Journal of Agricultural Science; Vol. 18, No. 6; 2026
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

Evaluation of Clethodim, Glufosinate, and Glyphosate Alone and in Tank-Mix with Residual Herbicides for Control of Johnsongrass (*Sorghum halepense*) Shoots and Rhizomes

Taghi Bararpour[1]

[1] Delta Research and Extension Center, Mississippi State University, Stoneville, MS, USA

Correspondence: Taghi Bararpour, Delta Research and Extension Center, Mississippi State University, Stoneville, MS, USA. E-mail: mtb436@msstate.edu

Received: April 7, 2025 Accepted: May 9, 2026 Online Published: May 15, 2026

doi:10.5539/jas.v18n6p1 URL: https://doi.org/10.5539/jas.v18n6p1

Abstract

Johnsongrass is one of the most difficult weeds to control due to its ability to regenerate from underground rhizomes. Johnsongrass has been a problematic weed for years in row crops in Mississippi. It can severely reduce yields in corn, cotton, soybean, and other row cropping systems. Two separate field studies were conducted in 2023 at the Delta Research and Extension Center in Stoneville, Mississippi to evaluate the effectiveness of clethodim, glufosinate, and glyphosate applied alone or tank-mixed with residual herbicides for johnsongrass rhizomes and seedlings control. No crops were included in this study, as it was carried out under non-crop conditions. The experiment was conducted as a randomized complete block design with 12 herbicide treatments and three replications in a natural johnsongrass population (rhizomes and seedlings). Herbicide treatments included clethodim, glyphosate, and glufosinate applied alone or tank-mixed with the residual herbicides brake, boundary, or acuron for control of johnsongrass rhizomes and seedlings. Johnsongrass shoot control from the application of clethodim alone was 83% four-weeks after application. Antagonism occurred when boundary or acuron were mixed with clethodim which reduced aboveground biomass control. Both glyphosate and glufosinate, whether applied alone or with residual herbicides, maintained excellent shoot control (>96%) with no evidence of antagonism. Four weeks after application, the entire test area was mowed down (after final johnsongrass evaluation) for possible johnsongrass regrowth. Johnsongrass regrowth was observed following all treatments except the glyphosate application. The residual herbicides brake, boundary, and acuron did not improve clethodim or glufosinate performance in preventing johnsongrass regrowth from rhizomes. Glyphosate alone or tank-mixed with residual herbicides were the only treatments that provided 100% of johnsongrass control with no-regrowth.

Keywords: *Sorghum halepense* L., herbicide, weed control

1. Introduction

Johnsongrass [*Sorghum halepense* (L.) Pers.], a perennial grass native to the Mediterranean region, is widely regarded as one of the most problematic weeds introduced into the United States in the early 1800s (Mitich, 1987). This warm-season species infests cultivated fields, ornamental production systems, rights-of-way, roadsides, and hayfields. McWhorter and Anderson (1981) identified johnsongrass as one of the ten most troublesome weeds in row crops across the southern United States, and it is currently listed as a noxious weed in more than twenty states (USDA 2022). Annual economic losses attributed to johnsongrass during the early 1990s were estimated at $5.8 million in cotton (*Gossypium hirsutum* L.) and $23.7 million in soybean [*Glycine max* (L.) Merr.] across Arkansas, Louisiana, and Mississippi (McWhorter & Anderson, 1993). Initially introduced in the southern U.S. to help restore cropland degraded during the Civil War (McWhorter, 1971), johnsongrass has since become difficult to manage due to its rapid growth and dual reproductive strategies-producing abundant seed and spreading vigorously through an extensive rhizome network. Individual plants can generate 40 to 90 m of branching rhizomes and up to 80,000 seeds and may also release allelopathic compounds that enhance their competitiveness (Mitich, 1987; Black et al., 1969; McWhorter, 1989; Warwick & Black, 1983; Klein & Smith, 2021; Pedireddi et al., 2025). Its rhizomes store substantial carbohydrate reserves, supporting regrowth and persistence (McWhorter, 1974), while its seeds can remain viable in soil for 10 to 20 years (Pedireddy et al., 2025). Johnsongrass interference has been associated with severe yield losses-up to 83% in corn (*Zea mays* L.),

60% in soybean, and 90% in cotton cropping systems across the southern United States (Carter & Keeley, 1987; Keeley & Thullen, 1989; Banks & Tripp, 1983; Whitwell et al., 1985; Webster & Coble, 1997; Mitskas et al., 2003; Toler et al., 1996).

Effective johnsongrass management requires controlling both seed-derived seedlings and plants emerging from rhizomes. Prior to the widespread adoption of herbicides, cultural practices-including adjustments in crop row spacing and plant population, cultivar selection, crop rotation, mowing, tillage, and the use of cover crops-were the primary tools for suppressing this weed (Nalewaja, 1999). Today, herbicide applications remain the most used and effective strategies for johnsongrass control (Griffin et al., 2006; Bararpour et al., 2023). Postemergence (POST) treatments with glyphosate (WSSA Group 9), ALS (Acetolactate synthase) inhibitors (WSSA Group 2), and ACCase (Acetyl-CoA carboxylase) inhibitors (WSSA Group 1) have historically provided strong control (Franz et al., 1997; Damalas & Eleftherohorinos, 2001; Johnson et al., 2003; Meyer et al., 2015), and the availability of these effective POST options significantly reduced infestations during the 1990s and early 2000s (Webster & Nichols, 2012). In soybean, Johnson et al. (1991) reported 70 to 90% control when ACCase-inhibiting herbicides such as clethodim, sethoxydim, fluazifop-P, haloxyfop, or quizalofop were applied POST in split applications. In corn, POST applications of the ALS-inhibiting herbicides nicosulfuron and primisulfuron provided 50 to 80% control of rhizome johnsongrass and resulted in higher yields compared to other herbicide programs (Camacho et al., 1991). Glyphosate has also delivered 90 to 100% control in row crops (Culpepper et al., 2000; Lanie et al., 1994). However, repeated and continuous use of these herbicides has contributed to the evolution of resistance to glyphosate, ALS inhibitors, and ACCase inhibitors in multiple cropping systems across the United States and Europe. The first ACCase-resistant johnsongrass population was documented in Missouri (Smeda et al., 1997), followed by ALS-resistant populations first identified in Arkansas and later in additional states (Bagavathiannan & Norsworthy, 2014). Glyphosate-resistant johnsongrass was confirmed in Arkansas in 2007 and in Mississippi in 2008 (Riar et al., 2011; Heap, 2025), and more recently, the first case of glyphosate resistance in Europe was reported in Spain (Vazquez-Garcia et al., 2020).

