 and 21 days after each treatment as well as pigweed densities per $3m^2$ taken in late July prior to trial destruction.

RESULTS

Waterhemp densities taken at the end of July in Taylor and Caldwell Counties ranged from 0 to 9 and 0 to 50 plants per $3m^2$, respectively (Table 1 and 2). These densities were in comparison to the untreated checks with densities of 89 plants per $3m^2$ at Taylor county and 71 plants per $3m^2$ at Caldwell County. Despite a large range of densities, especially at the Caldwell site, no interaction of preemergence herbicide and postemergence herbicide was found. Palmer amaranth densities in treated plots at Fulton County ranged from 0 to 20 plants per $3m^2$ as compared to 33 plants per $3m^2$ in the untreated plot (Table 3). Similar to the waterhemp sites, the Fulton site lacked an interaction of preemergence herbicide and postemergence herbicide. Due to a lack of interactions at all three sites, preemergence herbicides and postemergence herbicide factors were separated for analysis.

Waterhemp densities were significantly greater in plots not receiving a preemergence herbicide as a compared to those receiving a preemergent at the Taylor County site (Table 4). The Caldwell county site waterhemp densities in the Zidua and Intimidator plots were lower than the untreated and Fierce XLT plots (Table 4). The high number of plants in the Fierce XLT plots that were similar to those without a preemergent is likely due to crop injury observed, which delayed development of soybeans in the Fierce XLT plots. The injury is likely due to the chlorimuron within this herbicide product which resulted in stunting and delayed development of the soybean plants; thus, a delayed canopy closure provided an opportunity for further waterhemp emergence after postemergence applications. While injury due to preemergence herbicides is a concern it should be noted that this injury only occurred at one of three sites, where soil conditions were more conducive to injury. Differences in Palmer amaranth densities due to preemergent herbicides occurred between plots not receiving a preemergence herbicide and plots receiving Intimidator, a product that contains three effective sites of action (Table 5). Zidua and Fierce XLT were both similar to the no preemergence plots and the Intimidator plots. Overall results of the influenced of preemergence herbicides on waterhemp and Palmer amaranth further emphasis the need for a robust multiple site of action preemergence herbicide. As with previous studies, Intimidator consistently provided significantly lower pigweed densities than the plots not receiving a preemergence herbicide.

Plots receiving two postemergence applications of Xtendimax plus Roundup Powermax had significantly higher waterhemp densities than the other postemergence treatments at Taylor county (Table 6). Differences in waterhemp and Palmer amaranth densities due to postemergence treatments did not occur at the Caldwell or Fulton County sites (Table 6 and 7). Overall these results indicate that postemergence treatments did not have significant influence on end of season *Amaranthus* densities.

The addition of glufosinate-resistance within Xtend-Flex soybeans (a new generation of glufosinate, glyphosate, and dicamba-resistant soybean varieties), greatly increases the flexibility of postemergence applications as compared to the currently available RoundupReady2Xtend soybean system. This flexibility will allow for farmers to effectively control pigweeds while mitigating off target movement in cases where dicamba should not be applied late postemergence. In all cases of this research the inclusion of Liberty in the postemergence program resulted in equivalent or greater waterhemp or Palmer amaranth control as compared to a two pass Xtendimax plus glyphosate system. Despite a lack in significant benefits of postemergence programs, this research continued to emphasize the importance for preemergence herbicides, specifically those with multiple sites of action. The absence of a preemergence herbicide resulted in greater waterhemp and Palmer amaranth densities across all three locations in comparison to those that received a preemergence herbicide with three sites of action.

Table 1. Late July waterhemp density per $3m^2$ at Taylor County.

	Preemergence Herbicide			
Postemergence Herbicide	**Untreated**	**Zidua**	**Fierce XLT**	**Intimidator**
	---------------------- Waterhemp / $3m^{2a}$ ----------------------			
Xtendimax + Roundup[b]	9	2	2	1
Liberty[b]	2	0	1	0
Liberty + Roundup[b]	6	1	1	1
Xtendimax + Roundup	2	1	0	1
	P = 0.1085			
Untreated Density = 89 waterhemp / $3m^2$				

[a] Square root transformation conducted for analysis, Means presented as untransformed.
[b] A second postemergence application applied as needed and/or allowed.

Table 2. Late July waterhemp density per $3m^2$ at Caldwell County.

	Preemergence Herbicide			
Postemergence Herbicide	**Untreated**	**Zidua**	**Fierce XLT**	**Intimidator**
	---------------------- Waterhemp / $3m^{2a}$ ----------------------			
Xtendimax + Roundup[b]	21	18	50	16
Liberty[b]	44	3	15	0
Liberty + Roundup[b]	48	3	14	2
Xtendimax + Roundup	47	6	21	3
	P = 0.3154			
Untreated Density = 89 waterhemp / $3m^2$				

[a] Square root transformation conducted for analysis, Means presented as untransformed.
[b] A second postemergence application applied as needed and/or allowed.

Table 3. Late July Palmer amaranth density per $3m^2$ at Fulton County.

Postemergence Herbicide	Preemergence Herbicide			
	Untreated	Zidua	Fierce XLT	Intimidator
	---------------------- Palmer amaranth / $3m^{2a}$ ----------------------			
Xtendimax + Roundup[b]	4	20	5	3
Liberty[b]	4	2	1	0
Liberty + Roundup[b]	4	1	2	1
Xtendimax + Roundup fb Liberty	11	1	2	0
	P = 0.0655			
Untreated Density = 89 waterhemp / $3m^2$				

[a] Square root transformation conducted for analysis, means presented as untransformed.
[b] A second postemergence application applied as needed and/or allowed.

Table 4. Influence of preemergence herbicide on late July waterhemp density per $3m^2$ at Taylor and Caldwell County.

Preemergence Herbicide	Taylor County	Caldwell County
	------------- Waterhemp / $3m^{2ab}$ -------------	
Untreated	5 A	40 A
Zidua	1 B	7 B
Fierce XLT	1 B	25 A
Intimidator	1 B	5 B
Untreated	89	71

[a] Means within a column, followed by a different letter are significantly different. Tukey HSD α=0.05
[b] Square root transformation conducted for analysis of variance, means presented as untransformed.

Table 5. Influence of preemergence herbicide on late July Palmer amaranth density per $3m^2$ at Fulton County.

Preemergence Herbicide	Palmer amaranth / 3 m^{2ab}
Untreated	6 A
Zidua	6 AB
Fierce XLT	3 AB
Intimidator	1 B

[a] Means followed by a different letter are significantly different. Tukey HSD α=0.05
[b] Square root transformation conducted for analysis of variance, means presented as untransformed.

Table 6. Influence of postemergence herbicide on late July waterhemp density per $3m^2$ at Taylor and Caldwell County

Preemergence Herbicide	Taylor County	Caldwell County
	------------- Waterhemp / $3m^{2ab}$ -------------	
Xtendimax + Roundup[c]	3 A	26 A
Liberty[c]	1 B	15 A
Liberty + Roundup[c]	2 B	16 A
Xtendimax + Roundup fb Liberty	1 B	19 A
Untreated	89	71

[a] Means within a column, followed by a different letter are significantly different. Tukey HSD α=0.05
[b] Square root transformation conducted for analysis of variance, means presented as untransformed.
[c] A second postemergence application applied as needed and/or allowed.

