MISSISSIPPI SOYBEAN PROMOTION BOARD

Weed Management Programs for Mississippi Soybean Production (MSPB 20-2021)
Final Report

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Rationale/Justification for Research:

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. The dicamba-tolerant soybean technology has been utilized since 2017 in Mississippi, and others such as 2,4-D- and 4-HPPD-tolerant soybean have more recently been approved for use. Mixing herbicides with 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. Interactions between components of herbicide mixtures have been documented. 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 as a means 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 has proven optimal, but agronomic research indicates that drilled soybean often do not perform as well as soybean planted with a precision planter in wide rows (≥30 inches). However, agronomic performance and weed control are never mutually exclusive in commercial fields. In Mississippi, extensive research has demonstrated the benefit to soybean performance either for drainage or to facilitate furrow irrigation when grown on raised beds. Raised beds are typically 30 to 40 inches wide. 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. If growers could plant three rows on top of a standard bed to reduce spacing and maintain irrigation efficiency, then weed control and soybean agronomic performance could possibly both be enhanced. Postemergence weed control offered by the Roundup Ready 2 Xtend system could be a vital tool in the system described.

Objectives:

1. Evaluate new and/or currently registered herbicides and herbicide-resistant soybean technologies for positioning into Mississippi weed management programs.
2. Refine soybean production practices 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 bed system.
3. Strengthen 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 strategies that fit into current herbicide programs in Mississippi soybean.

Report of Progress/Activity:

<u>Objective 1 – 2021</u>

Nineteen studies were conducted at the Delta Research and Extension Center in 2021 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 and Enlist One in E3 soybean are a focus area.

One study of interest focused on a new pre-mix of two active ingredients from herbicide group 14, which are the PPO-inhibiting herbicides. Traditionally, herbicides within group 14 have been extremely effective for weed control with some potential for soybean injury. Therefore, mixing two active ingredients from this group is uncommon. Zone Defense is a premix of sulfentrazone (Authority) and flumioxazin (Valor). The strategy communicated from the manufacturer, Helm Agro, is that upon incorporation, sulfentrazone should form a herbicide layer closer to the soil surface with the layer of flumioxazin slightly deeper. That would allow the sulfentrazone to target small-seeded weed species such as Palmer amaranth emerging from the top 0.25 to 0.5-inch layer in the soil profile with the flumioxazin targeting larger seeded species such as morningglory which may germinate from a slightly deeper depth.

Soybean injury 12 and 28 d after treatment (DAT) never exceeded 9%, and injury to soybean was similar among treated plots (Table 1). Entireleaf morningglory and Palmer amaranth control was excellent and at least 90% with all treatments 12 and 28 DAT. Zone Defense holds promise as a safe and effective PRE treatment for residual weed control in soybean.

Table 1. Soybean injury and control of entireleaf morningglory and Palmer amaranth 12 and 28 d after treatment (DAT) with Zone Defense applied preemergence (PRE) at Stoneville, MS, in 2021.[a]

			Soybean injury		Entireleaf morningglory control		Palmer amaranth control	
Treatment	Rate	Timing	12 DAT	28 DAT	12 DAT	28 DAT	12 DAT	28 DAT
			%					
Nontreated			0 b	0 b	0 b	0 b	0 b	0 b
Zone Defense	4	PRE	8 a	5 a	95 a	90 a	95 a	95 a
Zone Defense	5	PRE	4 ab	3 ab	95 a	93 a	95 a	96 a
Zone Defense + Helmet	4 + 21.3	PRE	8 a	6 a	95 a	93 a	95 a	95 a
Zone Defense + Helmet	5 + 21.3 21.3	PRE	9 a	6 a	95 a	91 a	95 a	96 a
Authority Elite	26	PRE	5 a	4 ab	95 a	89 a	95 a	94 a

[a]Means within a column followed by the same letter are not different at $p \leq 0.05$.

Kyber, Valor plus TriCor plus Classic (formulated as Trivence), Sonic, and Boundary controlled barnyardgrass at least 94% 14 d after PRE (Table 2). Only Trivence controlled Palmer amaranth >79% at the same evaluation. Following POST treatments, barnyardgrass and Palmer amaranth control were at least 91%. Although some statistical differences in soybean yield were detected, all yields were 57 to 62 BU/A. Herbicide programs in E3 soybean are effective on common weed species in Mississippi. Should dicamba products lose labeling in the future, the E3 soybean system offers the opportunity to maintain a high level of weed control. However, variety development for E3 is well behind that for XtendFlex.