The rise in glyphosate-, ALS-, and ACCase-inhibitor resistance has prompted many growers to incorporate glufosinate (Group 10) into their weed management programs (Johnson & Norsworthy, 2014; Burke et al., 2006). Integrating both PRE and POST herbicide applications is widely recommended as an effective strategy for managing johnsongrass. Seedling emergence can be suppressed with timely preemergence treatments, and PRE herbicides such as Group 15 products [Dual (metolachlor), Zidua (pyroxasulfone)] and Group 3 products [Treflan (trifluralin), Prowl (pendimethalin)] remain important tools for controlling johnsongrass originating from seed, although they provide no control of plants emerging from rhizomes (Pedireddy et al., 2025). Recent studies in early-season corn and cotton production in Kansas and Mississippi have demonstrated excellent seedling control with PRE applications of acuron (*S*-metolachlor/atrazine/mesotrione/bicyclopyrone) and brake (fluridone) (Currie & Geier, 2023). The current study evaluates the effectiveness of clethodim, glufosinate, and glyphosate-applied alone or tank-mixed with residual herbicides brake, boundary, and acuron-for controlling johnsongrass rhizomes and seedlings in cropping systems.

2. Materials and Methods

Field studies were conducted in 2023 at the Mississippi State University, Delta Research and Extension Center in Stoneville, MS, on a Commerce silty clay loam soil (fine-silty, mixed, superactive, nonacid, thermic Fluvaquentic Endoaquepts) with a pH of 6.3 and 1.3% organic matter. Individual plots measured 4 m in width and 6 m in length. The experimental design was a randomized complete block with three replications. Each plot consisted of four rows, with only the two center rows (rows 2 and 3) receiving herbicide applications; the outer rows (rows 1 and 4) served as untreated weedy checks. Herbicide common names, trade names, sites of action, and manufacturers are listed in Table 1. Twelve herbicide treatments were evaluated for johnsongrass control (Table 2), and the experiment was repeated. The experiment was established in a natural johnsongrass population consisting of both rhizomes derived shoots and seedlings (Figure 1).

Herbicide applications were made on July 21 (air temperature = 34.5 °C; Relative humidity = 60%; soil temperature = 30 °C) to 4- to 8-leaf stage of johnsongrass (50-70 cm tall), with an average density of 3 plants m^{-2}. Herbicides were applied using a CO_2-pressurized backpack sprayer calibrated to deliver 141 L ha^{-1} at 276 kPa through a boom with 51-cm nozzle spacing equipped with Turbo TeeJet Induction (TTI 110015) nozzles (TeeJet Technologies, Springfield, IL). Visual injury (above-ground johnsongrass biomass control) was rated on a 0-100% scale, where 0% indicated no visible control and 100% represented complete plant death relative to the nontreated check.

The entire experimental site was mowed with the use of Case 155 tractor with Alamo Bush Hog after the last herbicide evaluation for johnsongrass control four weeks after application (WAA). Mowing the johnsongrass test area after the final evaluation allowed us to assess the effectiveness of the herbicides on both above-ground biomass and below-ground rhizomes. Controlling above-ground growth alone is insufficient, as underground rhizomes can cause new infestations. Visual johnsongrass regrowth from under-ground rhizomes was rated on a 0-100% scale, where 0% indicated no johnsongrass regrowth and 100% represented complete johnsongrass regrowth relative to the nontreated check.

All field data were analyzed using ARM (Agricultural Research Manager) software (Revision 2025.2, June 27, 2025; GDM Solutions, Inc., Brookings, SD.). Data met assumptions of normality. Herbicide treatments were treated as fixed effects, while replication and experimental run were considered random effects. Results for aboveground johnsongrass suppression were analyzed and presented separately for each experimental run at one, two, and three WAA to characterize the speed of activity. For the final evaluation, data from all runs were combined to assess aboveground biomass at four WAA and underground rhizome biomass. Mean comparisons were subsequently conducted using Fisher's protected least significant difference (LSD) test at $\alpha = 0.05$.

Table 1. Herbicide treatments include their common name and trade name, manufacturer, and site of action used in the study

No.	Herbicide Common Name	Herbicide Trade Name	Site of Action	Manufacture
1	Clethodim	Select	1	Valent
2	Glufosinate	Liberty	10	BASF
3	Glyphosate	Roundup	9	Bayer
4	Fluridone	Brake	12	Gowan
5	*S*-metolachlor + metribuzin	Boundary	15, 5	Syngenta
6	*S*-metolachlor + atrazine + bicyclopyrone + mesotrione	Acuron	15, 5, 27	Syngenta

Table 2. Herbicide treatments and rates for johnsongrass control

No.	Herbicide Trade Name	**Rate** (Kg ai ha^{-1})
1	Select	0.224
2	Select + Brake	0.224 + 0.168
3	Select + Boundary	0.224 + 1.37
4	Select + Acuron	0.224 + 1.45
5	Liberty	0.657
6	Liberty + Brake	0.657 + 0.168
7	Liberty + Boundary	0.657 + 1.37
8	Liberty + Acuron	0.657 + 1.45
9	Roundup	1.27
10	Roundup + Brake	1.27 + 0.168
11	Roundup + Boundary	1.27 + 1.37
12	Roundup + Acuron	1.27 + 1.45

Note. *Select and select herbicide combinations had COC (crop oil concentrate) at 1% v/v (volume by volume).



