

MISSISSIPPI SOYBEAN PROMOTION BOARD

Weed Management Programs for Mississippi Soybean Production (MSPB 20-2022) Annual Report

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Rationale/Justification for Research:

Glyphosate resistance has spread with documented cases in 51 species worldwide. Fifteen species in the United States have developed resistance to glyphosate, and Mississippi populations of horseweed, Italian ryegrass, johnsongrass, Palmer amaranth, tall waterhemp, giant and common ragweed, goosegrass, spiny amaranth, and barnyardgrass have evolved resistance to glyphosate. Ten glyphosate-resistant (GR) species are among the highest of any state in the United States.

Glyphosate-resistant Palmer amaranth and Italian ryegrass are the largest weed threats for Mississippi crops. Palmer amaranth competes for nutrients, water, light, and space because of its rapid, upright growth habit and allelopathic properties. Italian ryegrass can jeopardize burndown herbicide programs. Fields with GR Italian ryegrass not controlled at burndown will contain significant residue at planting. Residue will impede planting practices, contribute to competition between soybean seedlings and GR Italian ryegrass, and hinder herbicide programs due to inadequate coverage.

Paraquat is essential for weed control in Mississippi agriculture, and it is utilized in preplant herbicide programs in all major row crops. Paraquat is also used as a harvest aid in soybean. All herbicide products containing paraquat registered in the United States are designated as Restricted Use Pesticides (RUPs) by the United States Environmental Protection Agency (EPA). This means these products may only be used by trained certified applicators. The US-EPA recently implemented new packaging, handling, and training requirements for paraquat in recent years, and label updates for 2022 may further restrict the use of this important herbicide product. Paraquat has been a staple of GR weed management programs in Mississippi for many years. It is also the primary soybean desiccant in the state. It is imperative that alternative suggestions are available to replace paraquat should it be removed as an option for Mississippi soybean producers.

Objectives:

1. Evaluate new and/or currently registered herbicides and herbicide-resistant technologies for positioning into Mississippi weed management programs.
2. Refine soybean production practices by formulating herbicide and desiccant programs for Mississippi soybean that do not include paraquat.
3. Strengthen suggestions for management of GR Italian ryegrass by (a) evaluating control with fall-applied residual herbicides (Warrant, Outlook, Command) not currently used on a broad scale and (b) evaluating sequential applications of residual herbicides.

Report of Progress/Activity:

Objective 1 – 2022

Seventeen studies were conducted at the Delta Research and Extension Center in 2022 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 XtendFlex soybean. Additionally, weed control with Enlist Duo and Enlist One in E3 soybean are a focus area.

One study of interest focused on increased rates of common residual herbicide products applied PRE in soybean. Among the pre-mixed products evaluated, Prefix is a mixture of *s*-metolachlor and fomesafen, Boundary is a mixture of *s*-metolachlor and metribuzin, Broadaxe SC is a mixture of *s*-metolachlor and sulfentrazone, and Authority Supreme is a mixture of pyroxasulfone and sulfentrazone. Soil texture at the study site was a very fine sandy loam. Historically, soybean injury with residual herbicides applied PRE has been a concern for soybean growers in MS. However, demonstrated safety with higher rates along with a longer period of residual control could improve soybean weed management programs in the state.

Soybean density 14 d after emergence was not influenced by the treatments imposed in this study (Table 1). Barnyardgrass control with Sencor alone was poor 20 d after application. When *s*-metolachlor was mixed with metribuzin as Boundary, the higher rate was required to optimize barnyardgrass control. Zidua controlled more barnyardgrass than Dual Magnum (*s*-metolachlor) alone. Other herbicide products that were pre-mixes controlled barnyardgrass $\geq 91\%$. Morningglory is historically difficult to control with residual herbicides in soybean. In the current research, only Spartan alone, the higher rate of Broadaxe SC, and both rates of Authority Supreme controlled entireleaf morningglory $\geq 91\%$ 20 d after application. This indicates that sulfentrazone is an important component of herbicide programs when entireleaf morningglory is present. Herbicide pre-mixes were required to control prickly sida $\geq 90\%$. Among the pre-mixed herbicide products evaluated, the higher rates of Prefix and Boundary were required to optimize prickly sida control. All treatments controlled Palmer amaranth $>90\%$ except Dual Magnum and Sencor (metribuzin) applied alone. Herbicide pre-mixes are important to manage a mixed spectrum of weed species in soybean. Broadaxe SC and Authority Supreme controlled barnyardgrass, entireleaf morningglory, prickly sida, and Palmer amaranth $\geq 89\%$ 20 d after application at labeled and increased rates.

