Weed Management Programs for Mississippi Soybean Production
Mississippi Soybean Promotion Board Project 20-2020 Annual Report

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Background and Objectives:

Glyphosate-resistant Palmer amaranth is the most troublesome weed in Mississippi soybean. Palmer amaranth competes for nutrients, water, light, and space because of its rapid, upright growth habit and allelopathic properties. Barnyardgrass is one of the more problematic weeds in U.S. soybean production. Recently, Mississippi and Tennessee became the first states to confirm GR barnyardgrass. Mixing herbicides representing different modes of action provides the potential for increased weed control and a reduction in application costs. However, some components of herbicide mixtures can synergize or antagonize others. It is important to identify effective programs for broad-spectrum weed control in these technologies. Recommendations for weed control in Mississippi soybean will originate from this research.

Manipulation of row spacing to supplement weed control has been well documented. When only considering weed control, soybean planted with a grain drill in rows spaced 6 to 10 inches apart has been shown to be optimal. However, agronomic research indicates drilled soybean often do not perform to the level of soybean planted with a precision planter in wide row configurations of ≥30 inches.

Planting multiple rows (>2) on a raised bed with a grain drill has not been accepted in Mississippi; however, a twin row configuration on a raised bed is used extensively. There is growing interest among Mississippi growers in transitioning to a bedded system where the beds are 60 to 80 inches wide. Currently, if the wider bed configuration is utilized, soybean are planted with a twin-row planter. Although irrigation could possibly be improved, a system such as this does not enhance weed control because the “twin rows” are planted on the same spacing as used when beds are 30 to 40 inches.

OBJECTIVE(S):

1. Evaluate new and/or currently registered herbicides and herbicide-resistant technologies for positioning into Mississippi weed management programs.
2. Assess management of GR Palmer amaranth by (a) characterizing the agronomic benefits of combining the Roundup Ready 2 Xtend System with narrow row spacing on a raised bed in irrigated soybean, and (b) defining herbicide programs that optimize GR Palmer amaranth control when Roundup Ready 2 Xtend soybean are grown with narrow row spacing on a raised, wide bed system.
3. Refine suggestions for control of grass weed species by (a) identifying reasons for poor grass control in current soybean herbicide programs, and (b) designing grass control techniques that fit into current herbicide programs in Mississippi soybean.

Report of Progress/Activity:

Objective 1 – 2020

Seventeen studies were conducted at the Delta Research and Extension Center in 2020 to evaluate new and/or currently registered herbicides and herbicide-resistant soybean technologies for positioning into Mississippi weed management programs. Many of these studies focused on the efficacy of pre-mixes of currently registered herbicides or generic formulations of commercial herbicides. Use of Engenia, Xtendimax with VaporGrip, or Tavium with VaporGrip (dicamba plus *s*-metolachlor) continue to be evaluated in Roundup Ready 2 Xtend soybean. Additionally, weed control with Enlist Duo (glyphosate plus 2,4-D choline) and Enlist One (2,4-D choline) in E3 soybean are a focus area.

Research has been conducted annually since 2010 in the Mississippi Delta to evaluate weed control programs in the Roundup Ready Xtend weed control system, which was developed by Bayer Crop Science (formerly Monsanto Company). The Enlist (E3) weed control system, which was developed by Corteva Agrisciences (formerly Dow Agrosciences), has been evaluated at the Delta Research and Extension Center; however, this system has not been studied as thoroughly as the Roundup Ready Xtend weed control system. Furthermore, most previous research with these systems focused on herbicide programs for each technology. However, little work has been done comparing weed control between the two systems. Prickly sida has become a consistent problem in Roundup Ready 2 Xtend soybean because both glyphosate and dicamba offer only marginal control of this species.

Two studies conducted in 2020 evaluated prickly sida control with PRE or POST herbicide treatments representative of Roundup Ready 2, Roundup Ready 2 Xtend, and E3 soybean systems. The first study evaluated PRE-only treatments that could be utilized in any herbicide system. The second study compared prickly sida control with various POST treatments specific to different herbicide systems.

At 28 days after planting, all PRE treatments controlled prickly sida ≥ 90% 28 days after planting (Figure 1). Only Boundary and Prefix provided <90% prickly sida control 28 days after planting. Although Scepter, Command (1 or 2 pt/A), Scepter plus Command, and Python controlled prickly sida (Figure 1), none of these treatments provided >55% control of Palmer amaranth (Figure 2a). Treatments containing Dual Magnum (including Boundary and Prefix) or TriCor were required for Palmer amaranth control >85% at 28 days after planting (Figure 2a). Command is the foundational herbicide for barnyardgrass control in rice, and treatments with Command controlled barnyardgrass >80% in the current research (Figure 2b).