Table 7. Influence of postemergence herbicide on late July Palmer amaranth density per $3m^2$ at Fulton County.

Postemergence Herbicide	Palmer amaranth / 3 m^{2ab}
Xtendimax + Roundup[c]	8 A
Liberty[c]	2 A
Liberty + Roundup [c]	2 A
Xtendimax + Roundup fb Liberty	3 A

[a] Means followed by a different letter are significantly different. Tukey HSD α=0.05
[b] Square root transformation conducted for analysis of variance, means presented as untransformed.
[c] A second postemergence application applied as needed and/or allowed.

Two-Season Study to Compare Preventive Insecticide Sprays for the Management of Stink Bugs in Soybean

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INTRODUCTION

Stink bugs (Hemiptera: Pentatomidae) are pierce-sucking insects that affect many fruit, vegetables and field crops. There are several stink bug species (Figure 1) affecting soybeans, which are of high economic importance in Kentucky's agriculture production systems. Yeargan (1997) found that the green stink bug, *Chinavia hilaris* reduced seed sizes and de creased numbers of seeds produced, consequently reducing total sobean yields. Most stink bugs require a series of plants with overlapping periods of seed and fruit production to complete their development (Underhill, 1934). Kentucky growers often rely on prophylactic (calendar-based) sprays as a preventive practice to reduce stink bug populations. Insecticides provide faster control than other management tactics, with additional adavantages (i.e. insecticides are readily available and inexpensive). On the contrary, heavy use of pesticides may cause resurgence of target pests, emergence of secondary pests, and induce insecticide resistance if products of the same modes of action are used repetitively. In Kentucky, insecticide applications to control stink bugs are necessary when they are above the economic threshold of 9 stink bugs/25 net sweeps.

The objectives of this study were to compare the efficacy of insecticide applications to manage stink bugs using the economic threshold (9 stink bugs/25 sweep) vs. preventive (calendar or prophylactic) spray tactics and an unsprayed control over two growing seasons; and to compare yields of these treatments.

FIGURE 1. From left to right: The brown (*Euschistus servus*), green (*Chinavia hilaris*), red shouldered (*Thyanta custator*), and brown marmorated (*Halyomorpha halys*) stink bug species pests of soybeans in Kentucky. (Photos by R.T. Villanueva and R. Bessin).

MATERIALS AND METHODS

The studies were conducted in experimental plots of the University of Kentucky's Research and Education Center at Princeton in 2018 and 2019. Soybean *cv*. Caverndale RR2Y/STSn (MG 4.7) was planted in May 18, 2018; and the *cv*. Pioneer P40A7X (MG 4.0) was planted in June 7, 2019. Studies were conducted in 20 by 5 ft plots with 15-inch rows in a complete randomized block design (CRBD) with 4 replicates per treatment.

In 2018 and 2019, the treatments consisted of comparing two preventive treatments vs. the untreated control. In 2018, only one spray (July 18) was conducted as the 1st preventive treatment, and three sprays (July 18, August 12, September 12) for the 2nd preventive treatment. In 2019, the 1st preventive treatment had one spray (July 5), and the 2nd preventive treatment had 2 sprays (July 5 and August 2). The insecticide used was Warrior® II with Zeon Technology (*lambda-cyhalothrin*, 11.4% a.i.) at the rate of 3.84 oz/A. Tallies on the numbers of stink bugs/10 sweep nets were recorded weekly until the first week of August. Thereafter, tallies were conducted biweekly until harvest. Analysis of variance were conducted on the cumulated number of stink bugs tallied each sample date. Then significant differences of means were tested using Fisher's Leas Significant Differences post hoc test (p<0.05). Yields also were evaluated and mean yield comparisons were made using Fisher's LSD test.

RESULTS

Field studies

The average numbers of stink bugs in 2018 and 2019 did not reach the economic threshold of 9 stink bugs/25 sweep (=3.6 SB /10 sweeps) during any of the dates the tallies were conducted. In both years, the numbers of stink bugs were low, the cumulated numbers of stink bugs did not reach to 25 per the entire sampling seasons (Figure 2). It is worth noting that the population increased from mid-August to October.