Figure 1. Johnsongrass (seedlings and rhizomes) infestation at the experimental site

3. Results and Discussion

3.1 Johnsongrass Shoot Control (Run One)

3.1.1 One-Week After Application

Johnsongrass control with clethodim alone was 63% at one week after application (WAA). Adding boundary, a residual herbicide, as a tank mix to clethodim did not improve johnsongrass control (Figure 2). When clethodim was tank-mixed with brake or acuron, control declined to 33-40%, indicating a clear antagonistic interaction. Glufosinate alone provided 85% control, and tank-mixing it with brake increased control to 93%, suggesting a synergistic effect. However, adding boundary or acuron to glufosinate did not enhance performance. Glyphosate, whether applied alone or with residual herbicides, was the only treatment achieving 90-100% aboveground johnsongrass control. Overall, clethodim alone was not effective, and antagonism occurred when brake or acuron were added, whereas brake improved glufosinate activity.

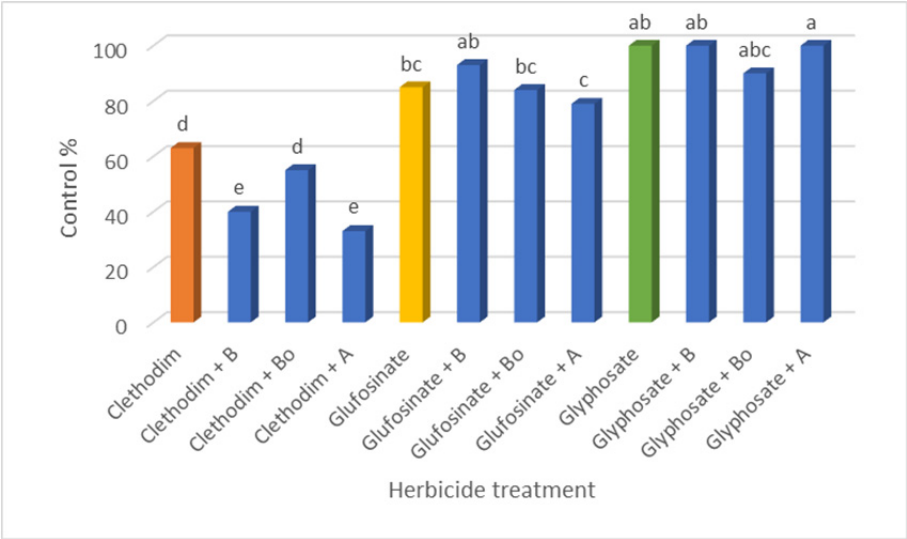


Figure 2. Johnsongrass response to herbicide applications one WAA. Treatments associated with the same letter are not significantly different (α = 0.05). B = brake, Bo = boundary, A = acuron, and WAA = Week After Application

3.1.2 Two-Weeks After Application

By two WAA, johnsongrass control with clethodim increased from 57% to 65% when boundary was included in the tank mixture (Figure 3). In contrast, the addition of brake or acuron resulted in significantly reduced control, indicating an antagonistic interaction with clethodim. The addition of brake to clethodim reduced johnsongrass control from 57 to 50% and the addition of acuron reduced johnsongrass control from 57 to 42%. Glufosinate provided similar levels of aboveground johnsongrass control whether applied alone or in combination with brake, boundary, or acuron. Glyphosate, applied alone or with residual herbicides, achieved 95-100% shoot control by two WAA. No synergistic or antagonistic interactions were observed when brake, boundary, or acuron were added to either glufosinate or glyphosate. However, antagonism was evident when brake or acuron were tank-mixed with clethodim. Overall, clethodim provided limited aboveground johnsongrass suppression, whereas glyphosate and glufosinate remained highly effective (Figures 10 to 12).

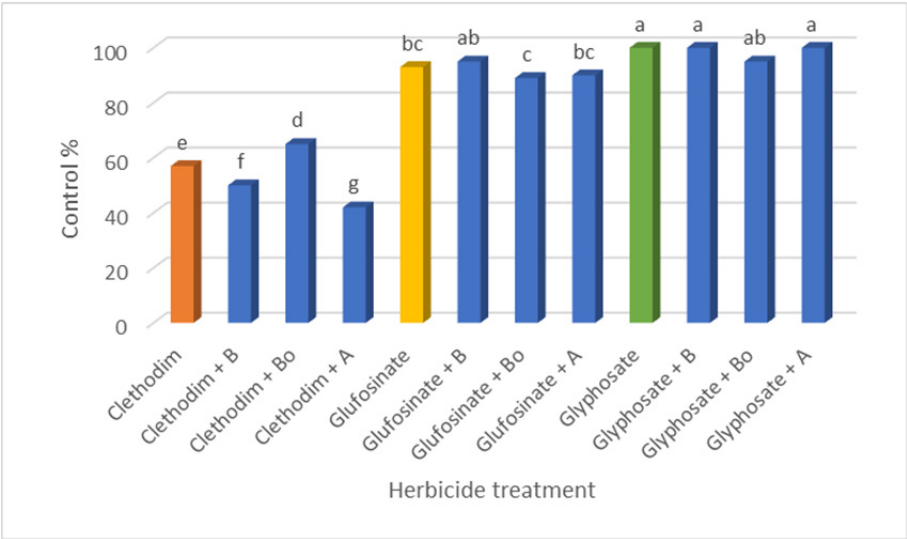


Figure 3. Johnsongrass response to herbicide applications two WAA. Treatments associated with the same letter are not significantly different (α = 0.05). B = brake, Bo = boundary, A = acuron, and WAA = Weeks After Application

3.1.3 Three-Weeks After Application

By three WAA, johnsongrass control with clethodim improved when either boundary or brake was included in the tank mixture (Figure 4). In contrast, the addition of acuron significantly reduced (from 70 to 60%) johnsongrass shoot control, indicating an antagonistic interaction. Glufosinate, whether applied alone or in combination with brake, boundary, or acuron, provided 95-100% aboveground johnsongrass control. Glyphosate and its tank-mix combinations achieved 100% shoot control by three WAA. The only antagonism observed at this timing occurred when acuron was added to clethodim, whereas no antagonistic or synergistic effects were detected when residual herbicides were combined with either glufosinate or glyphosate.