Tendovo is a new pre-mixed residual herbicide product from Syngenta. It is a combination of *s*-metolachlor, metribuzin, and cloransulam, so it would be similar to adding FirstRate (cloransulam) to Boundary. As evidenced earlier, entireleaf morningglory can be difficult to control with residual herbicides in soybean, and FirstRate has historically been an industry standard for control of these species. Tendovo would represent a premium addition to the arsenal of residual herbicide products available for soybean.

A study was conducted in 2022 at Stoneville, MS, to compare weed control with Tendovo to that with other common pre-mixed residual herbicide products when included as components of PRE/POST herbicide programs in XtendFlex soybean. Sonic is a mixture of metribuzin and cloransulam. Fierce XLT is a mixture of pyroxasulfone, flumioxazin, and chlorimuron. Zidua PRO is a mixture of pyroxasulfone, saflufenacil, and imazethapyr. Authority Edge is a mixture of pyroxasulfone and sulfentrazone in different ratios than in the Authority Supreme evaluated in the first study. Only Sonic failed to control barnyardgrass $\geq 91\%$ 21 d after the PRE application. By 14 d after POST treatment, barnyardgrass control was $\geq 90\%$ with all herbicide programs. Boundary controlled less entireleaf morningglory and Palmer amaranth and Sonic controlled less Palmer amaranth 21 d after application than the other pre-mixed residual herbicide products. However, control of both species $\geq 90\%$ 14 d after POST treatment. Soybean yields were optimized following all herbicide programs evaluated. Both rates of Tendovo controlled the weed species evaluated 98% 21 d after the PRE application, and soybean yield was 56 BU/A at season's end. This indicates that Tendovo represents an effective addition to the residual herbicide products available for soybean growers in Mississippi.

Table 1. Soybean density and weed control 20 days after application of different rates of residual herbicides applied preemergence at Stoneville, MS, in 2022.^a

Treatment	Rate	Rate Unit	Soybean density Plants/m ²	Barnyardgrass	Entireleaf morningglory	Prickly sida	Palmer amaranth
				%			
Nontreated			30 -	0 d	0 e	0 e	0 c
Prefix	2	PT/A	29 -	94 a	75 c	84 b	90 a
Prefix	3	PT/A	28 -	95 a	85 b	95 a	95 a
Boundary	1.2	PT/A	29 -	89 b	60 d	86 b	90 a
Boundary	3	PT/A	31 -	95 a	73 c	94 a	95 a
Broadaxe XC	19	FL OZ/A	31 -	94 a	89 ab	90 ab	91 a
Broadaxe XC	38.7	FL OZ/A	29 -	95 a	94 a	95 a	95 a
Authority Supreme	6	FL OZ/A	27 -	91 ab	91 ab	90 ab	94 a
Authority Supreme	11.5	FL OZ/A	29 -	95 a	94 a	95 a	95 a
Dual Magnum	1.6	PT/A	29 -	89 b	54 d	66 d	78 b
Spartan 4F	6.8	FL OZ/A	28 -	89 b	93 a	86 b	90 a
Sencor 75DF	0.625	LB/A	29 -	55 c	60 d	76 c	83 b
Zidua SC	5.75	FL OZ/A	30 -	94 a	73 c	85 b	90 a

^aMeans within a column followed by the same letter are not different at $p \leq 0.05$.

Table 2. Weed control and soybean yield following PRE and POST herbicide programs in XtendFlex soybean in Stoneville, MS, in 2022.^a

