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CHEMICAL CONTROL OF *Conyza sumatrensis*, *Digitaria insularis* AND *Commelina benghalensis* AT SOYBEAN PRE-SOWING IN THE SOYBEAN/CORN SYSTEM

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Abstract
Conyza sumatrensis, *Digitaria insularis*, and *Commelina benghalensis* are common weeds in Brazil's soybean/corn production systems. This study aimed to evaluate effective, sustainable control strategies for managing these difficult-to-control species. Two experiments were conducted in soybean/corn succession areas in Caarapó, MS, Brazil, during the 2020/2021 season. In Experiment 1, the area presented *D. insularis*, *C. sumatrensis*, and *C. benghalensis*. In Experiment 2, the area was dominated by *C. sumatrensis* at different development stages. Both experiments followed a randomized block design (RBD), with 4 replications. Weed control was evaluated 7, 14, and 28 days after the last application. The combination of glufosinate and carfentrazone followed by a sequential application of glyphosate and clethodim was effective in controlling *D. insularis*. For *C. benghalensis*, no herbicide alone or in combination provided satisfactory control. For *C. sumatrensis*, control depended on the stage of plant development, being effective with an isolated application of glufosinate or as part of a mixture.

Keywords: Benghal dayflower. Sourgrass. Sumatran fleabane. Weeds.

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1. Introduction

Weeds pose a major challenge to the soybean/corn production system practiced in several regions of Brazil, as weed establishment can compromise the management of subsequent crops and reduce the efficiency of the production system. Due to the management practices associated with these crops, over time, the environment tends to select some species that adapt more easily to the system (MacLaren et al. 2020). Among the species that have adapted to these systems, *Digitaria insularis* (sourgrass), *Commelina benghalensis* (Benghal dayflower), and *Conyza sumatrensis* (Sumatran fleabane) share a common characteristic: they are difficult to control with glyphosate. The issue of resistant biotypes is evident in the cases of *C. sumatrensis* (Mendes et al. 2021) and *D. insularis* (Correia 2023), while *C. benghalensis* has shown tolerance to glyphosate (Bottcher et al. 2022).

The interference of these difficult-to-control weeds in cultivated areas can lead to lower productivity and have a negative impact on the growth and development of crops such as soybeans and corn (Patil et al. 2020). Studies assessing the interference of *Conyza* spp. in soybean crops show that losses can reach 50% depending on coexistence duration and plant density per square meter (Trezzi et al. 2015). In the case of *D. insularis*, densities of 6 plants per square meter resulted in soybean yield losses ranging from 600 to 1,300 kg ha^{-1} (Gazziero et al. 2019).

Managing these weeds requires using herbicides with different mechanisms of action, combining herbicides, applying sequential treatments, and adopting management strategies beyond chemical control (Bottcher et al. 2022). These approaches are essential to reducing the interference of these weeds and minimizing the selection of resistant populations (MacLaren et al. 2020).

In the context of the weeds *D. insularis*, *C. benghalensis*, and *C. sumatrensis* in the soybean/corn system, this study aimed to evaluate herbicide strategies for weed control at soybean pre-sowing, seeking effective and sustainable management of these difficult-to-control species.

2. Material and Methods

Two experiments were conducted during the 2020/2021 harvest in soybean/corn succession areas to evaluate the post-emergence control of difficult-to-control species. In the municipality of Caarapó, state of Mato Grosso do Sul, at the geographic coordinates: Experiment 1 (Latitude: -22° 34' 7.45, Longitude: -54° 48' 34.91) and Experiment 2 (Latitude: -22° 44' 14.79, Longitude: -54° 52' 4.66).

In Experimental Area 1, we observed the predominance of clumps of *D. insularis* and *C. sumatrensis* with heights of less than 30 cm, as well as flowering *C. benghalensis*. In Experiment 2, the area was dominated by *C. sumatrensis* at different developmental stages, with plants reaching up to 50 cm in height.