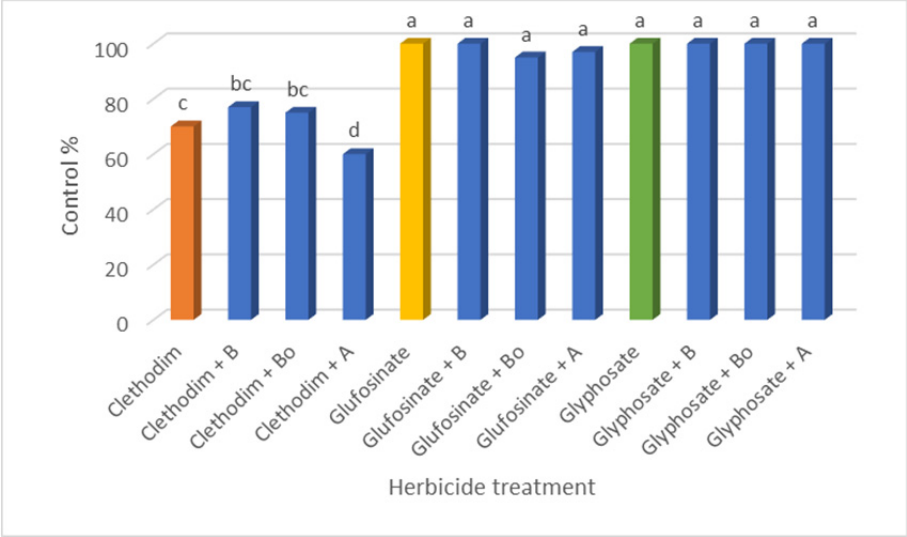


Figure 4. Johnsongrass response to herbicide applications three WAA. Treatments associated with the same letter are not significantly different (α = 0.05). B = brake, Bo = boundary, A = acuron, and WAA = Weeks After Application

3.2 Johnsongrass Shoot Control (Run Two)

3.2.1 One-Week After Application

Johnsongrass control with clethodim alone was 70% at one WAA. Tank-mixing clethodim with boundary or acuron did not improve control (Figure 5). In contrast, adding brake reduced control to 53%, indicating an antagonistic interaction. Glufosinate, applied alone or in combination with residual herbicides, provided 97-100% johnsongrass control. Glyphosate, whether applied alone or tank-mixed with boundary, acuron, or brake, achieved 90-100% shoot control. By three WAA, acuron continued to exhibit antagonism (Figure 7) when combined with clethodim, whereas no antagonistic or synergistic effects were observed when residual herbicides were added to either glyphosate or glufosinate.

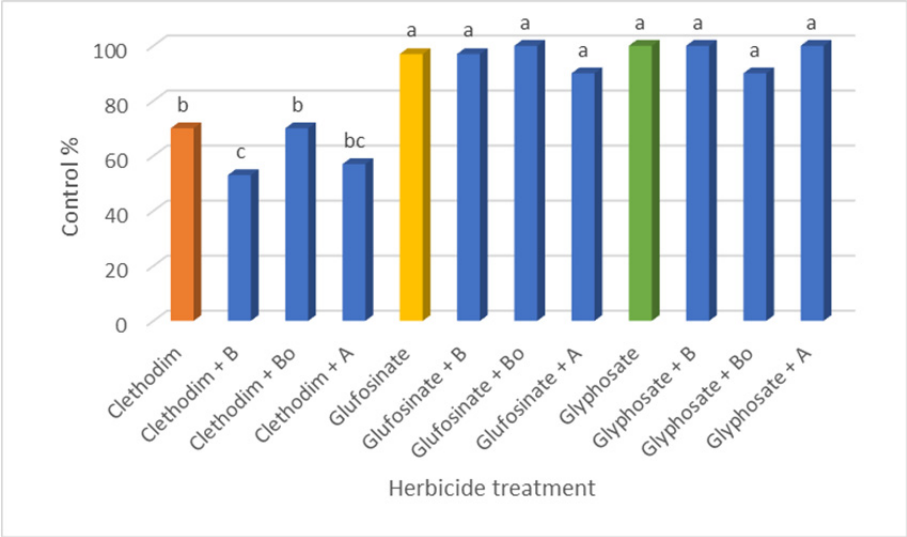


Figure 5. Johnsongrass response to herbicide applications one WAA. Treatments associated with the same letter are not significantly different (α = 0.05). B = brake, Bo = boundary, A = acuron, and WAA = Week After Application

3.2.2 Two-Weeks After Application

Johnsongrass control with clethodim alone was limited to 63% at two WAA. Adding boundary or brake to the clethodim tank mixture did not improve control (Figure 6). When acuron was included, control declined from 63% to 48%, indicating a pronounced antagonistic effect. Glufosinate provided similar levels of aboveground control whether applied alone or tank-mixed with brake, boundary, or acuron, achieving 93-98% control (Figure 6). Glyphosate, applied alone or in combination with residual herbicides, delivered 97-100% shoot control by two WAA. The only antagonism observed was the reduction in efficacy when acuron was added to clethodim; no antagonistic or synergistic interactions occurred when residual herbicides were combined with either glyphosate or glufosinate.