Even though multiple, labeled PRE treatments controlled prickly sida, weed species do not exist in a vacuum, and treatments must perform well across problematic species to be viable for commercial applications. Fortunately, multiple treatments evaluated in the current work controlled prickly sida, Palmer amaranth, and barnyardgrass, which are all among the most common and troublesome weeds of soybean in Mississippi. In situations where a PRE treatment for prickly sida is required, Mississippi soybean growers should rely on Scepter plus Dual Magnum or Command plus TriCor to manage prickly sida and provide control of Palmer amaranth and barnyardgrass.

Figure 1. Prickly sida control 28 days after planting with different residual herbicides at Stoneville, MS, in 2020.

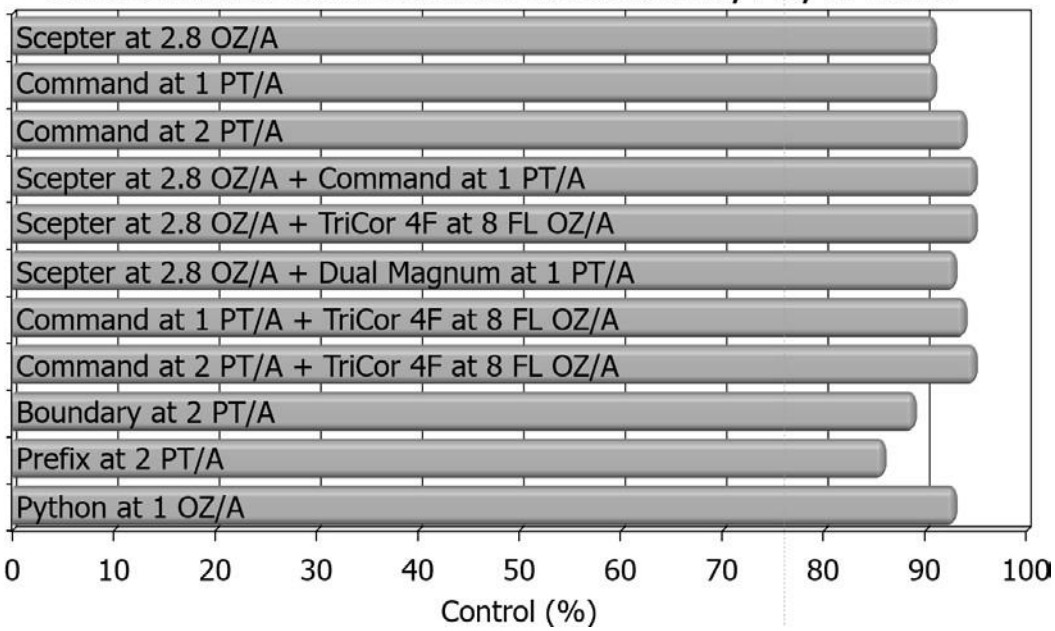


Figure 2. Palmer amaranth and barnyardgrass control 28 days after planting with different residual herbicides at Stoneville, MS, in 2020.

Figure 2a. Palmer amaranth control.

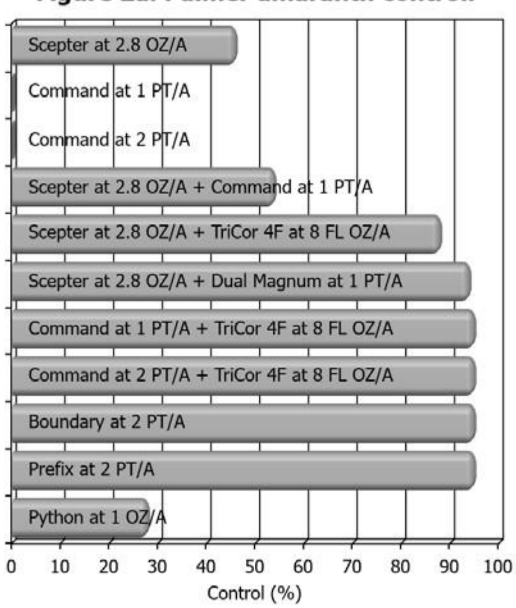
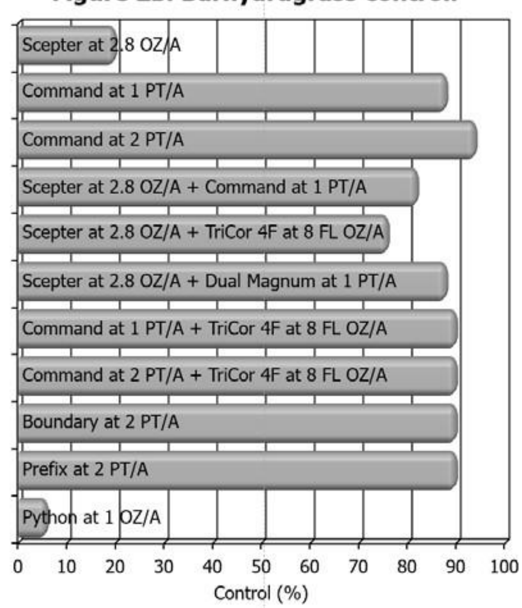