The experiment was a randomized block design, with 4 replications andplots measuring 3 m wide by 5 m long. The treatments consisted of applying herbicides alone or in mixtures (Table 1).

The treatments were applied using a CO_2-pressurized backpack sprayer, equipped with Magnojet 110.015 BD spray nozzles spaced 50 cm apart, at a pressure of 2 kgf cm², and a spray volume of 150 L ha^{-1}. The application speed was 3.6 km h^{-1}. The applications occurred at the time of soybean pre-sowing burndown, with a sequential application in the first experiment performed 14 days after the first application.

In Experiment 1, evaluations were performed at 7, 14, and 28 days after application (DAA) (sequential). In Experiment 2, evaluations were made at 7, 14, and 28 DAA. Evaluations consisted of a visual analysis of each experimental unit, and the assignment ofscores ranging from 0% (no injuries or control) to 100% (total plant death or total weed control), based on visible symptoms (Velini et al. 1995).

The data obtained from the evaluations were tested by an analysis of variance (F-test), followed by a Scott and Knott (1974) cluster test at a 5% probability, using the Sisvar® 5.3 software (Ferreira 2011).

Table 1. Post-emergence herbicide treatments. Caarapó, MS, 2021.

Treatments	Dose (g a.i. ha^{-1} or g a.e. ha^{-1})
Experiment 1	
1. control	-
2. clethodim	192
3. diquat	200
4. glufosinate	400
5. glufosinate + carfentrazone	400 + 30
6. clethodim + carfentrazone	192 + 30
7. glufosinate / glyphosate + clethodim	400
	seq. 960 + 192
8. diquat / glyphosate + clethodim	200
	seq960 + 192
9. clethodim + flumioxazin	192 + 50
10. diquat + flumioxazin / glyphosate + clethodim	200 + 50
	seq 960 +192
11. glufosinate + carfentrazone / glyphosate + clethodim	400 + 30
	seq 960 + 192
Experiment 2	
1. control	-
2. glyphosate + 2,4-D	1250 + 804
3. glyphosate + dicamba	1250 + 288
4. glyphosate + triclopyr	1250 + 576
5. glyphosate + 2,4-D + saflufenacil	1250 + 804 + 35
6. glyphosate + dicamba + saflufenacil	1250 + 288 + 35
7. glyphosate + triclopyr + saflufenacil	1250 + 576 + 35
8. glyphosate + 2,4-D + glufosinate	1250 + 804 + 500
9. glyphosate + dicamba + glufosinate	1250 + 288 + 500
10. glyphosate + triclopyr + glufosinate	1250 + 576 + 500
11. glyphosate + salflufenacil	1250 + 35
12. glyphosate + glufosinate	1250 + 500
13. glufosinate	500

*/= sequential application, 14 days after the first application. All treatments included an adjuvant at 0.5% v/v.

3. Results

In Experiment 1, the best treatment for controlling *D. insularis* at 28DAA was a mixture of glufosinate + carfentrazone, followed by the sequential application of glyphosate + clethodim, reaching 82.5% control. The application of glufosinate followed by glyphosate + clethodim at 28 DAA resulted in over 60% control, although it was inferior to the control achieved with the aforementioned combination. Nevertheless, this treatment performed better than the others, which showed significantly poorer control. No sequential application after glufosinate or glufosinate + carfentrazone resulted in reduced control efficacy after 14 DAA, indicating decreasedefficacy over time (Table 2).

As for the control of *C. benghalensis* in Experiment 1, none of the treatments achieved control rates above 50% at any of the evaluation dates (Table 3). Although all treatments were considered insufficient, those involving glufosinate and clethodim + carfentrazone showed the highest control rates, with values below 46.75%.

For the control of *C. sumatrensis* in the first experiment, treatments that included glufosinate produced the best results, achieving over 77% control at the 28 DAA evaluation (Table 4). Treatments involving diquat and diquat followed by glyphosate + clethodim presented lower control than glufosinate treatments but better performance than other treatments.