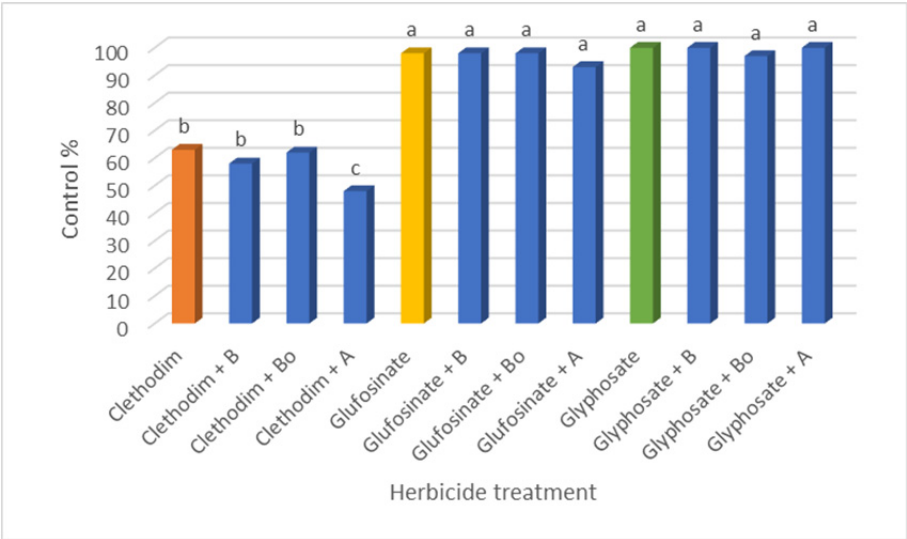


Figure 6. Johnsongrass response to herbicide applications two WAA. Treatments associated with the same letter are not significantly different (α = 0.05). B = brake, Bo = boundary, A = acuron, and WAA = Week After Application

3.2.3 Three-Weeks After Application

By three WAA, adding boundary or brake to clethodim did not improve johnsongrass control (Figure 7). In contrast, tank-mixing clethodim with acuron significantly reduced shoot control, demonstrating a clear antagonistic effect. Glufosinate, applied alone or in combination with brake, boundary, or acuron, consistently provided 95-100% aboveground control. Glyphosate and its tank-mix combinations achieved 100% shoot control by three WAA. The only antagonism observed at this timing occurred when acuron was added to clethodim; no antagonistic or synergistic interactions were detected when brake or boundary were added to clethodim, nor when any residual herbicide was combined with glufosinate or glyphosate.

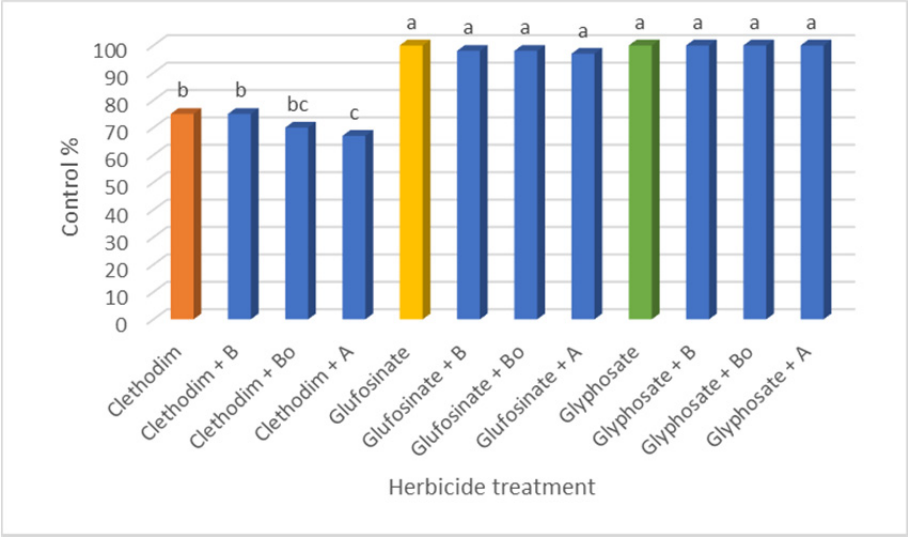


Figure 7. Johnsongrass response to herbicide applications three WAA. Treatments associated with the same letter are not significantly different (α = 0.05). B = brake, Bo = boundary, A = acuron, and WAA = Week After Application

3.3 Johnsongrass Shoot Control Four-Weeks After Application (Two Run Combined)

Johnsongrass control did not improve when brake was added to the clethodim tank mixture (Figure 8). In contrast, the addition of boundary or acuron significantly reduced shoot control compared with clethodim alone, indicating antagonistic interactions. Glufosinate, applied alone or tank-mixed with brake, boundary, or acuron, consistently provided 96-100% aboveground johnsongrass control. Glyphosate and its tank-mix combinations achieved 100% shoot control by four weeks after application. Both glyphosate and glufosinate, whether applied alone or with residual herbicides, maintained excellent control (> 96%) with no evidence of antagonism. The only antagonistic response observed was the reduction in efficacy when boundary or acuron was tank-mixed with clethodim.

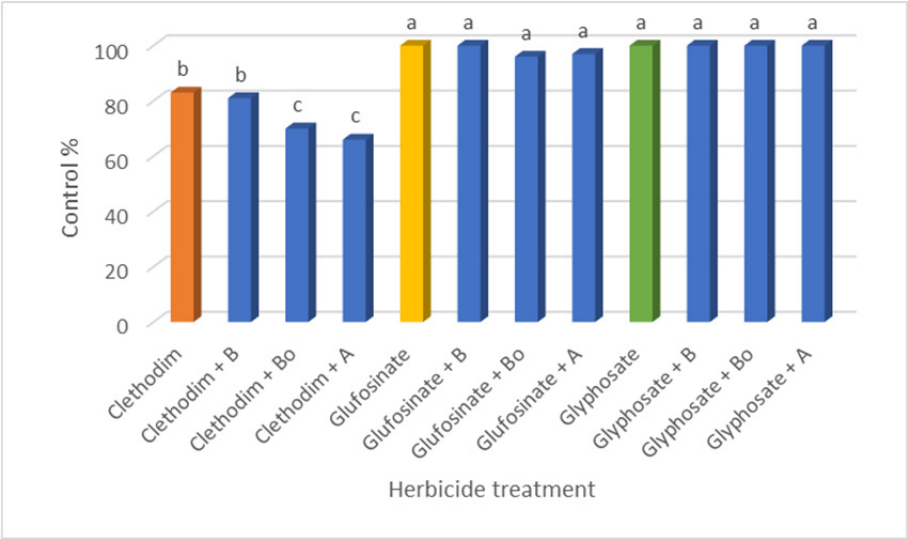


Figure 8. Johnsongrass response to herbicide applications four WAA (two run combined). Treatments associated with the same letter are not significantly different (α = 0.05). B = brake, Bo = boundary, A = acuron, and WAA = Week After Application