Table 2. Barnyardgrass and Palmer amaranth control with herbicide programs in E3 soybean at Stoneville, MS, in 2021.[a]

Treatment	Rate	Timing	Barnyardgrass 14 d after PRE	Barnyardgrass 14 d after POST	Palmer amaranth 14 d after PRE	Palmer amaranth 14 d after POST	Yield
	OZ/A		%				BU/A
Nontreated			0 b	0 b	0e	0 b	50 c
Kyber	16	PRE	95 a	95 a	71 cd	91 a	60 ab
Enlist One	32	POST					
Liberty 280 SL	32	POST					
Kyber	16	PRE	95 a	93 a	79 abc	95 a	59 ab
Enlist One	32	POST					
Liberty 280 SL	32	POST					
EverpreX	16	POST					
Valor EZ	1.8	PRE	95 a	95 a	91 a	95 a	57 b
TriCor 4F	6.3	PRE					
Classic	1.09	PRE					
Enlist One	32	POST					
Liberty 280 SL	32	POST					
Valor EZ	1.8	PRE	94 a	95 a	89 ab	95 a	59 ab
TriCor 4F	6.3	PRE					
Classic	1.09	PRE					
Enlist One	32	POST					
Liberty 280 SL	32	POST					
EverpreX	16	POST					
Sonic	4.5	PRE	95 a	95 a	64 d	93 a	61 a
Enlist One	32	POST					
Liberty 280 SL	32	POST					
Sonic	4.5	PRE	95 a	93 a	75 bcd	91 a	57 b
Enlist One	32	POST					
Liberty 280 SL	32	POST					
EverpreX	16	POST					
Boundary	32	PRE	95 a	93 a	75 bcd	91 a	62 a
Enlist One	32	POST					
Liberty 280 SL	32	POST					
EverpreX	16	POST					

[a]Means within a column followed by the same letter are not different at $p \leq 0.05$.

Objective 2a – 2019 to 2021 (all units metric in this section)

Planting date, seeding rate, soil texture, and row configuration are important factors in soybean production. Each of these factors can impact overall production and yield of soybean immensely. Growers can have difficulty making decisions about how to best manage their production systems with these factors in mind. Therefore, research was conducted from 2019 to 2021 at the Delta Research and Extension Center in Stoneville, MS, to evaluate the agronomic performance of soybean planted with different planting dates, row configurations, soil textures, and/or seeding rates.

Common row configurations (single- and twin-row) utilized in Mississippi soybean production were compared to a triple-row configuration on raised beds with this in mind. The recommended seeding rate for single- and twin-row configurations is 320,000 seed ha^{-1}. Because of this, each row configuration was planted at this rate for the Row Configuration Study. First planting dates occurred within the optimum planting windows for Mississippi soybean production from late-April to early-May. Emergence issues detected in the Row Configuration Study led to the need for determining the best seeding rate for the drill-seeded triple-row configuration. Therefore, the Seeding Rate Study was initiated where triple-row configuration plots were planted at 320,000, 445,000, and 553,000 seed ha^{-1}. Triple-row configuration plots at different seeding rates were compared to a single-row configuration planted at 320,000 seed ha^{-1}. Clay and silt loam soil textures were represented for both studies each siteyear. Plant density and height, days to canopy closure, and grain yield were measured each siteyear.

Twin- and triple-row configuration plots at the first planting date provided more rapid canopy closure than other row configurations at either planting date for the Row Configuration Study. Triple-row configuration had lower plant densities and produced lower yield than single- and twin-row configurations in the Row Configuration Study. Triple-row configuration plots planted at 320,000 seed ha^{-1} had lower plant height at V2 and R3 than all other seeding rates in the Seeding Rate Study. Triple-row configuration soybean planted on clay soil and at 445,000 and 553,000 seed ha^{-1} produced greater yield than any other seeding rate or soil texture. Triple-row configuration could become a viable option for growers in the future if proper equipment is available.

The lower soybean density in triple-row configuration plots in the Row Configuration Study led to reduction in yield. Results from the Seeding Rate Study confirm that increasing seeding rate in triple-row configuration improved soybean yield greater than or equal to that of single-row configuration. Additionally, these data suggest that triple-row configuration could perform better on clay than silt loam soil for yield. Plant heights were greater in single-row configuration for the Row Configuration Study and at R1 growth stage only for Seeding Rate Study. However, single-row configuration only produced greater yield in the Row Configuration Study and not in the Seeding Rate Study except for triple-row configuration mid-rate on silt loam soil. The Row Configuration Study demonstrated that soybean at the first planting date produced greater yields than at second planting date regardless of soil texture. This means that for the current work, planting date had a greater impact on soybean yield than soil texture. Additionally, triple-row configuration provided more rapid canopy closure compared with single-row regardless of planting date or soil texture. Results from the Seeding Rate Study confirmed that triple-row configuration could be a viable agronomic option in replacement of single-row configuration soybean production systems if seeding rate is adjusted, depending what soil texture present in a particular field. These data suggest that, on clay soil, 445,000 seed ha^{-1} is the optimum seeding rate for triple-row configuration. However, for silt loam soil, seeding rate can be the same as a single-row configuration standard at 320,000 seed ha^{-1}. These data could lay the foundation for future research and possible implementation of a new production practice for growers. Questions remain related to soybean production in a triple-row configuration on a raised bed; however, there is potential to offer soybean growers another option for their respective production systems.