In Experiment 2, the treatments that included glufosinate, glyphosate + dicamba + saflufenacil, and glyphosate + triclopyr + saflufenacil presented excellent control (≥ 80%) of *C. sumatrensis* over 15 cm tall in the 28 DAA evaluation. For *C. sumatrensis* over15 cm tall, none of the treatments tested in Experiment 2 obtained a control greater than 61.5%.

Table 2. *Digitaria insularis* control (%) at 7, 14, and 28 days after application (DAA) of herbicides (Experiment 1).

	Treatments	Control (%)		
		7 DAA	14 DAA	28 DAA
Experiment 1	1. control (no application)	0.00[b]	0.00[c]	0.00[f]
	2. clethodim	8.00[b]	31.25[b]	32.50[d]
	3. diquat	7.75[b]	5.75[c]	15.00[e]
	4. glufosinate	46.50[a]	62.25[a]	47.50[c]
	5. glufosinate + carfentrazone	43.75[a]	63.50[a]	52.50[c]
	6. clethodim + carfentrazone	15.50[b]	41.75[b]	50.00[c]
	7. glufosinate seq. glyphosate + clethodim	36.50[a]	56.25[a]	68.75[b]
	8. diquat seq. glyphosate + clethodim	5.00[b]	4.75[c]	36.25[d]
	9. clethodim + flumioxazin	12.00[b]	40.75[b]	48.75[c]
	10. diquat + flumioxazin seq. glyphosate + clethodim	6.50[b]	8.75[c]	42.5[c]
	11. glufosinate + carfentrazone seq glyphosate + clethodim	45.50[a]	50.50[a]	82.5[a]
	Mean	20.64	33.23	43.30
	CV%	39.47	34.40	19.58

seq.: sequential application, 14 days after the first application. Means followed by different letters, in the column, are significantly differentby Scott-Knott's test ($p < 0.05$).

Table 3. *Commelina benghalensis* control (%) at 7, 14, and 28 days after application (DAA) of herbicides (Experiment 1).

	Treatments	Control (%)		
		7 DAA	14 DAA	28 DAA
Experiment 1	1. control (no application)	0.00[b]	0.00[a]	0.00[b]
	2. clethodim	1.00[b]	3.25[a]	18.25[b]
	3. diquat	16.25[a]	8.25[a]	18.25[b]
	4. glufosinate	36.00[a]	8.25[a]	35.00[a]
	5. glufosinate + carfentrazone	31.00[a]	12.75[a]	38.25[a]
	6. clethodim + carfentrazone	17.25[a]	13.25[a]	43.75[a]
	7. glufosinate seq. glyphosate + clethodim	22.00[a]	13.75[a]	46.75[a]
	8. diquat seq. glyphosate + clethodim	19.00[a]	17.25[a]	23.75[b]
	9. clethodim + flumioxazin	14.00[a]	20.00[a]	16.75[b]
	10. diquat + flumioxazin seq. glyphosate + clethodim	19.25[a]	21.25[a]	17.50[b]
	11. glufosinate + carfentrazone seq glyphosate + clethodim	7.50[b]	23.00[a]	28.25[a]
	Mean	16.66	12.82	26.04
	CV%	69.69	90.35	45.95

seq.: sequential application, 14 days after the first application. Means followed by differentletters, in the same column, are significantly different by Scott and Knott´s test ($p < 0.05$).

4. Discussion

The application of glufosinate + carfentrazone followed by the sequential application of glyphosate + clethodim has resulted in effective control of perennial *D. insularis* in the clumping stage. This good performance may be linked to the synergism between glufosinate and PROTOX inhibitors (Takano et al. 2020), such as carfentrazone, which may have enhanced control of these weed species. Previous research suggests that the sequential application of glyphosate + clethodim is effective in controlling *D. insularis*, especially when regrowth height is limited to 20 cm, and applications are made between 17 and 24 days after the first application (Mendes et al. 2020). In the present study, the sequential application was carried out 14 days after the first application, which also proved to be an effective alternative to control this species. These results are consistent with weed management programs implemented at soybean pre-sowing, in which sequential herbicide applications are commonly used to improve the control of perennial *D. insularis* (Palharani et al. 2023).