3.4 Johnsongrass Regrowth (Two Run Combined)

Johnsongrass regrowth was evaluated three weeks after the test area was mowed, and substantial regrowth occurred following applications of clethodim or glufosinate, whether applied alone or tank-mixed with brake, boundary, or acuron. These results indicate that neither clethodim nor glufosinate alone or in combination with residual herbicides effectively suppressed underground rhizomes (Figure 9). The antagonistic interactions observed when boundary or acuron were mixed with clethodim further contributed to increased regrowth. Glufosinate alone and its tank-mix combinations resulted in 4-13% regrowth, reflecting incomplete control of rhizome-derived shoots. In contrast, glyphosate, applied alone or tank-mixed with brake, boundary, or acuron, nearly eliminated regrowth, with only 0.2-0.3% of shoots returning. The reduced aboveground control observed when clethodim was tank-mixed with boundary or acuron ultimately translated into greater rhizome-mediated regrowth.

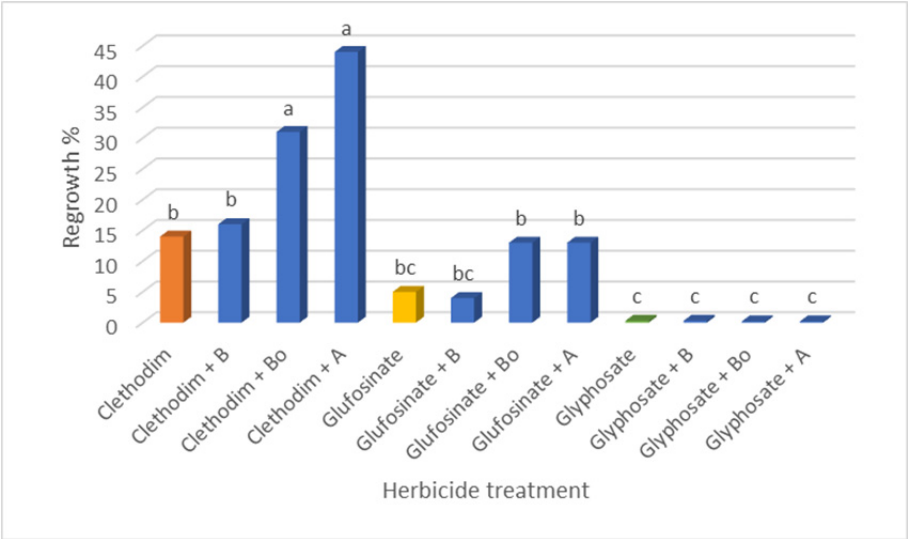


Figure 9. Response of johnsongrass regrowth to herbicide applications three weeks after mowing-down (two run combined). Treatments associated with the same letter are not significantly different (α = 0.05). B = brake, Bo = boundary, and A = acuron



Figure 10. Response of johnsongrass to clethodim herbicide two-weeks after application



Figure 11. Response of johnsongrass to glufosinate herbicide two-weeks after application



Figure 12. Response of johnsongrass to glyphosate herbicide two-weeks after application (only glyphosate-resistant *Amaranthus palmeri* survived)

Previously, more than 90% johnsongrass shoot control in cotton was achieved with clethodim applied at reduced rates (0.5×) (Rosales-Robles et al., 1999). Sequential applications of glufosinate at three and six weeks after soybean emergence have been shown to provide up to 97% control, compared with substantially lower control from a single glufosinate application (Johnson et al., 2014; Kelley et al., 2005; Stephenson et al., 2011). Similarly, Gardner et al. (2006) reported 94% johnsongrass control when glufosinate was applied in combination with clethodim. Johnsongrass has been challenging aggressive weed on cropland for decades. It owes its spread and dominance not only to its rapid rhizome development and prolific seed production but also to changing land-use patterns (Schantz, 2025).

In the present study, clethodim did not provide effective suppression of aboveground johnsongrass, and adding residual herbicides such as brake, boundary, or acuron to clethodim tank mix did not improve performance. Instead, antagonism occurred when boundary or acuron were mixed with clethodim, reducing aboveground biomass control. This same antagonistic response was reflected in regrowth from underground rhizomes, where clethodim tank-mixed with boundary or acuron resulted in significantly greater regrowth compared with clethodim alone. Glufosinate, whether applied alone or tank-mixed with brake, boundary, or acuron, provided excellent aboveground biomass control but was unable to prevent regrowth from rhizomes. In contrast, glyphosate-applied alone or in combination with residual herbicides achieved 100% aboveground control and effectively suppressed rhizome-derived regrowth. This strong performance aligns with previous findings (Bararpour et al., 2023). Because glyphosate alone controlled both shoots and rhizomes, adding residual herbicides offered no additional benefit for johnsongrass control, though such additions may still help manage other weed species. Importantly, brake, boundary, and acuron did not antagonize glyphosate activity. Glyphosate was effective in this study because the johnsongrass population was susceptible; however, glyphosate-resistant johnsongrass has been documented in Arkansas (Riar et al., 2011) and Mississippi (Mississippi State University Extension Service, 2026). This highlights the need for continued research into alternative herbicides or tank-mix strategies capable of controlling both aboveground biomass and rhizome-derived regrowth should resistance become more widespread.

4. Conclusions

Johnsongrass is difficult to manage because its underground rhizomes continually generate new shoots, making long-term control far more challenging than simply suppressing aboveground biomass. While aboveground growth can often be reduced with postemergence herbicides, effective management requires suppressing both shoots and rhizomes. Clethodim, a grass-selective herbicide, did not adequately control either aboveground johnsongrass biomass or its underground rhizomes. Moreover, antagonism occurred when boundary or acuron

was added to clethodim, reducing shoot control and ultimately leading to greater rhizome-derived regrowth. Glufosinate, applied alone or tank-mixed with brake, boundary, or acuron, provided excellent aboveground biomass control but was unable to prevent regrowth from rhizomes. In contrast, glyphosate whether applied alone or in combination with residual herbicides achieved complete control of aboveground biomass and effectively suppressed rhizome-derived regrowth.