Figure 2b. Barnyardgrass control.



The majority of soybean in Mississippi have been Roundup Ready 2 Xtend since commercialization of that technology in 2017. Consequently, most POST soybean herbicide programs over the last few years have had glyphosate and dicamba as the base treatments. Since these common treatments do not adequately control prickly sida, this species has increased in importance in Mississippi. Roundup PowerMax and Roundup PowerMax plus Engenia controlled prickly sida 66 and 78%, respectively, 14 days after application (Figure 3).

Figure 3. Prickly sida control 14 days after application of different POST herbicide treatments at Stoneville, MS, in 2020.

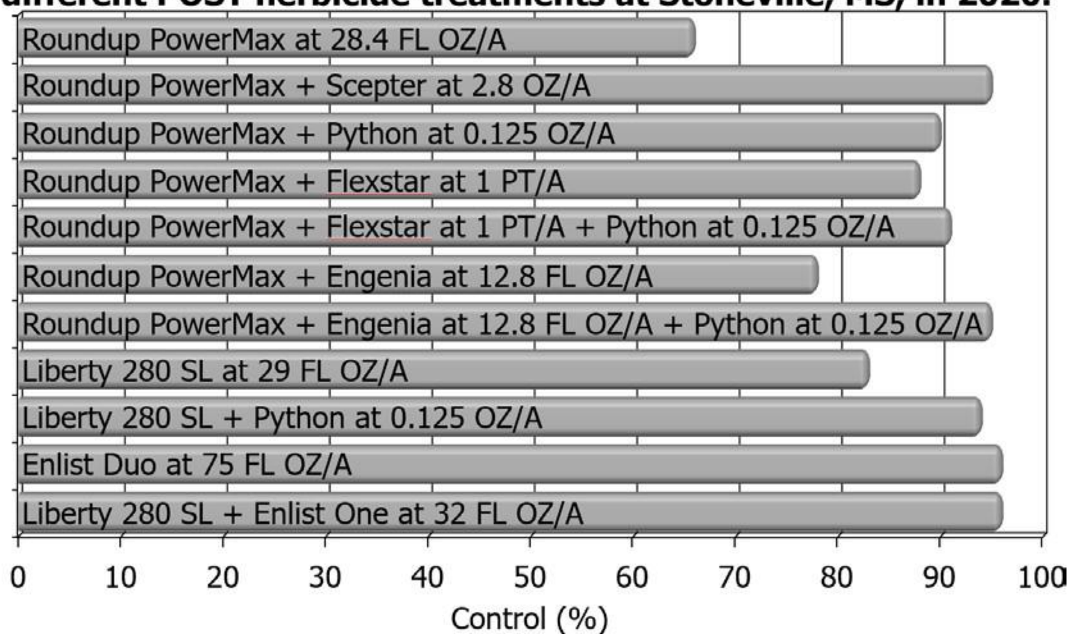
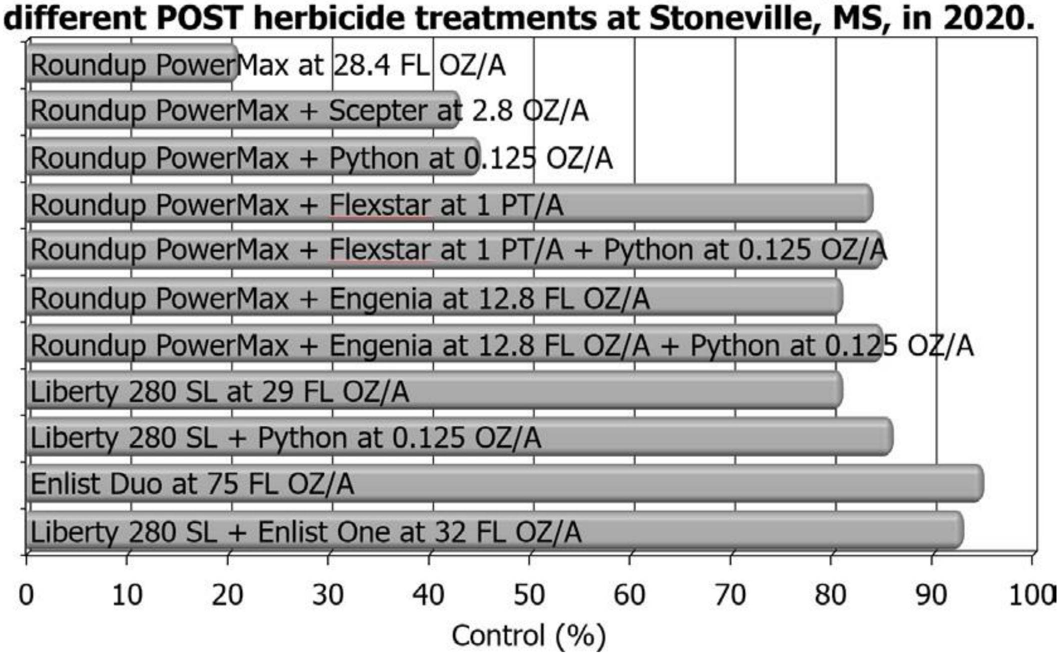