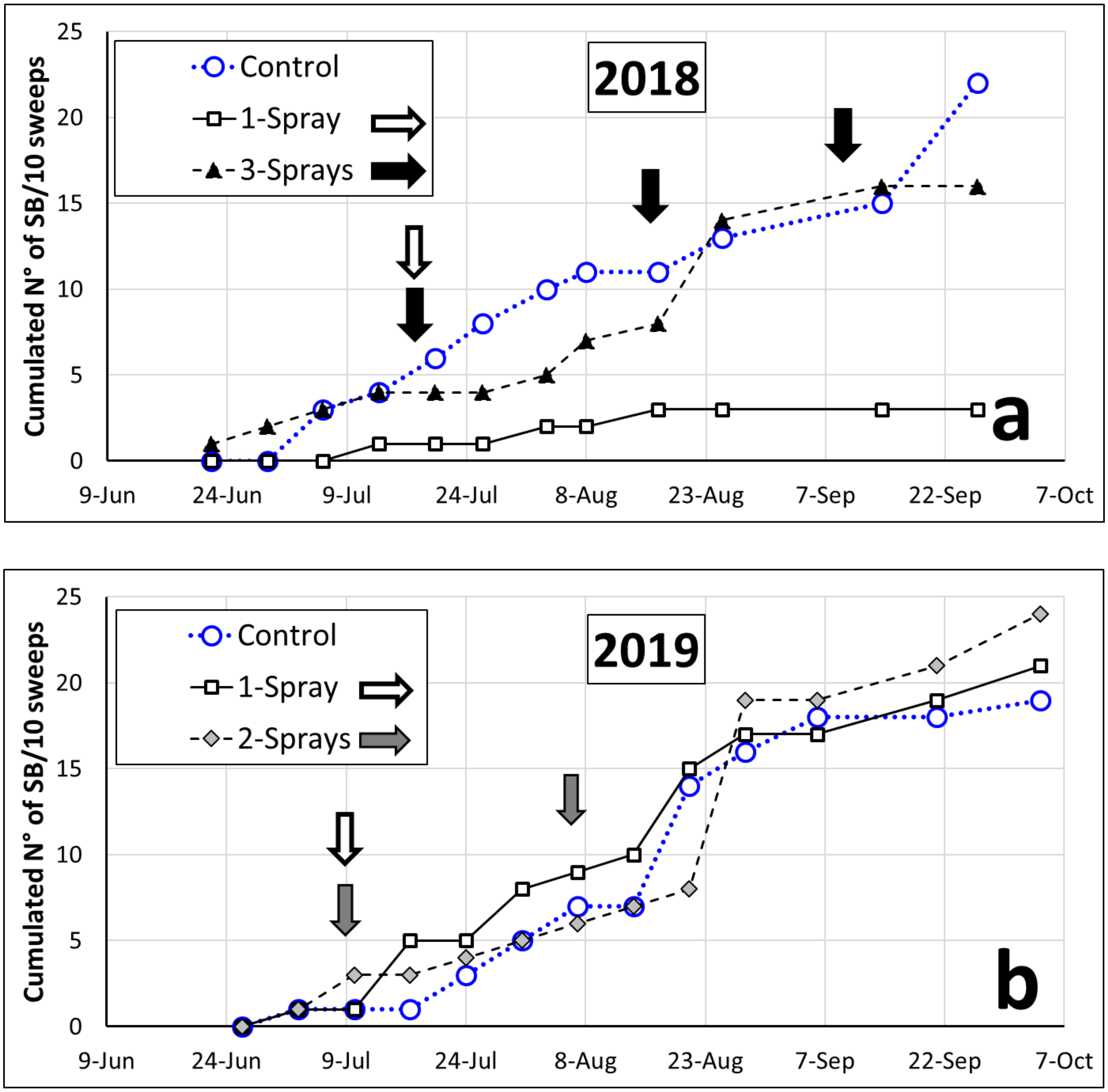

FIGURE 2. Cumulated number of stink bugs/10 sweeps in (a) 2018 and (b) 2019 for the management of stinkbugs (two preventive spray treatments were tested each year). Arrows indicate the dates of the insecticide applications. In 2018 and 2019, *lambda-cyhalothrin* (3.84 oz/A) was the insecticide utilized.

In 2018, after the sprays on 18 July, the stink bug populations were hold-on in plots where Warrior was sprayed except the unsprayed plots that populations increased (Figure 2a). However, the second spray, on 12 August, was not effective. Overall, the 1 spray treatment kept the stink bug population lower than the control or 3-sprays treatments (Figure 2a). In 2019, the 1-spray and 2-spray treatments did not show effectiveness compared to the control (Figure 2b). Significant differences (p>0.05) were not found between 2018 or 2019.

Yields

In 2018 and 2019, the highest yields were observed in the control plots (Figure 3), although significant differences were not observed (p<0.05). Yield in 2018 (Figure 3a) was twice as much as those obtained in 2019 (Figure 3b) across all treatments.

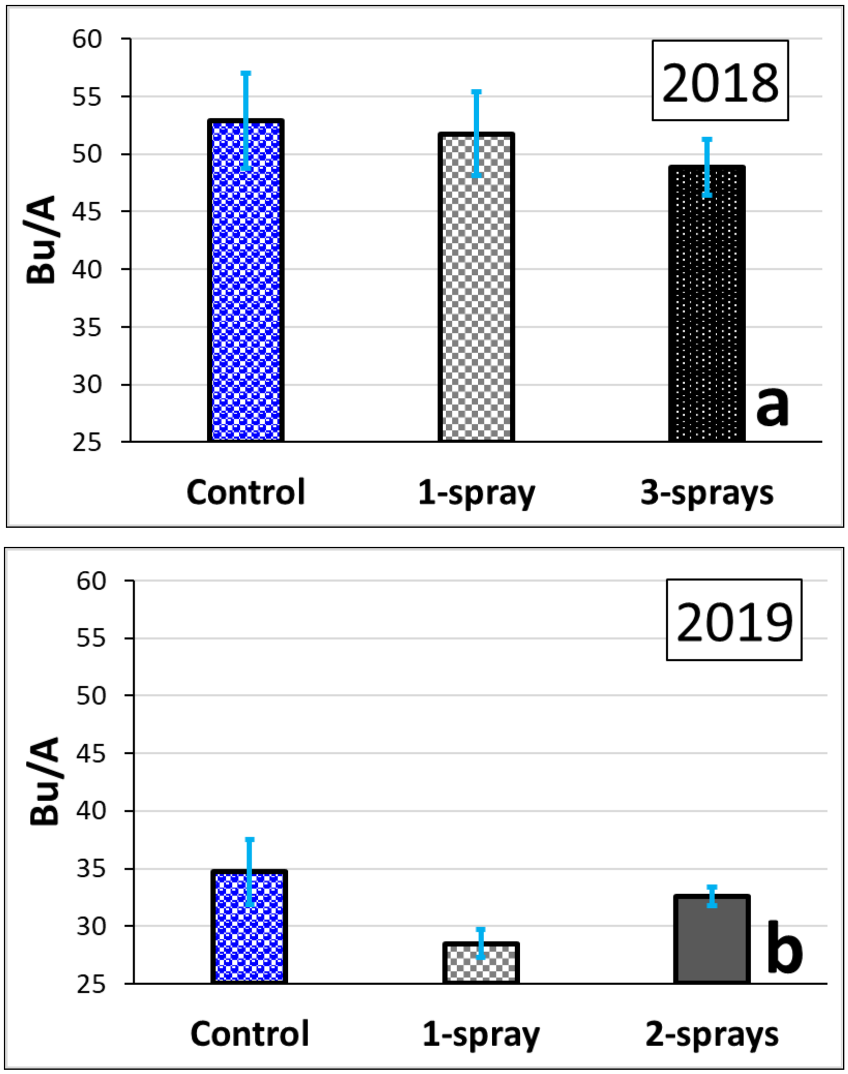

FIGURE 3. Mean yields (Bu/A) in (a) 2018 and (b) 2019. In control and two preventive spray treatments each year. No statistical differences were observed in 2018 (*p* = 0.35 $F_{2,9}$ = 0.71) or 2019 (*p* = 0.16, $F_{2,9}$ = 2.19).

DISCUSSION

Stinkbug outbreaks were not observed since the counts on all dates were below the threshold of 9 stinkbugs/25 sweeps in 2018 and 2019. This economic threshold is utilized by many states in the south such as Mississippi (Gore et al 2005) and Arkansas (Lorenz et al 2002), where there are higher populations of stinkbugs than in Kentucky. Furthermore, the species compositions are different in those states. In Kentucky the numbers of stink bugs might be smaller and present temporarily for shorter periods than in southern states. Here, we have similar species, with the exception of the redbanded stink bug, *Piezodorus guildinii* (Westwood). The latter is an invasive species of neotropical origin (Brazil) and probably the most important stink bug for soybean in the states surrounding the Gulf of Mexico (Vyavhare et al 2014). This economic threshold may need to be reviewed taking into account the species composition and management practices conducted nowadays.

The effects of the preventive insecticide (Warrior®) applications in 2018 and 2019 are puzzling. In 2018, the 1-spray treatment was the most effective; the control and the 3-spray treatments showed similar trends. In the 3-spray treatment the second and third applications may have affected natural enemies compared with the 1-spray, whereas stink bugs were not affected. The 1-spray may have targeted effectively the stink bug population. In 2019, all treatments had similar trends. In both years, the stink bug populations may have been low that any changes conducted by the preventive sprays and control were inconspicuous.

Yields in 2019 were almost half of yields obtained in 2018 (Figures 3a and 3b). The yield results between 2018 and 2019 might be related to several factors. Firstly, the soybean cultivar was different each year, and secondly, the planting date varied as well. In 2019, planting was carried out almost 20 days later than in 2018. Gore et al (2006) found that the earliest planting date had the lowest densities of stinkbugs, whereas the latest planting date had the highest densities of stinkbugs. In our study the late planting in 2019 compared with 2018 had highest cumulated stinkbugs (>15) (Figure 2b) by the end of August; whereas for the same period cumulated stink bugs were <15 (Figure 2a) in 2018.