References

Bagavathiannan, M. V., & Norsworthy, J. K. (2014). Do roadside herbicide applications select for resistance in johnsongrass populations? *Proc. South Weed Sci. Soc., 67*, 105.

Banks, P. A., & Tripp, T. N. (1983). Control of johnsongrass (*Sorghum halepense*) in soybeans (*Glycine max*) with foliar-applied herbicides. *Weed Sci., 31*, 628-633. https://doi.org/10.1017/S0043174500070090

Bararpour, T., Korres, N. E., Argenta, J., & Tseng, T. M. (2023). Evaluation of herbicides for the control of yellow nutsedge (*Cyperus esculentus* L.) and Johnsongrass (*Sorghum halepense* L.) Under Non-Crop Conditions. *Journal of Agricultural Science, 15*(3), 1. https://doi.org/10.5539/jas.v15n3p1

Black, C .C, Chen, T. M, & Brown, R. H. (1969). Biochemical basis for plant competition. *Weed Sci., 17*, 338-344. https://doi.org/10.1017/S0043174500054187

Burke, I. C., Wilcut, J. W., & Cranmer, J. (2006). Cross-resistance of johnsongrass (*Sorghum halepense*) biotype to Aryloxyphenoxypropionate and Cyclohexanedione herbicides. *Weed Technology, 20*(3), 571-575. https://doi.org/10.1614/WT-05-110R.1

Camacho, R. F., Moshier, L. J., Morishita, D. W., & Devlin, D. L. (1991). Rhizome johnsongrass (*Sorghum halepense*) control in corn (*Zea mays*) with primisulfuron and nicosulfuron. *Weed Technol., 5*, 789-794. https://doi.org/10.1017/S0890037X00033868

Carter, C. H., & Keeley, P. E. (1987). Selective control of johnsongrass (*Sorghum halepense*) in cotton (*Gossypium hirsutum*) with foliar herbicides. *Weed Sci., 35*, 418-421. https://doi.org/10.1017/S0043174500053923

Culpepper, A. S., York, A. C., Jennings, K. M., & Batts, R. B. (2000). Weed management in glufosinate- and glyphosate-resistant soybean (*Glycine max*). *Weed Technol., 14*, 77-88. https://doi.org/10.1614/0890-037X(2000)014[0077:WMIGAG]2.0.CO;2

Currie, R. S., & Geier, P. W. (2023). Residual herbicides as single and sequential treatments for efficacy in corn. *Kansas Agricultural Experiment Station Research Reports, 9*(6), 12. https://doi.org/10.4148/2378-5977.8496

Damalas, C. A., & Eleftherohorinos, I. G. (2001). Dicamba and atrazine antagonism on sulfonylurea herbicides used for johnsongrass (*Sorghum halepense*) control in corn (*Zea mays*). *Weed Technology, 15*(1), 62-67. https://doi.org/10.1614/0890-037X(2001)015[0062:DAAAOS]2.0.CO;2

Franz, J. E., Mao, M. K., & Sikorski, J. A. (1997). *Glyphosate: A unique global herbicide* (1st ed., pp. 3-15). Washington, DC: American Chemical Society.

Gardner, A. P., York, A. C., Jordan, D. L., & Monks, D. W. (2006). Glufosinate antagonizes postemergence graminicides applied to annual grasses and johnsongrass. *J. Cotton Sci., 10*, 319-327.

Griffin, J. L., Miller, D. K., & Salassi, M. E. (2006). Johnsongrass (*Sorghum halepense*) control and economics of using glyphosate-resistant soybean in fallowed sugarcane fields. *Weed Technol., 20*, 980-985. https://doi.org/10.1614/WT-05-027.1

Heap, I. (2025). *The International Survey of Herbicide Resistant Weeds*. Retrieved from http://www.weed science.com

Johnson, D. B., Norsworthy, J. K., & Scott, R. C. (2014). Herbicide programs for controlling glyphosate-resistant johnsongrass (*Sorghum halepense*) in glufosinate-resistant soybean. *Weed Technol., 28*, 10-18. https://doi.org/10.1614/WT-D-13-00099.1

Johnson, W. G., & Frans, R. E. (1991). Johnsongrass (*Sorghum halepense*) control in soybeans (*Glycine max*) with postemergence herbicides. *Weed Technol., 5*, 87-91. https://doi.org/10.1017/S0890037X00033315

Johnson, W. G., Li, J., & Wait, J. D. (2003). Johnsongrass control, total nonstructural carbohydrates in rhizomes, and regrowth after application of herbicides used in herbicide-resistant corn (*Zea mays*). *Weed Technol., 17*, 36-41. https://doi.org/10.1614/0890-037X(2003)017[0036:JCTNCI]2.0.CO;2

Keeley, P. E., & Thullen, R. J. (1989). Growth and interaction of johnsongrass (*Sorghum halepense*) with cotton (*Gossypium hirsutum*). *Weed Sci., 37*, 339-344. https://doi.org/10.1017/S0043174500072027

Kelly, S. T., Miller, D. K., & Stewart, A. M. (2005). Ignite weed control systems in Liberty Link cotton. *Proceedings of the Beltwide Cotton Conference, New Orleans, LA* (pp. 2926-2927). Memphis, TN: National Cotton Council of America.