Figure 4. Palmer amaranth control 14 days after application of different POST herbicide treatments at Stoneville, MS, in 2020.



Mixing Python with Roundup PowerMax or Roundup PowerMax plus Engenia improved prickly sida control with these treatments to > 89% 14 days after application. Enlist Duo and Enlist One plus Liberty 280 SL controlled prickly sida ≥ 95% at the same evaluation, and problematically, these were also the only treatments that controlled Palmer amaranth >90% 14 days after application (Figure 4). Python was required in Roundup Ready 2, Roundup Ready 2 Xtend, and LibertyLink treatments to adequately control prickly sida; however, the additional mixture was not needed in POST treatments common in E3 soybean. Sequential POST treatments would be required for complete control of prickly sida and Palmer amaranth with the treatments evaluated in the current work.

Objective 2 – 2020

One study evaluated the effects of row configuration on soybean growth and development. The experimental design was a split-plot with four replications. Whole plots were planting dates that included an early and a late planting date. The late planting date was planted 10 to 14 d after the early planting date. Sub-plots were soybean row configuration and included single-, twin-, and triple-row configurations planted at a seeding rate of 130,000 seed/A. Single-row configuration plots were planted with a four-row vacuum planter. Twin-row configuration plots were planted with a precision four-row vacuum planter with 7.5-inch spaced units. Triple-row configuration plots were planted with a grain drill with which three of the nine units were blocked off so that three 7.5-inch spaced units were on top of two of the 40-inch beds.

Soybean density was recorded by counting all plants in two randomly selected areas within a meter of row on rows two and three of each plot at soybean growth stages V2 (first trifoliate leaf fully emerged), V4 (three fully emerged trifoliate leaves), R1 (first flower anywhere on plant), R5 (visible seed in pod of upper four nodes), and maturity (50% of pods mature in color and containing mature seed). Soybean plant height was recorded by measuring from the base of the plant at the soil surface to the uppermost trifoliate with a meter stick on five randomly selected plants on rows two and three of each plot at the same soybean growth stage previously described. Days to canopy closure were collected and recorded by using a meter stick and measuring (cm) the distance between plant foliage on rows two and three. Once a plot measured zero cm, canopy closure was complete, and that date was recorded. Soybean dry weight (g) was collected from all plots at R6.5 (pod and pod wall beginning to turn mature color) by manually removing all above ground soybean biomass within 1 linear m of row on rows 2 and 3, letting the samples dry in a greenhouse and weighing them. Soybean yield components were recorded by collecting 5 random soybean plants at soybean growth stage R 6.5 in each plot and counting total number of pods, nodes, and seed. A soybean harvest index was calculated by taking the ratio of seed dry weight to vegetation dry weight. Lodging score was visibly estimated on a 0 to 10 scale with 0 meaning all plants were upright and 10 meaning all plants were lying completely flat. Soybean yield was collected and recorded with a small-plot combine at maturity. A subsample of soybean seed was collected from each plot during harvest and graded for quality. All data were subject to analysis of variance (ANOVA) utilizing the PROC GLIMMIX procedure with Fisher's protected LSD (α=0.05) in SAS 9.4.