Additionally, a severe drought was recorded in 2019 during almost the entire month of August, which might have influenced the low yields. During that time soybean pods were growing, with high demand of photoassimilates, water deficiency may have affected this process. All these factors in 2019 and including the cultivar effect might have affected and reduced yields compared with 2018.

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Soybean Cyst Nematode Survey in Kentucky – 2019

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OBJECTIVES

The objective of this research is to determine the percentage of fields in Kentucky that are infested with different levels of soybean cyst nematode (SCN).

MATERIALS AND METHODS

A total of 83 soil samples were collected from fields representing 19 Kentucky counties (Adair, Ballard, Breckinridge, Christian, Crittenden, Daviess, Edmonson, Fulton, Graves, Logan, Lyon, Marion, Muhlenberg, Russell, Spencer, Todd, Trigg, Union, and Wayne) during the 2019 growing season. Samples were collected from fields that had a history of soybean production. Samples were sent to the University of Illinois Plant Clinic, where cysts and eggs of SCN were extracted, and eggs were counted.

RESULTS

Counts of SCN eggs ranged from 0 to 10,640 eggs/100 cm^3 soil, with an average egg count of 1,280 eggs/100 cm^3 soil. Soybean cyst nematode eggs were detected in 84% of the fields tested with 45% of the fields having 1 to 499 eggs /100 cm^3 soil, 14% of the fields having 500 to 1,999 eggs/100 cm^3 soil, 24% of the field having 2,000 to 9,999 eggs/100 cm^3 soil, and 1% of the samples having at least 10,000 eggs/100 cm^3 soil (Figure 1).

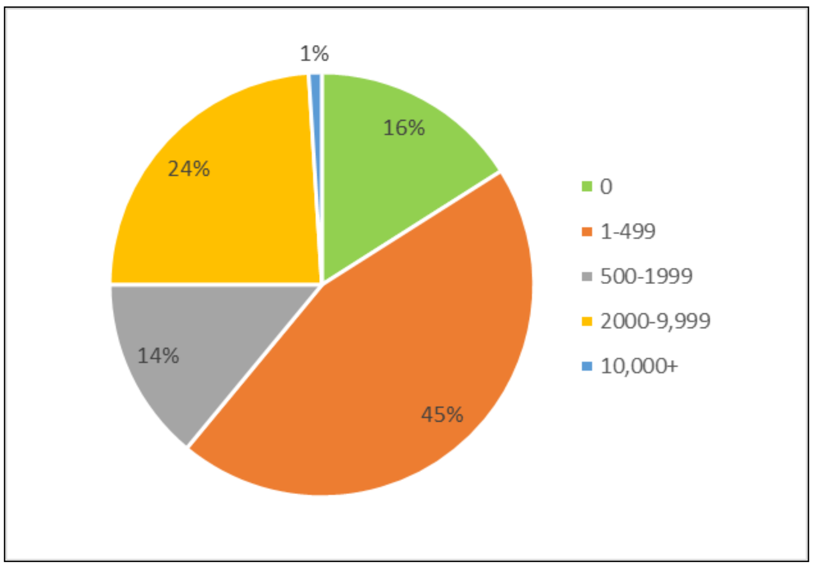

Figure 1. Percentage of Kentucky fields with different levels of soybean cyst nematode (SCN) eggs in the soil (0, 1-499, 500-1,999, 2,000-9,999, and at least 10,000 eggs/100 cm^3 soil) from a 2019 SCN survey.

CONCLUSIONS AND IMPLICATIONS

The risk of yield reductions due to SCN increases with greater numbers of SCN eggs in the soil. In general, fields with less than 500 eggs/100 cm^3 soil have a low risk of yield loss, fields with 500 to 1,999 eggs/100 cm^3 soil have a moderate risk of yield loss, and fields with at least 2,000 eggs/100 cm^3 soil have a high risk of yield loss. For fields that have over 10,000 eggs/100 cm^3, it is advised to plant a crop that is not a host to soybean (i.e corn or grain sorghum), so that SCN populations will decrease. Nearly 40% of the fields tested in Kentucky had at least a moderate risk of yield loss due to SCN (at least 500 eggs/100 cm^3 soil). It is important that Kentucky farmers test their fields for SCN on a regular basis to determine their risk of yield loss. Management practices that can help reduce the impact of SCN include rotating with a non-host crop, planting a SCN-resistant variety, and considering using a nematode-protectant seed treatment.

ACKNOWLEDGEMENTS

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Evaluating the Effects of *Dectes Texanus* in Soybeans Yields Using Exclusion Cages in Kentucky

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INTRODUCTION

Dectes texanus Leconte (Coleoptera: Cerambycidae) also known as Dectes stem borer is a pest that feeds on soybean inner stem tissue and is gaining notoriety in commercial soybeans of Kentucky (Villanueva 2018). Studies conducted in western Kentucky shown that *D. texanus* lays eggs on the pith of a leaf's petiole of soybeans by the end of July (Figure 1a), then after egg eclosion, a larva tunnels its way to the main stem while it consumes the pith, it moves up and down the stem to finally move downward to the base of the stem by mid-fall (Figure 1b and 1c). It overwinters as a larva in a well-protected chamber at base of the stem. This larva molts into a pupa by mid-June (Figure 1d). The pupa molts into an adult in approximately 10 days and changes to a dark grey-blackish color adult within this chamber (Figure 1e) to finally exit to feed, and mate (Figure 1f).