Table 4. *Conyza sumatrensis* control (%) at 7, 14, and 28 days after application (DAA) of herbicides (experiment 1 and 2).

	Treatments	Control (%)		
		7 DAA	14 DAA	28 DAA
Experiment 1	1. control (no application)	0.00^{b}	0.00^{c}	0.00^{e}
	2. clethodim	1.25^{b}	8.00^{c}	18.25^{d}
	3. diquat	79.50^{a}	70.75^{b}	71.75^{b}
	4. glufosinate	67.00^{a}	83.00^{a}	90.25^{a}
	5. glufosinate + carfentrazone	71.75^{a}	87.50^{a}	92.50^{a}
	6. clethodim + carfentrazone	10.25^{b}	11.25^{c}	20.00^{d}
	7. glufosinate seq. glyphosate + clethodim	64.50^{a}	81.25^{a}	77.25^{a}
	8. diquat seq. glyphosate + clethodim	67.25^{a}	74.50^{a}	65.00^{b}
	9. clethodim + flumioxazin	8.25^{b}	10.75^{c}	16.25^{d}
	10. diquat + flumioxazin seq. glyphosate + clethodim	62.75^{a}	59.25^{b}	48.75^{c}
	11. glufosinate + carfentrazone seq glyphosate + clethodim	70.75^{a}	76.75^{a}	81.75^{a}
	Mean	27.97	51.18	52.89
	CV%	45.75	17.30	17.28
Experiment 2	*Conyza sumatrensis* < 15 cm			
	1. control (no application)	0.00^{c}	0.00^{e}	0.00^{e}
	2. glyphosate + 2,4-D*	36.25^{b}	38.25^{d}	21.00^{d}
	3. glyphosate + dicamba*	30.00^{b}	35.00^{d}	40.00^{c}
	4. glyphosate + triclopyr*	36.75^{b}	45.00^{d}	45.00^{c}
	5. glyphosate + 2,4-D + saflufenacil*	63.75^{a}	63.75^{c}	60.00^{b}
	6. glyphosate + dicamba + saflufenacil*	71.25^{a}	80.00^{a}	80.00^{a}
	7. glyphosate + triclopyr + saflufenacil*	70.00^{a}	81.75^{a}	82.50^{a}
	8. glyphosate + 2,4-D + glufosinate*	66.25^{a}	82.75^{a}	85.00^{a}
	9. glyphosate + dicamba + glufosinate*	70.50^{a}	88.75^{a}	85.00^{a}
	10. glyphosate + triclopyr + glufosinate*	66.25^{a}	87.50^{a}	92.50^{a}
	11. glyphosate + salflufenacil*	56.25^{a}	73.75^{b}	69.00^{b}
	12. glyphosate + glufosinate*	63.25^{a}	81.25^{a}	70.00^{b}
	13. glufosinate*	63.25^{a}	80.50^{a}	87.50^{a}
	Mean	53.36	64.48	62.88
	CV%	13.90	9.08	11.08
	Conyza sumatrensis > 15 cm			
	1. control (no application)	0.00^{d}	0.00^{e}	0.00^{c}
	2. glyphosate + 2,4-D*	40.75^{b}	27.25^{d}	15.00^{c}
	3. glyphosate + dicamba*	25.00^{c}	24.25^{d}	30.00^{b}
	4. glyphosate + triclopyr*	28.75^{c}	30.75^{d}	37.50^{a}
	5. glyphosate + 2,4-D + saflufenacil*	48.75^{b}	45.00^{c}	36.25^{a}
	6. glyphosate + dicamba + saflufenacil*	56.25^{a}	61.25^{a}	56.75^{a}
	7. glyphosate + triclopyr + saflufenacil*	63.75^{a}	66.25^{a}	54.75^{a}
	8. glyphosate + 2,4-D + glufosinate*	60.00^{a}	64.25^{a}	61.50^{a}
	9. glyphosate + dicamba + glufosinate*	61.25^{a}	72.50^{a}	51.00^{a}
	10. glyphosate + triclopyr + glufosinate*	61.25^{a}	71.25^{a}	51.25^{a}
	11. glyphosate + salflufenacil*	40.00^{b}	55.50^{b}	30.00^{b}
	12. glyphosate + glufosinate*	58.75^{a}	69.00^{a}	45.00^{a}
	13. glufosinate*	58.75^{a}	72.50^{a}	43.25^{a}
	Mean	46.40	50.75	39.40
	CV%	14.04	12.71	41.93