This study was replicated five additional times at different sites at the Delta Research and Extension Center. Three studies were conducted on a Commerce silty clay loam (Fine-silty, mixed, superactive, nonacid, thermic Fluvaquentic Endoaquepts) and remaining studies were conducted on a Sharkey clay (Very-fine, smectitic, thermic Chromic Epiaquerts). All studies were weed-free.

Soybean yields were greater in single- and twin-row configurations compared to triple-row for both early and late planting dates (Table 1). However, no differences in yield were observed between single- and twin-row configurations at either planting date. Triple-row configuration plants had more pods/node than both single- and twin-row configurations. Additionally, there were no differences between single- and twin-row configurations in terms of pods/node. No differences were observed among row configurations for plant biomass.

Table 1. Soybean yield, pods per node, and biomass (g) for studies evaluating agronomic performance of soybean on different row configurations and planting dates.

	Yield (Bu/A)			
Row Configuration	Early Planting	Late Planting	Pods/Node	Biomass (g)
Single	53 a	47 a	2.7 b	836 a
Twin	56 a	48 a	2.7 b	876 a
Triple	50 b	45 b	4.1 a	823 a

*Means followed by the same letter for each parameter are not different at $p \leq 0.05$.

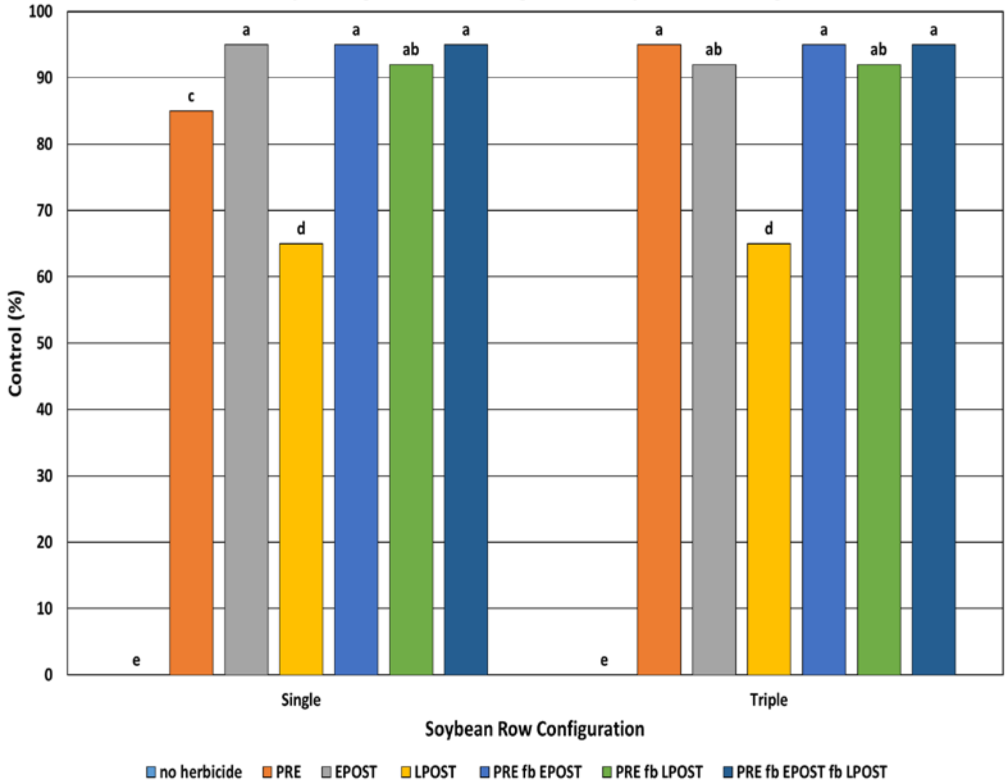
Another study evaluated herbicide programs including PRE and POST applications for soybean planted in different row configurations. Experimental design was a randomized complete block with a two-factor factorial treatment arrangement and four replications. Factor A was row configuration and consisted of soybean planted in single- or triple-row planting patterns. Factor B was herbicide treatment and consisted of no herbicide treatment, PRE only, early-POST (EPOST) at soybean growth stage V3 (vegetative growth stage where three unfolded trifoliate leaves are visible), LPOST (late post application at 14 d after V3), PRE followed by (fb) EPOST, PRE fb LPOST, and PRE fb EPOST fb LPOST. The PRE treatments were Boundary at 2 pt/A, and POST treatments were a combination of Roundup PowerMax, Engenia, and Warrant. Visible estimates of Palmer amaranth control were recorded 14 d after EPOST (DA-EPOST) and 14 d after LPOST (DA-LPOST). Soybean yield was collected with a small-plot combine and adjusted to 13% moisture content. All data were subjected to ANOVA utilizing PROC GLIMMIX in SAS 9.4.