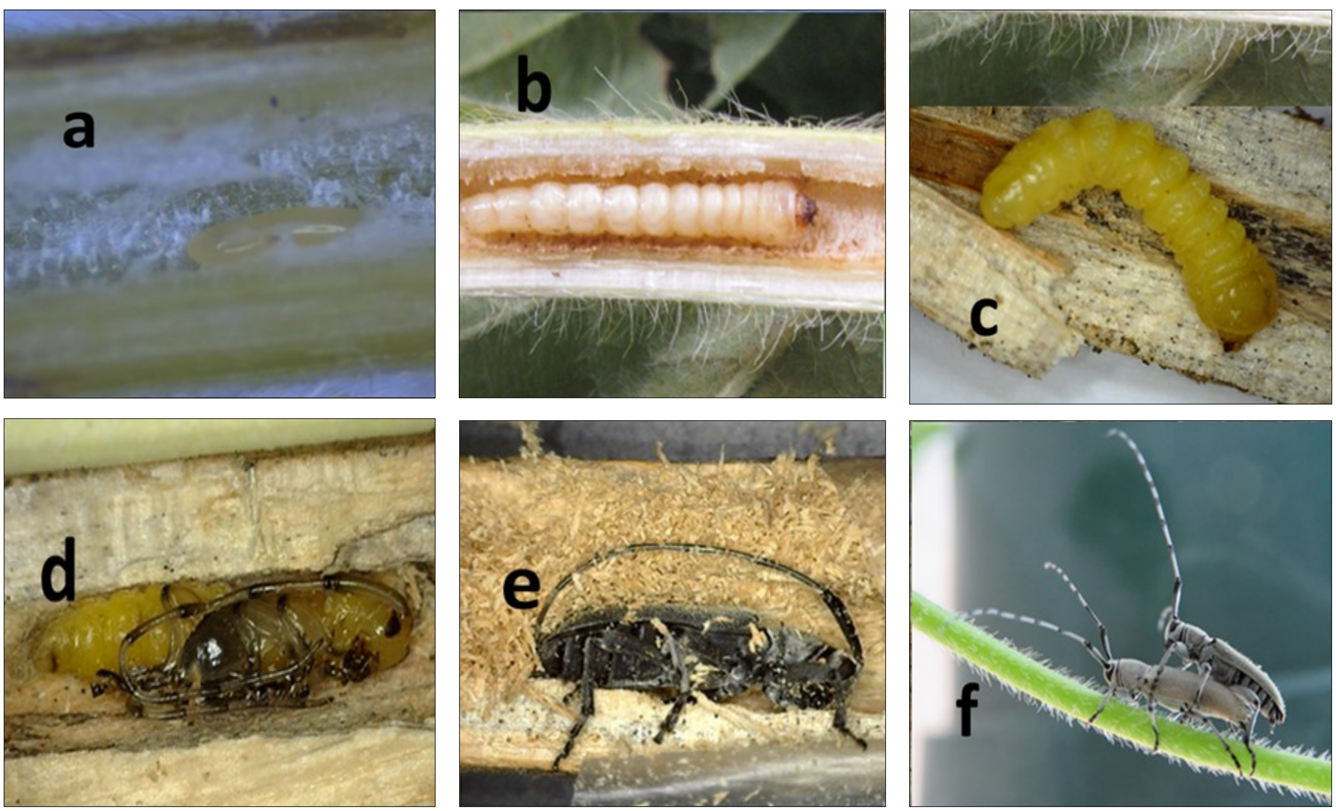

FIGURE 1. Different stages of *Dectes texanus:* a) Light-greenish egg oviposited in pith of petiole; b) Larva and tunnel in developing plants, c) Late instar larva, d) Pupa, e) Adult chewing an exit hole, and f) Fully developed adult. (Photos by C. Bradley and R. T. Villanueva).

Dectes texanus is a native insect of North America, reported originally as a pest of wild sunflower and weeds from the family Asteraceae (formerly Compositae). *Dectes texanus* was detected infesting stems of soybeans (*Glycine max* (L.) in 1968 (Daugherty and Jackson, 1969; Falter, 1969), and expanded its geographical range through over 20 states in the southwestern and central United States (Buschman and Sloderbeck, 2010). The losses associated with Dectes stem borer are caused by larval girdling and plant lodging. In 2017 and 2018, Kentucky farmers noticed infestations and found that more than 50% of their plants had *D. texanus* tunnels in some locations (Villanueva 2017). Similar observations were reported in southern Indiana and Illinois. The objectives of this study were to evaluate the infestations and yields of soybeans planted in exclusion cages with and without *D. texanus* release, and to compare their yields with plants in an open field.

MATERIALS AND METHODS

Full-season soybeans of the cultivar 470 RR/STSn (Caverndale Farms Brand Seeds, Danville, KY) were planted on 17 May 2018, and 22 May 2019; and double-crop soybeans of the cultivars 286 RR2Y/STSn (Caverndale) and AG27X7 (Asgrow Seed Co LLC, Bayer Co.) were planted on 19 June 2018, and 8 July 2019; respectively. Sixteen outdoor cages (1.8 m x 1.8 m x 1.8 m; width, length, height) were constructed on planted soybean fields using Proteknet Exclusion Insect Netting (Dubois Agrinovation, Quebec, Canada), and two crossed 6-m long steel rebar (Figure 2). Foam pool noodles were placed on the rebar to protect netting from damage owing to close contact with the bars. Studies and exclusion cages were set in experimental plots of soybeans in the University of Kentucky's Research and Education Center at Princeton.

FIGURE 2. Cages for exclusion studies, half of them containing 20 or 40 *D. texanus* stem borers (1:1 Sex ratio) released in 2018, and 2019, respectively. (Photo by, R.T Villanueva)

Each full-season and double-crop soybeans had 8 exclusion cages. In 2018, 20 adult *D. texanus* beetles, in a 1:1 sex ratio, were randomly released in each of the four cages of full-season and double-crop plots. Full-season was in R2 stage and double-crop was in V4. The remaining four cages in each field were kept as control (*D. texanus* free). In 2019, the same number of cages and treatments were repeated; however, 40 *D. texanus* adults (1:1 sex ratio) were released into each study cage in full season and double crop at the R2 and V3 stages, respectively. Soybean plants from 2 ft of the middle row were hand-harvested from each cage plus 4 sites outside the cages. Percentages of plants with tunnels and *D. texanus* larvae in plants were tallied. Full sample of the plot was weighted and corrected to 13% moisture to determine yield.

Mean yields were submitted to an analysis of variance (ANOVA) using PROC GLM (SAS 9.4; SAS Institute Inc. Cary, NC). Significant differences among yields were compared by the Tukey's HSD (honestly significant difference) test ($p \leq 0.05$).

RESULTS AND DISCUSSION

Net cages successfully excluded *D. texanus* beetles infesting full-season and double-crop soybeans in 2018 and 2019 (Table 1). Table 1 shows the mean percentages of plants with tunnels and with *D. texanus* larva. Significant differences on tunnels and larval presence between the caged plants with *D. texanus* releases in 2018 and 2019 and plants in the open fields (without exclusion nets) were not found ($p>0.05$). *Dectes texanus* larvae were not found in all tunneled plants. This might be related to unknown causes of mortalities including entomopathogenic organisms in caged or open field plants; or hymenopteran parasitoids in plants in the open field. The short-season plants in 2019 escaped from infestations of *D. texanus* because during the ovipositional period of *D. texanus* these plants had not developed the pith in the stem, and *D. texanus* only oviposits in plants with a well-developed pith, since this tissue is the larva's food source. Adult female *D. texanus* tests the suitability of the host by chewing a hole in the stem or branch epidermis and probing with the ovipositor to detect presence of pith (Hatchett et al., 1975).

TABLE 1. Percentages of plants with tunnels caused by *D. texanus* larva; and plants where *D. texanus* larvae were found in full-season and double-crop soybeans in screened cages or open field plants. Adults *D. texanus* were released in 2018 (10 males and 10 females), and 2019 (20 females and 20 males). Open field plants where adjacent to the insect exclusion caged plants.

Treatments Maturity group	% of plants with tunnels or larva	Cage with *D. texanus*	Cage without *D. texanus*	Plants without exclusion net
Full-season 2018 (470 RR/STSn)	% tunneled plants	66.7%	0%	66.8%
	%plants with larva	33.5%	0%	37.5%
Short-season 2018 (286 RR2Y/STSn)	% tunneled plants	25.0%	0%	33.3%
	%plants with larva	4.3%	0%	12.5%
Full-season 2018 (470 RR/STSn)	% tunneled plants	83.5%	0%	96.3%
	%plants with larva	83.5%	0%	96.3%
Short-season 2019* (AG27X7)	% tunneled plants	-	-	-
	%plants with larva	-	-	-

*Not infested by *D. texanus* because plants did not developed pith during oviposition period.