				Barnyardgrass		Entireleaf morningglory		Palmer amaranth		
				21 d after PRE	14 d after POST	21 d after PRE	14 d after POST	21 d after PRE	14 d after POST	Yield
Treatment	Rate	Rate Unit	Timing	%						BU/A
Nontreated				0 d	0 c	0 d	0d	0c	0 c	44 b
Tendovo	1.75QT/A		PRE	98 a	97 a	98 a	97 ab	98 a	96 ab	56 a
Tavium Plus VaporGrip	3.53PT/A		POST							
Roundup PowerMax 3	30FL OZ/A		POST							
Tendovo	2.1QT/A		PRE	96 ab	97 a	98 a	98 a	98 a	96 ab	58 a
Tavium Plus VaporGrip	3.53PT/A		POST							
Roundup PowerMax 3	30FL OZ/A		POST							
Boundary	1.8PT/A		PRE	93 ab	96 a	83 c	92 c	88 b	90 b	55 a
Tavium Plus VaporGrip	3.53PT/A		POST							
Roundup PowerMax 3	30FL OZ/A		POST							
Broadaxe XC	25FL OZ/A		PRE	93 ab	94 ab	98 a	97 ab	97 a	92 ab	59 a
Tavium Plus VaporGrip	3.53PT/A		POST							
Roundup PowerMax 3	30FL OZ/A		POST							
Sonic	6.45OZ/A		PRE	86 c	90 b	97 ab	97 ab	88 b	90 b	59 a
Tavium Plus VaporGrip	3.53PT/A		POST							
Roundup PowerMax 3	30FL OZ/A		POST							
Fierce XLT	4.5 ^{OZ} _{WT/A}		PRE	94 ab	95 a	96 ab	97 ab	98 a	97 a	56 a
Tavium Plus VaporGrip	3.53PT/A		POST							
Roundup PowerMax 3	30FL OZ/A		POST							
Zidua PRO	6FL OZ/A		PRE	91 bc	94 ab	93 b	93 bc	90 b	92 ab	57 a
Tavium Plus VaporGrip	3.53PT/A		POST							
Roundup PowerMax 3	30FL OZ/A		POST							
Authority Edge	9FL OZ/A		PRE	93 ab	95 a	97 ab	96 abc	96 a	93 ab	55 a
Tavium Plus VaporGrip	3.53PT/A		POST							
Roundup PowerMax 3	30FL OZ/A		POST							

^aMeans within a column followed by the same letter are not different at $p \leq 0.05$.

Objective 2 – 2022 (all units metric in this section)

Paraquat is a non-selective group 22 herbicide inhibiting photosynthesis at photosystem I. Paraquat was applied to U.S. crops in totals of 769,292 kg to cotton, 407,325 kg to corn, and 49,441 kg to rice in 2020. Palmer amaranth has been noted causing more economic damage than all glyphosate-resistant weeds in the southern United States, and paraquat is often utilized at planting for Palmer amaranth control. Uncertainty of paraquat's future due to high mammalian toxicity and few treatments for accidental poisoning provokes the need to study alternative herbicide options for control of Palmer amaranth.

Two studies were conducted at the Delta Research and Extension Center in Stoneville, MS, in 2022 to evaluate control of Palmer amaranth with different herbicides and adjuvants. Both studies were designed to simulate herbicide treatments targeting Palmer amaranth applied immediately following planting. Both studies were conducted in fallow areas and were arranged as a two-factor factorial within a randomized complete block design with four replications. In the Herbicide Treatment Study, Factor A was herbicide treatment and included paraquat (Gramoxone SL) at 841 g ai ha⁻¹ plus metribuzin (TriCor) at 140 g ai ha⁻¹, glyphosate (Roundup PowerMax 3) at 1,121 g ae ha⁻¹ plus tiafenacil (Reviton) at 25 g ai ha⁻¹, glyphosate at 1,121 g ha⁻¹ plus tiafenacil at 50 g ha⁻¹, glyphosate at 1,121 g ha⁻¹ plus dicamba (Clarity) at 560 g ae ha⁻¹, glufosinate (Liberty 280 SL) at 656 g ai ha⁻¹, glyphosate plus 2,4-D choline (Enlist One) at 2,164 g ae ha⁻¹, and 2,4-D choline at 1,065 g ae ha⁻¹ plus glufosinate at 656 g ha⁻¹. All treatments containing paraquat or dicamba included NIS (nonionic surfactant) at 0.5% v/v, while treatments containing tiafenacil included MSO (methylated seed oil) at 1% v/v. Factor B was application timing with treatments applied when Palmer amaranth was 7 or 25 cm (3 or 10 inches) in height. In the Adjuvant Study, Factor A was herbicide treatment and included paraquat 841 g ha⁻¹ plus metribuzin at 280 g ha⁻¹, two different isopropylamine salts of glyphosate (IPA-1, IPA-2) at 1,121 g ha⁻¹ plus tiafenacil at 25 g ha⁻¹. Factor B was adjuvant and included no adjuvant, MSO at 1% v/v, AMS (ammonium sulfate) at 1.25% v/v, COC (crop oil concentrate) at 1% v/v, MSO at 1% v/v plus AMS at 1.25% v/v, and COC at 1% v/v plus AMS at 1.25% v/v. All treatments were applied to 15-cm (6-inch) Palmer amaranth.