Table 3. Planting date by row configuration interaction for soybean height at V2 growth stage and number of days to canopy closure in the Row Configuration Study conducted from 2019 to 2021 at Stoneville, MS.[a]

Planting date[b]	Row configuration	Height at V2	Canopy closure
		cm	Growth stage closed
First planting date	Single row	16 c	R5.5 c
	Twin row	15 d	R5 d
	Triple row	14 e	R5 d
Second planting date	Single row	19 ab	R6.5 a
	Twin row	19 a	R6 b
	Triple row	18 b	R6 b

[a]Data averaged across two soil textures, five experiments, and four replications. Means within a column followed by the same letter for each parameter are not different at $p \leq 0.05$.

[b]First planting date occurred between late April and early May each siteyear and second planting date occurred 21 d later.

Table 4. Planting date effect on soybean height at R1 growth stage in the Row Configuration Study conducted from 2019 to 2021 in Stoneville, MS.[a]

Planting date[b]	Height at R1
	cm
First planting date	33 b
Second planting date	41 a

[a]Data averaged across three row configurations, two soil textures, five experiments, and four replications. Means followed by the same letter are not different at $p \leq 0.05$.

[b]First planting date occurred between late April and early May each siteyear and second planting date occurred 21 d later.

Table 5. Row configuration effect on soybean height at growth stages R1, R3, and R8, density at maturity, and yield in the Row Configuration Study conducted from 2019 to 2021 in Stoneville, MS.[a]

Row configuration	Height R1	Height R3	Height R8	Density at maturity	Yield
		cm		Plants m^{-2}	kg ha^{-1}
Single row	40 a	81 a	97 a	26 a	3,760 a
Twin row	37 ab	77 b	94 b	24 a	3,780 a
Triple row	34 b	71 c	87 c	21 b	3,480 b

[a]Data averaged across two planting dates, two soil textures, five experiments, and four replications. Means followed by the same letter for each parameter are not different for at $p \leq 0.05$.

Table 6. Planting date by soil texture interaction for soybean height at growth stage R3, number of days to canopy closure, and yield in the Row Configuration Study conducted from 2019 to 2021 in Stoneville, MS.[a]

Planting date[b]	Soil texture	Height at R3	Canopy closure	Yield
		cm	d after R3	kg ha^{-1}
First planting date	Clay	74 a	R5 c	4,160 a
	Sandy loam	80 a	R5 c	3,720 ab
Second planting date	Clay	81 a	R6.5 a	3,490 bc
	Sandy loam	70 b	R6 b	3,330 c

[a]Data averaged across three row configurations, five experiments, and four replications. Means followed by the same letter for each parameter are not different at $p \leq 0.05$.

[b]First planting date occurred between late April and early May each siteyear and second planting date occurred 21 d later.

Table 7. Soybean height at growth stages V2, R1, and R3 in the Seeding Rate Study conducted in 2021 at Stoneville, MS.[a]

Treatment[b]	Height		
	V2	R1	R3
		cm	
Standard	9 a	29 a	69 a
Triple-row 320 K	8 b	24 c	61 c
Triple-row 445 K	9 a	24 c	65 b
Triple-row 543 K	9 a	27 b	70 a

[a]Data averaged across two soil textures, two experiments, and four replications. Means followed by the same letter for each evaluation are not different at $p \leq 0.05$.

[b]Standard and triple-row, low seeding rate treatments planted at 320,000 seed ha^{-1}. Triple-row, mid seeding rate planted at 445,000 seed ha^{-1} and triple-row, high seeding rate planted at 543,000 seed ha^{-1}.

Table 8. Soil by treatment interaction for soybean density and height at growth stage R8, and yield in the Seeding Rate Study conducted in 2021 at Stoneville, MS.[a]

Soil texture	Treatment[b]	Density at maturity	Height at R8 growth stage	Yield
		Plants m^{-2}	cm	kg ha^{-1}
Clay	Standard	34 ab	100 a	4,720 bc
	Triple-row 320 K	23 c	93 bc	4,650 bc
	Triple-row 445 K	38 ab	98 ab	5,070 ab
	Triple-row 543 K	49 ab	102 a	5,220 a
Sandy loam	Standard	24 bc	88 c	2,560 c
	Triple-row 320 K	24 bc	80 d	2,660 c
	Triple-row 445 K	33 bc	75 d	2,160 d
	Triple-row 543 K	53 a	80 d	2,780 bc

[a]Data averaged across two experiments and four replications. Means followed by the same letter for each parameter are not different at $p \leq 0.05$.