Klein, P., & Smith, C. M. (2021). Invasive johnsongrass, a threat to native grasslands and agriculture. *Biologia, 76*, 413-420. https://doi.org/10.2478/s11756-020-00625-5

Lanie, A. J., Griffin, J. L., Vidrine, P. R., & Reynolds, D. B. (1994). Herbicide combinations for soybean (*Glycine max*) planted in stale seedbed. *Weed Technol., 8*, 17-22. https://doi.org/10.1017/S0890037X00039130

McWhorter, C. G. & Anderson, J. M. (1981). The technical and economic effects of johnsongrass (*Sorghum halepense*) control in soybeans. *Weed Sci., 29*, 245-25. https://doi.org/10.1017/S0043174500061907

McWhorter, C. G. & Anderson, J. M. (1993). Effects of johnsongrass (*Sorghum halepense*), hemp sesbania (*Sesbania exaltata*), and delayed harvest on soybeans. *Weed Technology, 7*(2), 355-360. https://doi.org/10.1017/S0890037X0002772X

McWhorter, C. G. (1971). Introduction and spread of johnsongrass in the United States. *Weed Sci., 19*, 496-500. https://doi.org/10.1017/S0043174500050517

McWhorter, C. G. (1974). Water-soluble carbohydrates in johnsongrass. *Weed Science, 22*(2), 159-163. https://doi.org/10.1017/S0043174500036778

McWhorter, C. G. (1989). History, biology, and control of johnsongrass. *Rev. Weed Sci., 4*, 85-121.

Meyer, C. J., Norsworthy, J. K., Stephenson, D. O., Bararpour, M. T., Landry, R. L., & Woolam, B. C. (2015). Control of johnsongrass in the absence of glyphosate in midsouth cotton production systems. *Weed Technology, 29*(4), 730-739. https://doi.org/10.1614/WT-D-15-00057.1

Mississippi State University Extension Service. (2026). *2026 Weed Management Suggestions for Mississippi Row Crops* (P3171). Retrieved from https://extension.msstate.edu/publications/2026-weed-management-suggestions-for-mississippi-row-crops

Mitich, L. W. (1987). Colonel johnson's grass: Johnsongrass. *Weed Technology, 1*(1), 112-113. https://doi.org/10.1017/S0890037X00029249

Mitskas, M. B., Tsolis, C. E., Eleftherohorinos, I. G., & Damalas, C. A. (2003). Interference between corn and johnsongrass (*Sorghum halepense*) from seed or rhizomes. *Weed Science, 51*, 540-545. https://doi.org/10.1614/0043-1745(2003)051[0540:IBCAJS]2.0.CO;2

Nalewaja, J. D. (1999). Cultural practices for weed resistance management. *Weed Technol., 13*, 643-646. https://doi.org/10.1017/S0890037X00046339

Pedireddi, U., Sias, C., & Bagavathiannan, M. (2025) *GROW*. Retrieved from https://growiwm.org/wp-content/uploads/2022/11/Johnsongrass-Nov14.pdf

Riar, D. S., Norsworthy, J. K., Johnson, D. B., Scott, R. C., & Bagavathiannan, M. (2011). Glyphosate resistance in a johnsongrass (*Sorghum halepense*) biotype from Arkansas. *Weed Sci., 59*, 299-304. https://doi.org/10.1614/WS-D-10-00150.1

Rosales-Robles, E., Chandler, J. M., Senseman, S. A., & Prostko, E. P. (1999). Integrated johnsongrass management in cotton with reduced rates of clethodim and cultivation. *J. Cotton Sci., 3*, 27-34.

Schantz, M. C. (2025). Johnsongrass (*Sorghum halepense*): A review of its invasion, management, and spread in the changing climate of the Southern Great Plains. *Weed Sci., 73*(e31), 1-7. https://doi.org/10.1017/wsc.2025.7

Smeda, R. J., Snipes, C. E., Barrentine, W. L. (1997). Identification of graminicide-resistant johnsongrass (*Sorghum halepense*). *Weed Sci., 45*, 132-137. https://doi.org/10.1017/S0043174500092584

Stephenson, D. O., Griffin, J., & Burgos, N. R. (2011). Glyphosate resistant johnsongrass monitoring and management. *Proc. South Weed Sci. Soc., 64*, 228.

Toler, J. E., Guice, J. B., & Murdock, E. C. (1996). Interference between johnsongrass (*Sorghum halepense*), smooth pigweed (*Amaranthus hybridus*), and soybean (*Glycine max*). *Weed Science, 44*, 331-338. https://doi.org/10.1017/S0043174500093966

USDA. (2022). *State noxious-weed seed requirements recognized in the administration of the Federal Act*. Retrieved from https://www.ams.usda.gov/sites/default/files/media/StateNoxiousWeedsSeedList.pdf

Vazquez-Garcia, J. G., Palma-Bautista, C., Rojano-Delgado, A. M., De Prado, R., & Menendez, J. (2020). The first case of glyphosate resistance in johnsongrass (*Sorghum halepense* (L.) Pers.) in Europe. *Plants, 9*(3), 313. https://doi.org/10.3390/plants9030313

Warwick, S. I., & Black, L. D. (1983) The biology of Canadian weeds.61. *Sorghum halepense* (L.) Pers. *Can. J. Plant Sci., 63*, 997-1014. https://doi.org/10.4141/cjps83-125

Webster, T. M., & Coble, H. D. (1997). Changes in the weed species composition of the southern United States: 1974 to 1995. *Weed Technol., 11*, 308-317. https://doi.org/10.1017/S0890037X00043001

Webster, T. M., & Nichols, R. (2012). Changes in the weed species in the major agronomic crops of the United States: 1994/1995 to 2008/2009. *Weed Sci., 60*, 145-157. https://doi.org/10.1614/WS-D-11-00092.1

Whitwell, T., Wehtje, G., Walker, R. H., & McGuire, J. A. (1985). Johnsongrass (*Sorghum halepense*) control in soybeans (*Glycine max*) with postemergence grass herbicides applied alone and in mixtures. *Weed Sci., 33*, 673-678. https://doi.org/10.1017/S0043174500083077

Acknowledgments

This publication is a contribution of the Mississippi Agricultural and Forestry Experiment Station. This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, Hatch project under accession number 151510.

Authors Contributions

Not applicable.

Funding

Not applicable.

Competing Interests

The authors declare no conflict of interest.

Informed Consent

Obtained.

Ethics Approval

The Publication Ethics Committee of the Canadian Center of Science and Education.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and Peer Review

Not commissioned; externally double-blind peer reviewed.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data Sharing Statement

No additional data are available.

Open Access

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (http://creativecommons.org/licenses/by/4.0/).

Copyrights

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.