Differences in Palmer amaranth control 14 DA-EPOST and 14 DA-LPOST were detected among herbicide treatments in soybean grown in single- and triple-row configurations (Figures 1 and 2). With the exception of the no herbicide treatment, Palmer amaranth control 14 DA-EPOST was least with LPOST applications regardless of row configuration. For PRE-only treatments, Palmer amaranth control 14 DA-EPOST was greater in triple- compared with single-row soybean configurations. Control in single- and triple-row configurations was similar among EPOST-only and treatments including PRE fb POST herbicide programs.

In all plots receiving a LPOST-only treatment, Palmer amaranth control 14 DA-LPOST was greater in triple- compared with single-row configurations (Figure 2). LPOST-only treatment controlled less Palmer amaranth than all other herbicide treatments across both row configurations. Additionally, treatments with PRE fb POST herbicide programs provided comparable Palmer amaranth control across both row configurations.

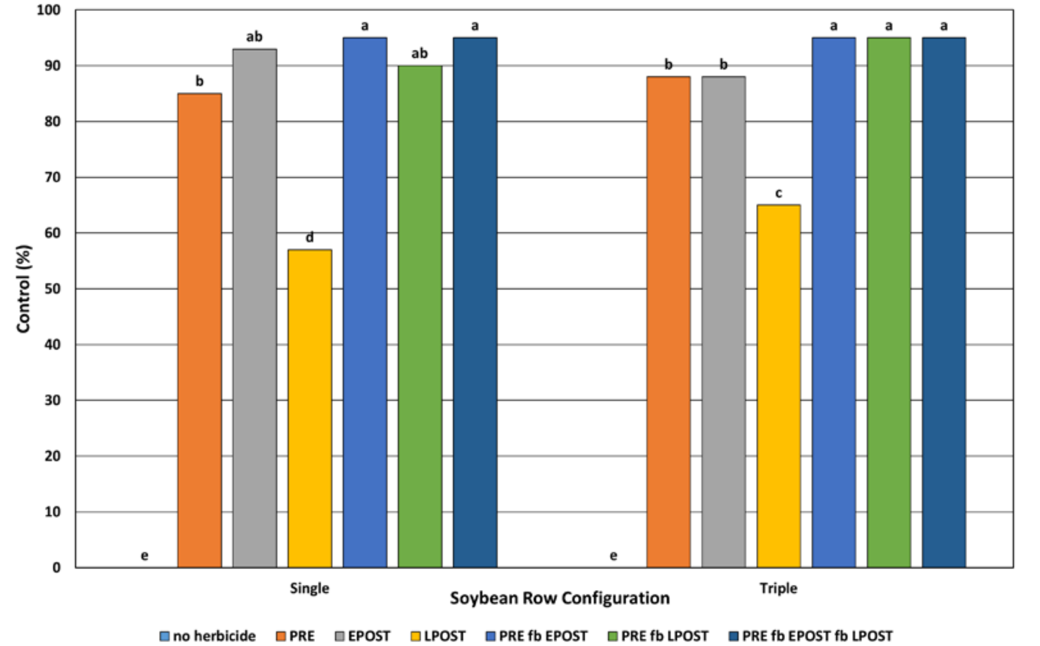
Soybean yields following any herbicide treatment were greater than in plots receiving no herbicide for soybean grown in single- or triple-row configurations. Soybean yield in plots receiving EPOST-only treatments was greater in triple- compared with single-row configuration. For both soybean row configurations, PRE fb EPOST herbicide programs led to greater yields than PRE fb LPOST treatments.

Figure 1. Palmer amaranth control 14 DA-EPOST with different herbicide treatments in soybean grown with single- and triple-row configurations.



***Bars labeled with the same letter are not different (α=0.05)**

Figure 2. Palmer amaranth control 14 DA-LPOST with different herbicide treatments in soybean grown with single- and triple-row configurations



*Bars labeled with the same letter are not different (α=0.05)

Objective 3 – 2019 and 2020

Implementation of new herbicide technology often results in a shift of problematic weeds. Understanding the cause of this shift is vital for control of troublesome weeds. Recent reports of poor grass control have become common in the midsouthern U.S.; therefore' on-going research is being conducted at the Delta Research and Extension Center to address these issues.