[b]Standard and triple-row, low seeding rate treatments planted at 320,000 seed ha^{-1}. Triple-row, mid seeding rate planted at 445,000 seed ha^{-1} and triple-row, high seeding rate planted at 543,000 seed ha^{-1}.

Objective 2b – 2019 to 2021 (all units metric in this section)

Palmer amaranth is one of the most problematic weed species in midsouthern agriculture. The ability to rapidly develop resistance to common herbicides, rapid biomass accumulation, and prolific seed production can make it difficult to manage. Alternate methods of weed control, coupled with herbicide applications, can help improve control of herbicide resistant weed species such as Palmer amaranth. Therefore, research was conducted at the Delta Research and Experiment Station in Stoneville, MS to evaluate PRE and/or POST herbicide programs and timings for soybean planted in different row configurations.

Two row configurations, single- and triple-row, were planted on raised beds for both the Herbicide Program and Herbicide Timing studies. Programs included PRE only, EPOST (POST at V3 soybean), LPOST (2 wk after EPOST), PRE fb EPOST, PRE fb LPOST, and PRE fb EPOST fb LPOST for the Herbicide Program Study. Herbicide timings included 7, 14, 21, and 28 d after crop emergence (DAE) and each timing was followed by a sequential application 14 d after the initial application for the Herbicide Timing Study. A standard herbicide treatment including PRE fb POST at 14 DAE fb POST at 28 DAE was also included. Soybean injury, plant density and height, visible estimates of Palmer amaranth control, and yield were collected for both studies.

No differences were detected for soybean injury at any evaluation timing for either study. Programs including PRE fb EPOST and PRE fb EPOST fb LPOST controlled Palmer amaranth ≥ 92% and was greater than with other programs 7 and 14 DA-EPOST for the Herbicide Program Study. Mature soybean height was lower following LPOST-only herbicide programs than other herbicide programs in the Herbicide Program Study. Similar visible control of Palmer amaranth was detected at 14 d after initial application between initial POST timings at 7 and 21 DAE and the standard herbicide program treatment in the Herbicide Timing Study. Triple-row configuration did not improve control of Palmer amaranth however, it did provide greater than or equal to that of single-row configuration plots for both studies.

Data from the Herbicide Program Study suggest that regardless of row configuration, applying a herbicide early in the growing season is beneficial. The combination of PRE and POST herbicide treatments is the best option for combating Palmer amaranth infestations. However, if a grower is delayed in applying a POST herbicide following a PRE, a triple-row configuration provided an increase in control of Palmer amaranth 7 and 14 DA-EPOST. Even with triple-row configuration plots exhibiting lower soybean density than single-row configuration plots, control with the PRE fb LPOST herbicide program was greater in triple-row. Additionally, yield was similar following EPOST-only program in a triple-row configuration to those of all programs that included a herbicide for single-row configuration plots. This supports applying a herbicide early in the growing season and even in the absence of a PRE treatment, triple-row maintains yields with single-row.

Similar conclusions can be discerned from the Herbicide Timing Study. Although triple-row configuration plots had lower soybean density than the single-row configuration, yields were comparable except for nontreated and 14 DAE initial timing treatments. In fact, in nontreated plots and for the 14 DAE initial herbicide timing, triple-row configuration provided greater yield than single-row. This suggest that if growers are unable to apply herbicides in a timely manner that triple-row configuration will maintain yields with that of timings that are earlier or include a PRE.

Table 9. Palmer amaranth control 7 and 14 d after (DA) early-POST (EPOST) treatment influenced by different PRE/POST herbicide programs in the Herbicide Program Study conducted from 2019 to 2021 at Stoneville, MS.[a]

	7 DA-EPOST		14 DA-EPOST	
Herbicide program[b,c]	Single row	Triple row	Single row	Triple row
	% Control			
PRE only	5 d	5 d	5 e	5 e
PRE fb EPOST	92 a	92 a	93 ab	93 ab
PRE fb LPOST	5 d	19 c	5 e	19 d
PRE fb EPOST fb LPOST	94 a	93 a	95 a	93 ab
EPOST only	82 b	81 b	82 c	88 bc
LPOST only[d]	-	-	-	-

[a]Data averaged across four experiments. Means followed by the same letter for each evaluation interval are not different at $p \leq 0.05$.