The effects of *D. texanus* on full-season soybeans yields were not significant (p>0.05) for the three treatments in both 2018 and 2019 (Figures 3a, and 3c). For double-crop soybeans in 2018, caged soybeans (regardless the presence of D. texanus) had significantly higher yield compared to the open field plants (Figure 3b). Caged soybeans, with and without *D. texanus* infestation in 2018 significantly doubled (37.8±3.3 and 38.4±3.3 (Mean ± SEM) Bu/A, respectively) the yields of soybeans from open fields (uncaged)(19.5±1.6 (Mean ± SEM) Bu/A) (Figure 3b).The latter might be caused by other factors including weed competition, and attack from other pests including defoliator caterpillars, and pod feeders such stink bugs and bean leaf beetles that were not present in the caged plants.

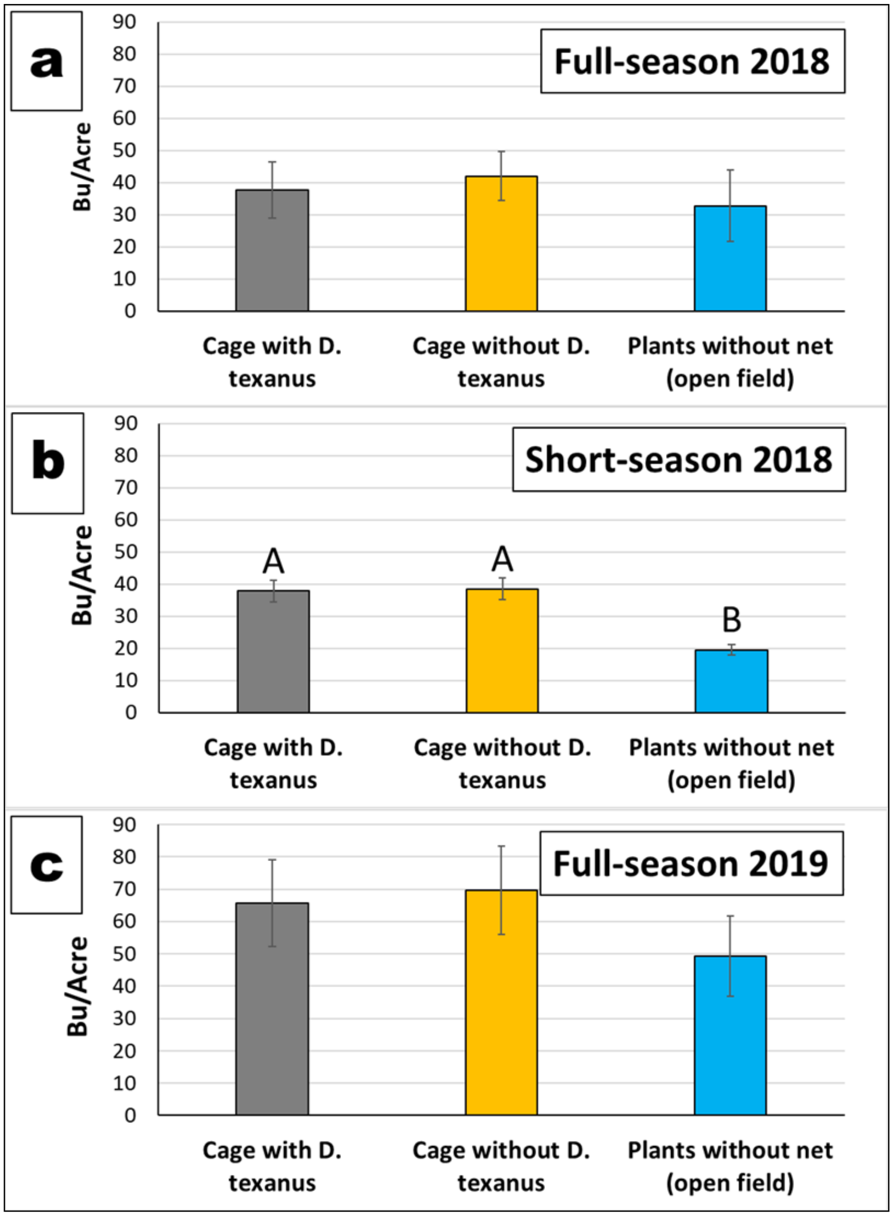

FIGURE 3. Mean yields (±SEM) (Bu/A)) for full-season (2018 and 2019) and short-season (2018) soybeans in caged plants with and without *D. texanus* and plants in the open field in the UK's REC at Princeton, KY. Significant differences among means are shown by different letters (*p*≤0.05, Tukey's HSD post-hoc test) within each maturity group each year.

Although, soybean yields between cages with and without *D. texanus* were not statistically significant ($p>0.05$) (Figures 3a, 3b, and 3c), they were numerically different. Small amounts of reduction in yield in the cages with *D. texanus* can be relevant when total acreages of large commercial soybeans farms are taken into consideration. Also, previous studies shown that *D. texanus* affect the physiological yield losses in soybean plants around 10-11% (Richardson, 1975; Buschman et al., 2006).

Although in these studies significant differences on soybean yields were not found in cages with and without *D. texanus*, the potential damage of this pest is in economic losses associated with lodging of soybean. If there are larger numbers of plants infested with *D. texanus* in a field, and environmental conditions such as strong winds and rains, they can increase lodging rates and reducing yields compared with plants without *D. texanus* infestations.

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Quantifying the Yield Potential and Yield Gap Associated to Water Stress in Kentucky Soybean Production

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JUSTIFICATION AND GOAL

Productivity of rainfed grain crops in Kentucky can be limited by water availability depending on precipitation patterns and the timing of critical crop developmental stages. Unfortunately, on any given year the size of the yield gap due to water stress is unknown for producers. This limits their ability to make informed decisions on the need to invest on irrigation equipment. A research project was funded by the KY Soybean Board in 2017 to quantify the soybean yield potential under no water limitation, and evaluate the response to irrigation across soybean maturities and planting dates.

METHODS

Field trials were stablished during 2017-2019 in Lexington, KY under irrigated and rainfed conditions, with two planting dates (May and June) and MG 2 to 5 cultivars (16 cultivars in total). In addition, a trial was conducted in Princeton, KY during 2017 with a May planting date. Data collected will be used to report the yield response to irrigation on these sites, but also for future research efforts that will calibrate a crop simulation model to predict across different locations and soil types in KY.

RESULTS

Soybean yield under irrigation was highly dependent on the year, planting date, and MG choice, ranging from 53 to 87 bu ac^{-1} (Figure 1). The effect of cultivar selection within a MG on yield was small relative to the effect of MG selection (data not shown). These results suggest that genetic differences in yield potential across cultivars were small, and mostly associated by different timing of developmental stages and environmental conditions during critical phases.