In the Herbicide Treatment Study, only paraquat plus metribuzin and 2,4-D choline plus glufosinate controlled 3- and 10-inch Palmer amaranth > 90% across all evaluations (Figure 1). Glyphosate plus both rates of tiafenacil, glyphosate plus dicamba, glufosinate, and glyphosate plus 2,4-D choline controlled 3-inch Palmer amaranth similar to paraquat plus metribuzin and 2,4-D choline plus glufosinate. These treatments did not provide comparable control of 10-inch Palmer amaranth. In the Adjuvant Study, paraquat plus metribuzin provided the greatest control of Palmer amaranth (≥97%) regardless of adjuvant (Figure 2). Methylated seed oil mixed with IPA-1 and COC mixed with IPA-2 plus tiafenacil were the only treatments to provide Palmer amaranth control similar to paraquat plus metribuzin. In summary, control of Palmer amaranth with paraquat is still very effective. Through this research, it is believed that there are other potential herbicide options for control of Palmer amaranth if used correctly.

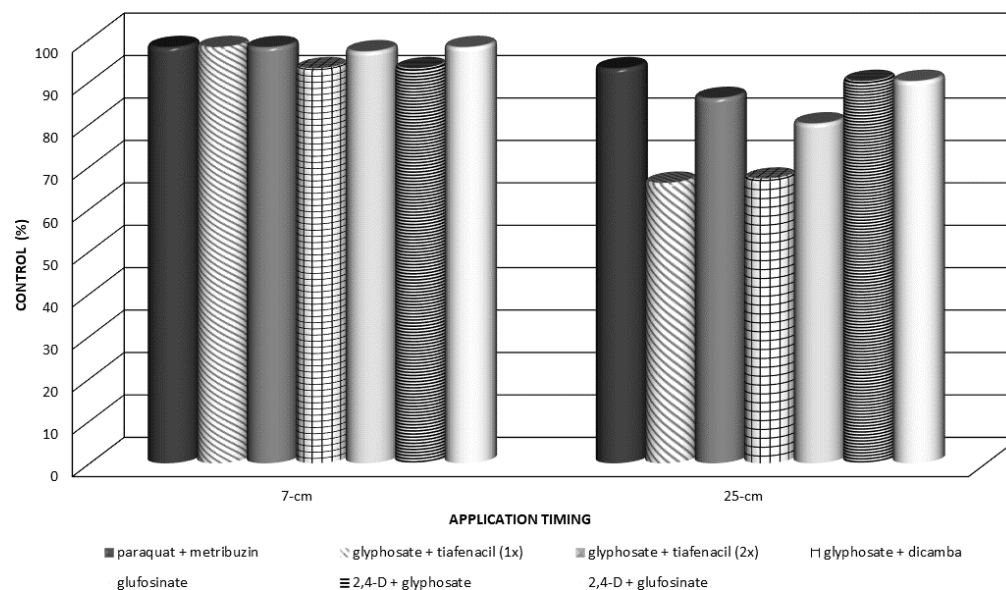


Figure 1. Control of 7- and 25-cm Palmer amaranth with different herbicide mixtures at 7 days after treatment in Stoneville, MS, in 2022.

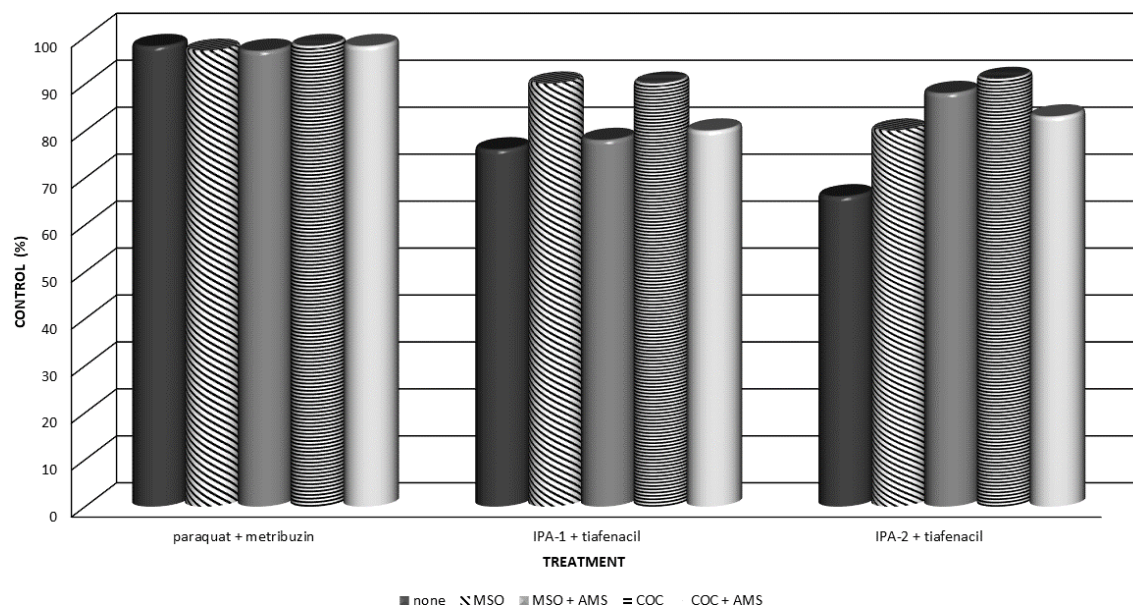


Figure 2. Palmer amaranth control with herbicide treatments mixed with different adjuvants at Stoneville, MS, in 2022.