[b]PRE treatments were *s*-metolachlor at 791 g ai ha^{-1} plus metribuzin applied at 188 g ai ha^{-1}; POST treatments were glyphosate applied at 1,120 g ae ha^{-1} plus dicamba at 560 g ae ha^{-1} plus acetochlor at 1,270 g ai ha^{-1}.

[c]EPOST application timing was at soybean growth stage V3, and LPOST application timing was 14 d after EPOST.

[d]LPOST treatments were not applied at these evaluations.

Table 10. Row configuration effect on soybean plant density and height at maturity in the Herbicide Program Study conducted from 2019 to 2021 in Stoneville, MS.[a]

Row configuration	Mature soybean density	Mature soybean height
	no. m^{-2}	cm
Single row	27 a	78 a
Triple row	17 b	68 b

[a]Data averaged across four experiments and seven herbicide programs. Means followed by the same letter for each parameter are not different at $p \leq 0.05$.

Table 11. Herbicide program effect on Palmer amaranth control 7 d after (DA) late POST (LPOST) and soybean height at maturity in the Herbicide Program Study conducted from 2019 to 2021 in Stoneville, MS.[a]

Herbicide program[b,c]	7 DA-LPOST	Mature soybean height
	% Control	cm
Nontreated	-	73 a
PRE only	5 e	75 a
PRE fb EPOST	94 a	74 a
PRE fb LPOST	74 c	72 a
PRE fb EPOST fb LPOST	94 a	73 a
EPOST only	87 b	73 a
LPOST only	61 d	69 b

[a]Data pooled across four experiments and two row configurations. Means followed by the same letter for each parameter are not different at $p \leq 0.05$.

[b]PRE treatments were *s*-metolachlor at 791 g ai ha^{-1} plus metribuzin applied at 188 g ai ha^{-1}; POST treatments were glyphosate applied at 1,120 g ae ha^{-1} plus dicamba at 560 g ae ha^{-1} plus acetochlor at 1,270 g ai ha^{-1}.

[c]Early POST (EPOST) application timing was at soybean growth stage V3, and LPOST application timing was 14 d after EPOST.

Table 12. Influence of herbicide program by row configuration on soybean yield in the Herbicide Program Study conducted from 2019 to 2021 in Stoneville, MS.[a]

Herbicide program[b,c]	Row Configuration	
	Single row	Triple row
	kg ha^{-1}	
Nontreated	3,700 d	3,550 d
PRE only	4,560 a	4,080 c
PRE fb EPOST	4,440 ab	4,130 bc
PRE fb LPOST	4,420 ab	4,170 bc
PRE fb EPOST fb LPOST	4,540 a	4,200 bc
EPOST only	4,550 a	4,530 a
LPOST only	4,550 a	3,700 d

[a]Data averaged across four experiments. Means followed by the same letter are not different at $p \leq 0.05$.

[b]PRE treatments were *s*-metolachlor at 791 g ai ha^{-1} plus metribuzin applied at 188 g ai ha^{-1}; POST treatments were glyphosate applied at 1,120 g ae ha^{-1} plus dicamba at 560 g ae ha^{-1} plus acetochlor at 1,270 g ai ha^{-1}.

[c]Early-POST (EPOST) application timing was at soybean growth stage V3, and late-POST (LPOST) application timing was 14 d after EPOST.

Table 13. Control of Palmer amaranth 14 d after (DA) initial POST treatment in the Herbicide Timing Study conducted from 2019 to 2021 in Stoneville, MS.[a]

	Control
Initial POST herbicide timing[b]	14 DA-initial POST
	%
PRE[b] fb POST[b] program	90 a
7 DAE fb 21 DAE	91 a
14 DAE fb 28 DAE	79 b
21 DAE fb 35 DAE	84 ab
28 DAE fb 42 DAE	76 b

[a]Data averaged across four experiments and two row configurations. Means followed by the same letter are not different at $p \leq 0.05$.
[b]PRE treatments were *s*-metolachlor at 791 g ai ha^{-1} plus metribuzin applied at 188 g ai ha^{-1}; POST treatments were glyphosate applied at 1,120 g ae ha^{-1} plus dicamba at 560 g ae ha^{-1} plus acetochlor at 1,270 g ai ha^{-1}.

Table 14. Row configuration effect on soybean density and height at maturity for the Herbicide Timing Study conducted from 2019 t0 2021 in Stoneville, MS.[a]

Row configuration	Maturity soybean density	Maturity soybean height
	no. m^{-2}	cm
Single row	29 a	94 a
Triple row	20 b	88 b

[a]Data averaged across four experiments and six initial POST herbicide timings. Means followed by the same letter for each parameter are not different at $p \leq 0.05$.