The three growing seasons in this study provided an excellent range in precipitation to evaluate our research question. In Lexington, precipitation was greatest during the 2018 growing season, followed by 2017, and lowest during 2019. During 2018, excess precipitation during one week (5 inches total) following beginning flowering of MG 3 cultivars planted in May caused a drastic yield drop in this treatment (Figure 1, middle). Similarly, high precipitation at the end of the growing season in 2018 caused severe seed damage of MG 5 cultivars planted in June that led to a complete harvest loss. Overall, the yield response to irrigation ranged from no response to a yield increase of 37 bu ac^{-1} depending on the year, planting date, and MG cultivar.

CONCLUSIONS

There was a large variability in soybean yield potential under no water stress, and on the response to irrigation depending on the location, planting date, and MG. The different yield response observed by planting date and MG cultivars indicates scope for management adaptation strategies that reduce the risk of low yields under rainfed conditions in KY. Given the large year to year variability in yield across treatments, combining field experiments with predictions across more years with a calibrated crop simulation model can provide more robust planting date, maturity group choice, and irrigation recommendations to producers.

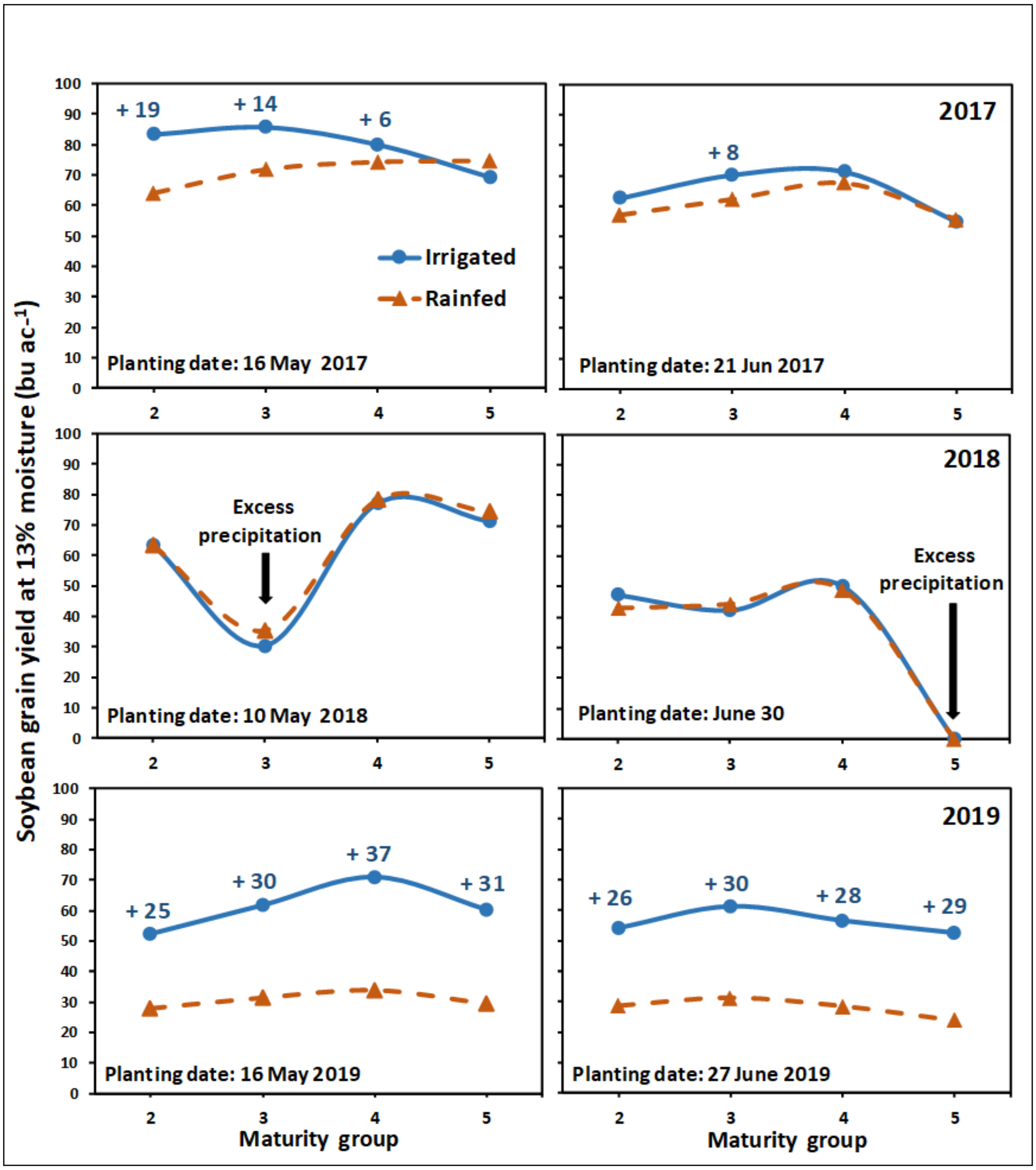

Figure 1: Effect of irrigation on average soybean yield by planting date and MG cultivar during 2017 - 2019. Values on top of symbols indicate a significant yield increase from the rainfed treatment in bu ac^{-1}. There was a yield reduction due to excessive precipitation in 2018, depending on the planting date and MG cultivar.

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How Does Management Increase Soybean Seed Protein? A Mechanistic Approach to Identifying Limitations and Opportunities

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INTRODUCTION AND GOALS

Soybean is a main source of protein for livestock and poultry feed. Although U.S. soybean yield in the U.S. has increased at a rate of 0.49 bu ac^{-1} since 1986, there has been a decrease in seed protein concentration of 0.038% per year. This has generated major economic and marketing concerns, in particular for soybean from northern states, that typically produce seed with lower protein concentration compared to more southern latitudes.

In addition to genetics, seed composition and meal value are the results of environmental and management factors (Figure 1). Soybean producers adopt a diversity of new management practices (i.e. use of cover crops) that can largely influence N availability and thus potentially seed protein. However, the potential to influence seed composition with different management and cultural practices has received little attention. Understanding how management practices can be adapted in different U.S. regions to ensure both high productivity and improved seed quality is essential to improve the N balance in soybean cropping systems and increase soybean value in the marketplace. Moreover, developing tools that evaluate the crop N status and allow to adapt inputs to different crop N demands to different locations and years are necessary.

This project is evaluating different maturity groups and cultivars across a wide range of environmental conditions (AR, KY, and MN) to: (1) quantify the potential of late season N fertilizer applications and *B. japonicum* inoculations to improve protein quantity and quality (amino acid and fatty acid profiles), (2) evaluate these practices in soybean grown after fallow or after a winter cereal cover crop, and (3) to determine if aerial images can be used to detect crop N limitations and adapt inputs. In addition, the dataset generated from this project will be key to test and improve simulation models that can predict C and N cycling in soybean to accurately estimate seed composition under different environments and management practices. Results from the first year of trials conducted in Kentucky are presented in this report.