Two studies were conducted at the Delta Research and Extension Center in 2019 and 2020 to evaluate the interaction of glyphosate mixed with dicamba for barnyardgrass control . The first study evaluated different formulations of glyphosate (Roundup PowerMax, Makaze, Envy Six Max, Conerstone 5 Plus, and Honcho K6) in combination with Engenia. The different formulations of glyphosate were chosen to (1) represent products sold by common retailers in Mississippi and (2) represent the different salt bases used in glyphosate. The second study evaluated different formulations of dicamba (Engenia, Xtendimax with VaporGrip, and Fexapan plus VaporGrip) as well as 2,4-D (Enlist One) in combination with Roundup PowerMax.

Table 1. Barnyardgrass control 21 days after application of different glyphosate formulations with and without Engenia.

Treatment	Rate FL OZ/A	Timing	Barnyardgrass 2019 %		Barnyardgrass 2020 %	
Roundup PowerMax	32	6-8 in ECHCG	91	a	97	a
Makaze	32	6-8 in ECHCG	90	a	96	a
Envy Six Max	22	6-8 in ECHCG	89	a	87	b
Cornerstone 5 Plus	23.3	6-8 in ECHCG	91	a	92	ab
Honcho K6	23.3	6-8 in ECHCG	90	a	97	a
Engenia	12.8	6-8 in ECHCG	0	c	0	c
Roundup PowerMax Engenia	32 12.8	6-8 in ECHCG	83	b	97	a
Makaze Engenia	32 12.8	6-8 in ECHCG	81	b	92	ab
Envy Six Max Engenia	22 12.8	6-8 in ECHCG	80	b	86	b
Conerstone 5 Plus Engenia	23.3 12.8	6-8 in ECHCG	80	b	90	ab
Honcho K6 Engenia	23.3 12.8	6-8 in ECHCG	81	b	96	a

[a]Means within a column followed by the same letter are not different at $p \leq 0.05$.
[b]Abreviations: ECHCG, barnyardgrass.

2019:
Glyphosate formulation had no effect on the level of barnyardgrass control (Table 1). Also, barnyardgrass control did not differ between glyphosate formulation in the addition of Engenia.

2020:
Envy Six Max was the only glyphosate formulation applied which resulted in reduced barnyardgrass control. This reduction was seen when Envy Six Max was applied alone and in combination with Engenia.

Table 2. Barnyardgrass control 21 days after application of Roundup PowerMax and different formulations of dicamba or 2,4-D.

Treatment	Rate FL OZ/A	Timing	Barnyardgrass 2019 %		Barnyardgrass 2020 %	
Enlist One	32	6-8 in ECHCG	0	c	0	c
Engenia	12.8	6-8 in ECHCG	0	c	0	c
Xtendimax plus VaporGrip	22	6-8 in ECHCG	0	c	0	c
Fexapan plus VaporGrip	22	6-8 in ECHCG	0	c	0	c
Roundup PowerMax	32	6-8 in ECHCG	90	a	97	a
Enlist One Roundup PowerMax	32 32	6-8 in ECHCG	73	b	94	b
Engenia Roundup PowerMax	12.8 32	6-8 in ECHCG	71	b	95	b
Xtendimax plus VaporGrip Roundup PowerMax	22 32	6-8 in ECHCG	73	b	95	b
Fexapan plus VaporGrip Rounup PowerMax	22 32	6-8 in ECHCG	73	b	95	b

[a]Means within a column followed by the same letter are not different at $p \leq 0.05$.
[b]Abreviations: ECHCG, barnyardgrass.

2019 and 2020:
Dicamba formulation, when applied with Roundup PowerMax, had no effect on the negative interaction associated with control of barnyardgrass (Table 2). However, it is important to note that Roundup PowerMax alone provided the greatest control of barnyardgrass (90% in 2019 & 97% in 2020). It is also important to note that while the negative interaction was still seen in 2020, barnyardgrass control was still higher than anything achieved in 2019.

Another study was conducted at the Delta Research and Extension Center in 2019 and 2020 to evaluate if a difference existed in barnyardgrass control between nozzle type utilized in Xtend soybean weed management programs. The study evaluated different nozzle types with applications of glyphosate (Roundup PowerMax) in combination with dicamba (Engenia) and/or clethodim (Select Max). Nozzles included were flatfan (XR), AIRMIX (AM), and Turbo Teejet Induction (TTI) to provide a range of droplet size from fine to very course.