Table 15. Influence of initial POST herbicide timing and row configuration on soybean yield in the Herbicide Timing Study conducted from 2019 to 2021 in Stoneville, MS.[a]

	Row Configuration	
Initial POST herbicide timing[b]	Single row	Triple row
	kg ha^{-1}	
Nontreated	3,690 c	4,310 ab
PRE fb POST program	4,470 a	4,360 ab
7 DAE fb 21 DAE	4,450 a	4,370 ab
14 DAE fb 28 DAE	3,680 c	4,060 b
21 DAE fb 35 DAE	4,440 a	4,440 a
28 DAE fb 42 DAE	4,500 a	4,370 ab

[a]Data averaged across four experiments. Means followed by the same letter are not different at $p \leq 0.05$.

[b]PRE treatments were *s*-metolachlor at 791 g ai ha^{-1} plus metribuzin applied at 188 g ai ha^{-1}; POST treatments were glyphosate applied at 1,120 g ae ha^{-1} plus dicamba at 560 g ae ha^{-1} plus acetochlor at 1,270 g ai ha^{-1}.

The objective of these studies was to evaluate herbicide programs and timings for Palmer amaranth control utilizing PRE and/or POST herbicide treatments in soybean planted in different row configurations. Triple-row configuration could become beneficial to some growers in Mississippi, but the system requires further refinement. Therefore, further research is needed to continue to evaluate benefits and/or adoption of triple-row configuration production system and how it can best fit in grower practices in the future.

Objective 3a – 2019 to 2021 (all units metric in this section)

The adoption of dicamba-tolerant soybean has led to problematic weed shifts within the crop. Applying dicamba plus glyphosate POST provides growers the ability to control Palmer amaranth. However, reduced control of barnyardgrass has been reported with dicamba-based herbicide programs. Therefore, research was conducted to evaluate the influence of herbicide mixtures, carrier volumes, and nozzle types on barnyardgrass control with POST herbicide treatments.

Results indicated that barnyardgrass control with glyphosate plus dicamba was not decreased by drift-reducing nozzles. Carrier volume of $\geq$ 94 L ha^{-1} provided greater control of barnyardgrass compared to 47 L ha^{-1}. These results indicate potential of reduced barnyardgrass control with glyphosate plus dicamba.

Results demonstrate barnyardgrass control $\geq$ 90% can be achieved with glyphosate. However, adverse effects can occur when glyphosate is mixed with herbicides such as clethodim and/or dicamba. Minimizing other factors affecting control such as reduced carrier volumes should be considered when applying glyphosate in combination with clethodim and/or dicamba. With confirmed glyphosate-resistant barnyardgrass in the mid-southern U.S., proper stewardship and weed control should be emphasized. When reduced carrier volumes are unavoidable, it may be necessary to apply glyphosate alone and follow with a sequential application of clethodim and/or dicamba. Utilizing sequential herbicide applications could offer growers protection against crop loss due to weed interference.

Table 16. Barnyardgrass control with glyphosate and auxin herbicide mixtures in the Herbicide Mixture Study at Stoneville, MS, from 2019 to 2021.[a,b]

		Barnyardgrass control	
Glyphosate rate	Auxin herbicide treatment[c]	14 DAT	28 DAT
g ae ha^{-1}		-----%-----	
0	None	0 c	0 c
	DGA dicamba	0 c	0 c
	BAPMA dicamba	0 c	0 c
	Choline 2,4-D	0 c	0 c
1120	None	90 a	89 a
	DGA dicamba	85 b	71 b
	BAPMA dicamba	86 b	71 b
	Choline 2,4-D	84 b	74 b
P value		0.0087	0.0049

[a]Data are pooled over three experiments. Means followed by the same letter within a column are not different at ($P \leq 0.05$).

[b]Abrevations: DAT, days after treatment; DGA, diglycolamine salt of dicamba; BAPMA, bis-aminopropylmethylamine salt of dicamba; Choline, choline salt of 2,4-D.

[c]The DGA and BAPMA formulations of dicamba were applied at 560 g ae ha^{-1}, and choline salt of 2,4-D was applied at 1065 g ae ha^{-1}.

Table 17. Barnyardgrass control 14 d after treament (DAT) in the Carrier Volume Study conducted at Stoneville, MS, from 2019 to 2021.[a]

Herbicide treatment[b]	Carrier volume	Control
	L ha^{-1}	%
Glyphosate	47	68 c
	94	89 ab
	140	93 a
Glyphosate + clethodim	47	80 b
	94	88 ab
	140	82 b
Glyphosate + dicamba	47	65 c
	94	87 ab
	140	87 ab
Glyphosate + clethodim + dicamba	47	67 c
	94	80 b
	140	81 b
P value		0.0392

[a]Data are pooled over three experiments. Means followed by the same letter are not different at ($P \leq 0.05$).