Means followed by different letters, in the same column, aresignificantly different by Scott and Knott's test ($p < 0.05$).

None of the treatments applied in Experiment 1 showed satisfactory control of *C. benghalensis*. This may be because the *C. benghalensis* plants were creeping at the time of application, making control difficult. Previous studies indicate that auxin herbicides are effective in controlling this plant (Bottcher et al. 2022; Filus et al. 2024). However, it is worth noting that no herbicides with this mechanism of action were tested in the present study, which may have contributed to the low efficacy of the treatments.

Treatments containing glufosinate showed excellent control of *C. sumatrensis* in Experiment 1 and also effective control of *C. sumatrensis* smaller than 15 cm in Experiment 2. These results highlights the importance of early herbicide applications, typically performed at soybean pre-sowing, for effective control of *Conyza* (Albrecht et al. 2021). Other studies have also reported the efficacy of glufosinate in controlling *C. sumatrensis*, especially in chemical management to control this species (Zobiole et al. 2018; Albrecht et al. 2020; Cassol et al. 2024). At this plant size, glufosinate alone showed satisfactory control. Previous studies have also demonstrated good results in the control of *C. sumatrensis* with a single application of glufosinate at doses of 600 and 700 g ai ha^{-1} (Albrecht et al. 2022; Cassol et al. 2024). In the present study, doses of 400 and 500 g ai ha^{-1} were effective in controlling *C. sumatrensis* in Experiments 1 and 2 (for plants smaller than 30 and 15 cm, respectively).

In addition, the application of glufosinate with glyphosate in Experiment 2 on *C. sumatrensis* smaller than 15 cm showed lower control at 28 DAA compared to the application of glufosinate alone. The application of these two herbicides in combination may lead to antagonism in weed control (Meyer et al. 2022).

For *C. sumatrensis* taller than 15 cm, none of the treatments in Experiment 2 showed good control. Effective chemical control of *Conyza* is achieved by applying herbicides in the early stages of development (Gazola et al. 2022; Doğan et al. 2023). The control of *Conyza* over 15 cm tall requires sequential herbicide applications (Albrecht et al. 2020; Silva et al. 2021; Bottcher et al. 2022).

From a practical perspective, weed management strategies implemented at soybean pre-sowing within the soybean/corn production system, particularly those involving herbicide mixtures and sequential applications containing glufosinate, allow for more effective control of early weed growth. This approach reduces weed pressure at crop establishment and improves management efficiency (Albrecht et al. 2020; Albrecht et al. 2022; Cassol et al. 2024).

5. Conclusions

Application of glufosinate and carfentrazone, followed by glyphosate and clethodim, was effective in controlling perennial *D. insularis* at the clumping stage.

No herbicide alone or in combination provided satisfactory control for *C. benghalensis*.

Conyza sumatrensis plants from Experiment 1 and those smaller than 15 cm from Experiment 2 were well controlled by the application of glufosinate alone or in combination. However, For *C. sumatrensis* taller than 15 cm, no treatment, either alone or in combination, was effective with a single application.

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