Objective 3 – 2022:

Fall applications of residual herbicides have proven to be the most effective tactic for controlling glyphosate-resistant Italian ryegrass in Mississippi soybean. Popular treatments for this application have included herbicide products containing *s*-metolachlor (Dual Magnum, Boundary) and pyroxasulfone (Zidua, Anthem, Fierce). Warrant and Outlook have not been thoroughly evaluated for their effectiveness for control of Italian ryegrass. Even though they are also group 15 herbicides like *s*-metolachlor and pyroxasulfone, they could provide competition for products in this use pattern, possibly leading to positive effects for growers. Additionally, mixtures of group 15 herbicides with Valor may improve Italian ryegrass control and increase the control spectrum with these herbicide treatments. Therefore, research was conducted at Stoneville, MS, in 2022 to evaluate Italian ryegrass control with fall applications of Warrant and Outlook applied with or without Valor EZ.

Outlook controlled Italian ryegrass similar to Zidua SC and Dual Magnum 28 and 100 d after fall application (Table 3). Control with Warrant at 3 or 5 PT/A 28 and 100 d after fall application was similar to that with Valor EZ but less than with other treatments including group 15 herbicides at. Adding Valor EZ did not improve Italian ryegrass control with Zidua SC, Dual Magnum, or Outlook. However, at 100 d after fall application, Valor EZ plus both rates of Warrant controlled more Italian ryegrass than either herbicide product applied alone. By 160 d after fall application, only Outlook and Valor EZ plus Outlook controlled Italian ryegrass >80%. Based on this first year of research, Outlook appears promising as a tool for Italian ryegrass control, but Warrant did not offer adequate control. Warrant is a microencapsulated formulation of acetochlor. It is possible the capsule does not release the herbicide active ingredient rapidly enough under the environmental conditions that prevail in Mississippi during the fall.

Table 3. Italian ryegrass control and dry weight with fall applications of different Group 15 herbicides with and without Valor EZ at Stoneville, MS, in 2022.

				Italian ryegrass control			
				28 d after PRE	100 d after PRE	160 d after PRE	
Treatment	Rate	Rate Unit	Timing	%			Dry weight g/m ²
No Group 14 herbicide				0 e	0 f	0 h	308 a
No Group 15 herbicide							
No Group 14 herbicide				94 ab	91 abc	31 ef	275 a
Zidua SC	4.1FL	OZ/A	OCT.-NOV.				
No Group 14 herbicide				97 a	93 ab	58 cd	54 b
Dual Magnum	1.33PT/A		OCT.-NOV.				
No Group 14 herbicide				98 a	97 a	81 ab	0 b
Outlook	1PT/A		OCT.-NOV.				
No Group 14 herbicide				68 d	58 e	10 gh	282 a
Warrant	3PT/A		OCT.-NOV.				
No Group 14 herbicide				86 c	76 d	13 gh	287 a
Warrant	5PT/A		OCT.-NOV.				
Valor EZ	2.05FL	OZ/A	OCT.-NOV.	84 c	75 d	24 fg	265 a
No Group 15 herbicide							
Valor EZ	2.05FL	OZ/A	OCT.-NOV.	94 ab	93 ab	49 de	256 a
Zidua SC	4.1FL	OZ/A	OCT.-NOV.				
Valor EZ	2.05FL	OZ/A	OCT.-NOV.	97 a	91 abc	69 bc	4 b
Dual Magnum	1.33PT/A		OCT.-NOV.				
Valor EZ	2.05FL	OZ/A	OCT.-NOV.	98 a	95 ab	91 a	0 b
Outlook	1PT/A		OCT.-NOV.				
Valor EZ	2.05FL	OZ/A	OCT.-NOV.	90 bc	84 c	28 fg	407 a
Warrant	3PT/A		OCT.-NOV.				
Valor EZ	2.05FL	OZ/A	OCT.-NOV.	89 bc	88 bc	31 ef	356 a
Warrant	5PT/A		OCT.-NOV.				