[b]Glyphosate was applied at 1120 g ae ha^{-1}, clethodim was applied at 57 g ai ha^{-1}, dicamba was applied at 560 g ae ha^{-1}.

Table 18. Barnyardgrass control 28 d after treament (DAT) and relative dry weight 21 DAT in the Carrier Volume Study conducted at Stoneville, MS, from 2019 to 2021.[a]

Carrier Volume	Control	Barnyardgrass dry weights
L ha^{-1}	----------%----------	
47	52 b	28 a
94	68 a	13 b
140	71 a	7 b
P value	0.0020	<0.0001

[a]Data are pooled over four herbicide treatments and three experiments. Means followed by the same letter within a column are not different at ($P \leq 0.05$).

Table 19. Barnyardgrass control 14 and 28 d after treatment (DAT) and relative dry weight 21 DAT in the Nozzle Study conducted at Stoneville, MS, from 2019 to 2021.[a]

Herbicide treatment[c]	Nozzle type[b]	Control 14 DAT		Control 28 DAT		Dry weight 21 DAT	
		-----%-----				%	
Glyphosate	AM	95	a	94	a	0	b
	XR	95	a	95	a	0	b
	TTI	93	a	88	ab	0	b
Glyphosate + clethodim	AM	87	ab	86	ab	7	b
	XR	87	ab	89	ab	10	b
	TTI	85	abc	86	ab	3	b
Glyphosate + dicamba	AM	83	abc	81	ab	39	a
	XR	62	de	50	c	35	a
	TTI	78	bc	79	b	43	a
Glyphosate + clethodim + dicamba	AM	83	abc	82	ab	9	b
	XR	54	e	44	c	44	a
	TTI	74	cd	74	b	13	b
P value		0.0079		<0.0001		0.0154	

[a]Data are pooled over three experiments. Means followed by the same letter within a column are not different at ($P \leq 0.05$).

[b]Abrevations: AM, AIRMIX; XR (drift-reducing nozzle), flat-fan; TTI, turbo TeeJet induction (drift reducing nozzle).

[c]Glyphosate was applied at 1120 g ae ha^{-1}, clethodim was applied at 57 g ai ha^{-1}, dicamba was applied at 560 g ae ha^{-1}.

<u>Objective 3b – 2020 to 2021 (all units metric in this section)</u>

Dicamba-tolerant soybean was developed and commercialized by Monsanto in 2016, and in recent years, barnyardgrass has become more troublesome in soybean. To address the issue of barnyardgrasss control, field studies were conducted from 2019 to 2021 in Stoneville, MS, to evaluate barnyardgrass control when glyphosate or glyphosate plus dicamba treatments were mixed with residual herbicides, as well as glyphosate or glyphosate plus dicamba sequential herbicide applications.

In the first field study, glyphosate at 1120 g ae ha^{-1} and glyphosate plus dicamba at 560 g ae ha^{-1} was applied in combination with common residual herbicides. The second field study included an initial treatment of glyphosate at 1120 g ha^{-1}, glyphosate plus dicamba at 560 g ha^{-1}, and glyphosate plus dicamba plus *S*-metolachlor at 1064 g ai ha^{-1} followed by a sequential treatment of glyphosate or glyphosate plus dicamba at 3 and 7 d after initial herbicide treatment.

Results indicated glyphosate alone provided greater barnyardgrass control than glyphosate plus dicamba. Additionally, at 28 d after treatment (DAT) pyroxasulfone, pyroxasulfone + fluthiacet, dimethenamid-p, and *S*-metolachor did not affect barnyardgrass control from glyphosate plus dicamba treatments. Furthermore, sequential herbicide treatments of glyphosate or glyphosate plus dicamba led to no difference in barnyardgrass control 28 DAT. These results indicate options for the addition of residual herbicides with glyphosate plus dicamba treatments and the effectiveness of utilizing sequential glyphosate or glyphosate plus dicamba treatments.

These results demonstrate potential for reduced barnyardgrass control when applying glyphosate plus dicamba, glyphosate plus dicamba plus acetochlor, and glyphosate plus dicamba plus *S*-metolachlor. However, pyroxasulfone, pyroxasulfone plus fluthiacet, and dimethenamid-p did not reduce barnyardgrass control 28 d after final treatment (DAFT) when applied with glyphosate plus dicamba. Utilizing sequential herbicide treatment of glyphosate or glyphosate plus dicamba 3 or 7 d after initial treatment (DA-I) application of glyphosate, glyphosate plus dicamba, and glyphosate plus dicamba plus *S*-metolachlor can provide $\geq$ 87% barnyardgrass control for up to 28 DAT (data not presented). Not all residual herbicides reduce barnyardgrass control when mixed with glyphosate or glyphosate plus dicamba, as well as the abilty to utilize sequential herbicide treatments for control of barnyardgrass. These data also suggest that growers have options to combat reduced barnyardgrass control associated with glyphosate plus dicamba applications by making sequential applications.