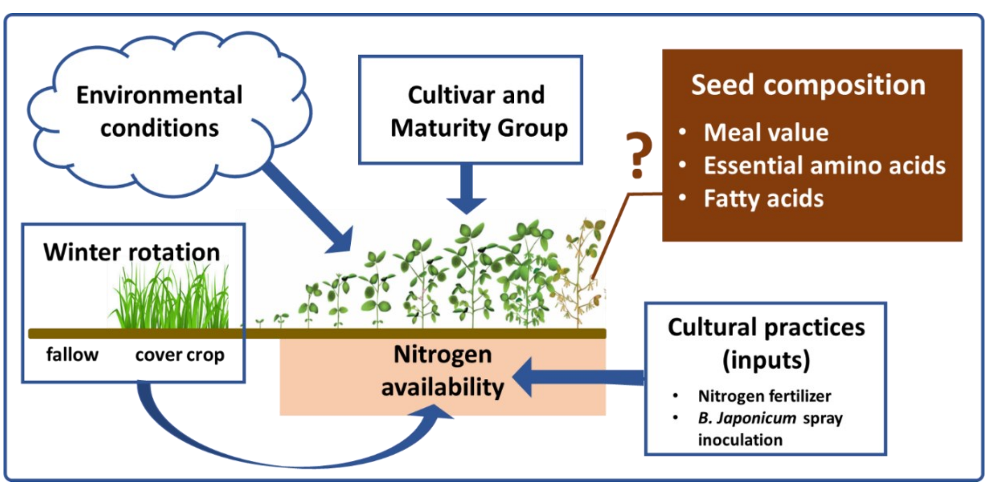

Figure 1. Conceptual model describing the interactive factors that influence seed composition and meal value with blue arrows. This study employs a systems approach that considers all these different factors to achieve a better understanding of the potential and limitations to enhance seed composition with cultural and management practices.

MATERIALS AND METHODS

Field experiments were conducted during 2019 in three locations, and will be repeated in 2020: Lexington, KY (Upper-Midsouth), Fayetteville, AR (Midsouth), and in St. Paul, MN (Upper-Midwest) (Figure 2). Experiments in AR and KY were irrigated. Treatments evaluated include two types of rotation (soybean after fallow or after a winter cereal rye cover crop), two cultivar maturity groups within each location (MG), and three late-season input treatments (no nitrogen application, 180 lb N ac^{-1} at R5, or *Bradyrhizobium japonicum* inoculant application at R3). Nitrogen was applied in two side-dress applications (R5 and 14 days after R5). *Bradyrhizobium japonicum* liquid inoculant (Cell-Tech liquid, Monsanto BioAg) was applied at a rate of 1 oz per 1,000 ft row on the soil surface at R3. Aerial images were also collected to determine soybean N status (Figure 3).

Figure 2. Soybean experimental plots (left), and winter rye cover crop (right) in Lexington, KY.

Figure 3. Example from aerial images collected during the soybean growing season to identify differences in the crop N status as a result of the treatments applied. Orthomosaic RGB image of experimental plots in KY on 8/28/2019 (top), and orthomosaic RGB (middle) and NDVI image (bottom) of experimental plots in AR on 8/6/2019.

RESULTS FROM 2019 IN KENTUCKY

Soybean yields after a cover crop compared to winter fallow were 5-10 bu ac^{-1} greater in two out of six cultivars in our study (Figure 4, A). The different late-season input treatments evaluated did not affect soybean yield in KY (data not shown). The late N fertilizer application was effective increasing seed protein concentration relative to the control (Figure 4, B). However, late N fertilizer applications also reduced oil protein concentration (Figure 4, C).

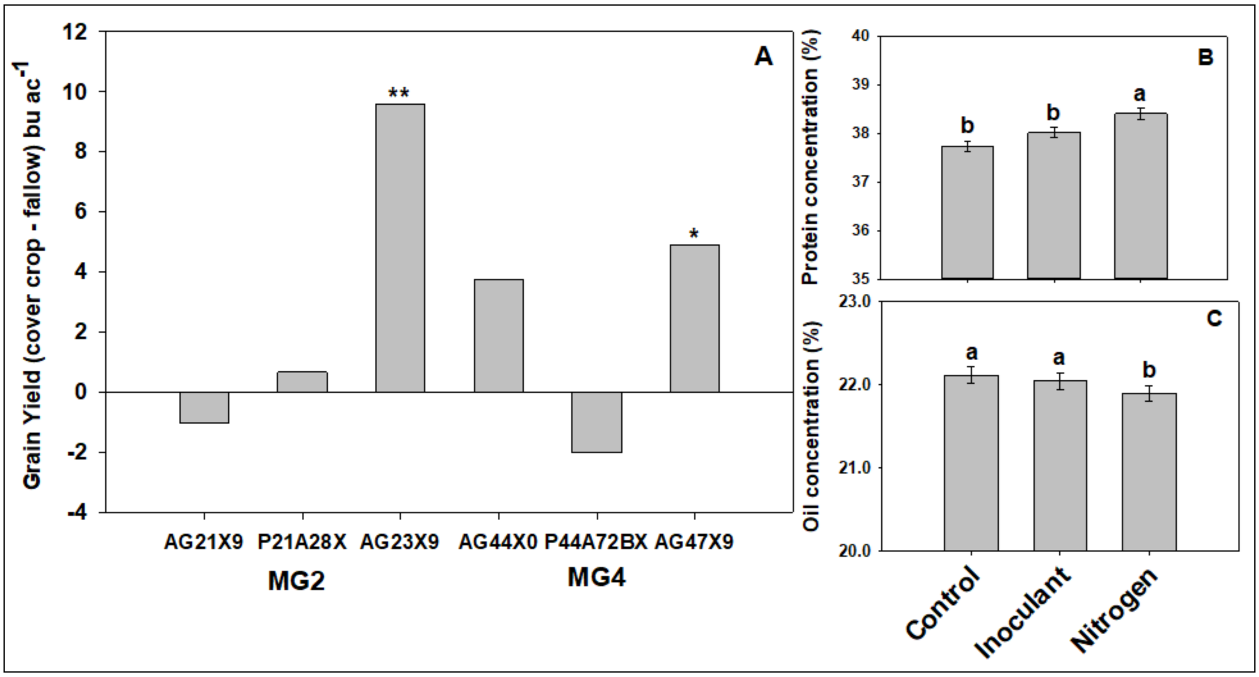

Figure 4. Cover crop effect on relative grain yield in Kentucky by cultivar (A); Effect of late-season input treatments on seed protein concentration (B); and oil concentration (C). * and ** indicate a significant yield difference between the fallow and cover crop treatment at the 0.05 and 0.01 probability level, respectively. Different letters in B and C indicate significant differences between treatments at P<0.05.

CONCLUSIONS

Preliminary results from our first year of trials indicate that growing irrigated soybean after a winter cereal rye cover crop did not cause a yield reduction. Instead, soybean yields after a cover crop were 4-9 bushels/acre greater in two out of the six cultivars evaluated. Late nitrogen fertilizer application after R5 increased seed protein concentration, supporting our hypothesis that N availability during the seed filling phase is partially limiting protein concentration, and this may be palliated with management practices.

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