1

Table 3. Barnyardgrass control 21 days after application of Roundup PowerMax alone and in combination with Select Max and/or Engenia applied with different nozzles.

Treatment	Rate FL OZ/A	Nozzle	Timing	Control 2019 %		Control 2020 %	
Roundup PowerMax	32	XR	6-8 in ECHCG	95	a	96	a
Roundup PowerMax	32	AM	6-8 in ECHCG	96	a	97	a
Roundup PowerMax	32	TTI	6-8 in ECHCG	85	bc	93	a
Select Max	16	XR	6-8 in ECHCG	30	f	95	a
Select Max	16	AM	6-8 in ECHCG	29	f	97	a
Select Max	16	TTI	6-8 in ECHCG	25	f	95	a
Roundup PowerMax Select Max	32 16	XR	6-8 in ECHCG	89	ab	96	a
Roundup PowerMax Select Max	32 16	AM	6-8 in ECHCG	84	bc	97	a
Roundup PowerMax Select Max	32 16	TTI	6-8 in ECHCG	78	cd	96	a
Roundup PowerMax Engenia	32 12.8	XR	6-8 in ECHCG	73	de	96	a
Roundup PowerMax Engenia	32 12.8	AM	6-8 in ECHCG	75	cde	95	a
Roundup PowerMax Engenia	32 12.8	TTI	6-8 in ECHCG	70	de	94	a
Roundup PowerMax Select Max Engenia	32 16 12.8	XR	6-8 in ECHCG	75	cde	97	a
Roundup PowerMax Select Max Engenia	32 16 12.8	AM	6-8 in ECHCG	75	cde	95	a
Roundup PowerMax Select Max Engenia	32 16 12.8	TTI	6-8 in ECHCG	64	e	92	a
Nontreated	-			-		-	

[a]Means within a column followed by the same letter are not different at $p \leq 0.05$.
[b]Abreviations: ECHCG, barnyardgrass; XR, flatfan; AM, AIRMIX; TTI Turbo Teejet Induction.

2019:
Barnyardgrass control was greatest when Roundup PowerMax was applied alone using XR (95%) and AM (96%) nozzles or when Roundup PowerMax + Select were applied with an XR (89%) nozzle. The increased droplet size associated with TTI nozzles as well as the combination of Roundup PowerMax + Select Max + Engenia reduced control of barnyardgrass to 64% (Table 3).
2020:
Barnyardgrass control ratings ranged from 92 to 97%, with no difference between any herbicide mix applied.

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Objective 3 Summary:
Mixing dicamba and glyphosate has the potential to result in a negative interaction, leading to poor control of weedy grasses such as barnyardgrass. The negative interaction cannot be overcome by pairing different formulations of glyphosate and dicamba together. Barnyardgrass control from applications of Roundup PowerMax and Engenia did not differ with nozzle type used. Also, sublethal rates of dicamba with a full rate of glyphosate did not result in reduced barnyardgrass control from that of glyphosate alone. From preliminary data, it appears that glyphosate and dicamba may need to be applied in separate applications or another application of glyphosate approximately 10 days following may be needed for control of barnyardgrass.

Impacts and Benefits to Mississippi Soybean Producers:

Mississippi has averaged close to 2 million acres of soybean over the past five years, and a majority of soybean-producing counties contain at least one GR weed species. The data generated from this research will allow producers to implement effective control options for GR weeds, become aware of developing resistance problems, receive information on prevention and control tactics for resistant weeds, and allow Mississippi soybean producers to remain competitive regionally while improving economic returns.

Publications:

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4

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Presentations:

1. Mississippi Agricultural Consultants’ Association Meeting – Grass and broadleaf weed control in Roundup Ready 2 Xtend soybean; [Online] (March 1, 2021)
2. Arkansas Agricultural Consultants’ Association Meeting – Italian ryegrass: best management practices to flatten the curve; Jonesboro, AR (January 20, 2021)
3. National Conservations Systems Cotton and Rice Conference – Grass and broadleaf weed control in Roundup Ready 2 Xtend soybean [Online] (January 2021)
4. National Conservations Systems Cotton and Rice Conference – Thoughts and considerations for the 2021 soybean cropping season [Online] (January 2021)
5. Syngenta Crop Protection The Benefits of Fall Weed Management Meeting – Fall residual herbicides in Mississippi; Stoneville, MS (October 6, 2020)

5