Table 20. Barnyardgrass control in the Residual Herbicide Study conducted at Stoneville, MS, from 2020 and 2021.[a,b,c]

Postemergence herbicide	Residual herbicide[b]	14 DAT	21 DAT	28 DAT
		– – – – – – – – – – –	% – – – – – – – – – –	–
Glyphosate	None	93 a	93 ab	86 abc
	pyroxasulfone	91 ab	97 a	95 a
	pyroxasulfone + fluthiacet	93 a	94 a	91 abc
	acetochlor	85 cde	90 ab	93 ab
	dimethenamid-p	93 a	95 a	94 ab
	S-metolachlor	89 abc	92 ab	92 ab
Glyphosate + dicamba	None		ab	
		86 bcd	87 c	86 bc
	pyroxasulfone	83 de	84 bc	89 abc
	pyroxasulfone + fluthiacet		ab	
		87 bcd	90 c	90 abc
	acetochlor	67 f	54 d	48 d
	dimethenamid-p	91 ab	94 a	95 a
	S-metolachlor	81 e	78 c	83 c
P value		0.0023	<0.0001	<0.0001

[a]Data are pooled over two experiments. Means followed by the same letter within a column are not different at $P<0.05$.

[b]Glyphosate was applied at 1120 g ae ha^{-1}; dicamba was applied at 560 g ae ha^{-1}; pyroxasulfone was applied at 93 g ai ha^{-1}; pyroxasulfone + fluthiacet was applied at 91 + 3 g ai ha^{-1}; acetochlor was applied at 1267 g ai ha^{-1}; dimethenamid-p was applied at 527 g ai ha^{-1}; *S*-metolachlor was applied at 1064 g ai ha^{-1}.

[c]Abbreviations: DAT, days after treatment.

Table 21. Control of barnyardgrass 7 d after initial herbicide treatment in the Sequential Application Study conducted at Stoneville, MS from 2020 and 2021.

Initial herbicide treatment	Rate	Barnyardgrass control[a]
	g ha^{-1}	%
Glyphosate	1120	92 a
Glyphosate + dicamba	1120 + 560	87 b
Glyphosate + dicamba + *S*-metolachlor	1120 + 560 +1064	86 b
P value		<0.0001

[a]Data are pooled over four sequential treatments and two experiments. At this time no sequential treatments had been applied. Means followed by the same letter are not different at P<0.05.

Table 22. Barnyardgrass control 14 d after sequential herbicide treatment in the Sequential Application Study conducted at Stoneville, MS, from 2020 and 2021.[a,b,c]

Initial herbicide	Sequential herbicide	Timing	Barnyardgrass control
			%
Glyphosate	Glyphosate	3 DA-I	94 a
		7 DA-I	97 a
	Glyphosate + dicamba	3 DA-I	96 a
		7 DA-I	95 a
Glyphosate + dicamba	Glyphosate	3 DA-I	97 a
		7 DA-I	96 a
	Glyphosate + dicamba	3 DA-I	95 a
		7 DA-I	97 a
Glyphosate + dicamba + *S*-metolachlor	Glyphosate	3 DA-I	98 a
		7 DA-I	94 a
	Glyphosate + dicamba	3 DA-I	97 a
		7 DA-I	87 b
P value			0.0003

[a]Data are pooled over two experiments. Means followed by the same letter are not different at $P<0.05$.

[b]Glyphosate was applied at 1120 g ae ha^{-1}; dicamba was applied at 560 g ae ha^{-1}; *S*-metolachlor was applied at 1064 g ai ha^{-1}.

[c]Abbreviations: DA-I, days after the initial herbicide treatment.

Table 23. Soybean yield in the Sequential Application Study conducted at Stoneville, MS from 2020 and 2021.

Sequential herbicide	Timing	Soybean yield[b]
		% of nontreated
Glyphosate	3 DA-I	143 a
	7 DA-I	145 a
Glyphosate + dicamba	3 DA-I	139 b
	7 DA-I	144 a
P value		0.0204

[a]Data are pooled over three initial herbicide treatments and two experiments. Means followed by the same letter are not different at P<0.05.

[b]Average soybean yield in nontreated plots was 3420 kg ha^{-1}.

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