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Original Article

Desiccation strategies for *Conyza* spp. in pre-sowing soybean production areas of Mato Grosso do Sul[1]

Estratégias de dessecação de *Conyza* spp. em áreas de produção de soja em pré-semeadura no Mato Grosso do Sul

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HIGHLIGHTS:

Sequential applications of ammonium glufosinate enhance control of Conyza *spp. in taller plants(>10 cm), improving efficacy.*
Saflufenacil inclusion in single application accelerates control of Conyza *spp. in pre-seeding soybean.*
Dicamba + glyphosate and triclopyr + glyphosate achieve >90% control of taller Conyza *spp. plants (>10 cm).*

ABSTRACT: The increasing occurrence of *Conyza* spp. biotypes resistant to 2,4-D have highlighted the increased need for alternative herbicides in pre-sowing soybean desiccation. Therefore, this study aimed to evaluate the efficacy of alternative herbicides to replace 2,4-D for controlling *Conyza* spp. at two different growth stages. Two simultaneous field experiments were conducted. The first experiment consisted of 13 treatments, involving single and combined applications of fluroxypyr, clethodim, dicamba, glyphosate, saflufenacil, triclopyr, chlorimuron, mesotrione, atrazine, 2,4-D, halauxifen, diclosulam, and tembotrione. In the second experiment, selected treatments were followed by a sequential application of ammonium glufosinate. Control efficacy (%) was evaluated from 7 to 35 days after application (DAA). For plants taller than 10 cm at 35 DAA, dicamba + glyphosate, triclopyr + glyphosate, and halauxifen + diclosulam + glyphosate provided over 90% control, whereas chlorimuron + glyphosate achieved less than 60%. For plants shorter than 10 cm at 42 DAA, dicamba + glyphosate + saflufenacil, triclopyr + glyphosate + saflufenacil, mesotrione + atrazine + glyphosate, and halauxifen + diclosulam + glyphosate reached nearly 100% control. The results indicate that herbicide efficacy depends on plant height, with sequential applications enhancing control of taller plants and the inclusion of saflufenacil accelerating control in single applications.

Key words: hairy fleabane, sequential application, chemical control, auxin herbicides

RESUMO: A ocorrência de biótipos de *Conyza* spp. resistentes ao 2,4-D aumentou a necessidade de herbicidas alternativos na dessecação pré-semeadura da soja. O objetivo deste estudo foi avaliar a eficácia de herbicidas alternativos ao 2,4-D para o controle de *Conyza* spp. em dois diferentes estágios fenológicos. Foram conduzidos dois experimentos de campo simultâneos. O primeiro experimento testou 13 tratamentos, incluindo aplicações únicas e combinadas de fluroxipir, clethodim, dicamba, glyphosate, saflufenacil, triclopyr, clorimuron, mesotrione, atrazine, 2,4-D, halauxifen, diclosulam e tembotrione. No segundo experimento, tratamentos selecionados foram seguidos por aplicação sequencial de glufosinato de amônio. A eficácia do controle (%) foi avaliada de 7 a 35 dias após a aplicação (DAA). Para plantas com mais de 10 cm aos 35 DAA, dicamba + glyphosate, triclopyr + glyphosate e halauxifen + diclosulam + glyphosate alcançaram mais de 90% de controle, enquanto clorimuron + glyphosate apresentou menos de 60%. Para plantas com menos de 10 cm aos 42 DAA, dicamba + glyphosate + saflufenacil, triclopyr + glyphosate + saflufenacil, mesotrione + atrazine + glyphosate e halauxifen + diclosulam + glyphosate atingiram quase 100% de controle. Os resultados indicam que a eficácia dos herbicidas depende da altura das plantas, sendo que aplicações sequenciais aumentam o controle de plantas mais altas e a inclusão de saflufenacil acelera o controle em aplicações únicas.

Palavras-chave: buva, aplicação sequencial, controle químico, herbicidas auxínicos

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Introduction

In Brazil, three *Conyza* species (*C. bonariensis*, *C. canadensis*, and *C. sumatrensis*) infest up to 49% of soybean areas, equivalent to over 16 million hectares (Cesco et al., 2019; Lucio et al., 2019). Their occurrence is also reported in other soybean-producing countries such as Argentina, Uruguay, Bolivia, Paraguay, the United States, and Canada (HEAP, 2025). In southern Mato Grosso do Sul, average winter temperatures of approximately 20 °C favor the continuous emergence of *Conyza* spp. from the end of the maize cycle until soybean sowing, resulting in plants at different growth stages (Albrecht et al., 2020; Cantu et al., 2021; Silva et al., 2023). During the 2022/23 season, most soybean sowing in the state occurred in October, with approximately 150 mm of rainfall and mild temperatures (FAMASUL, 2023). Management usually relies on pre-sowing desiccation: single applications are effective on plants under 10 cm, while taller plants require sequential treatments combining systemic and contact herbicides (Albrecht et al., 2020; Schneider et al., 2021).

A commonly used management strategy consisted of a first application of the 2,4-dichlorophenoxyacetic acid (2,4-D) + glyphosate combination, followed by a sequential paraquat application after 10–15 days. After the paraquat ban, diquat was used as a substitute (Silva et al., 2021), but this approach has been shown to be ineffective unless accompanied by sequential applications (Monteiro et al., 2025). In 2017, multiple resistance in *Conyza sumatrensis* biotypes to five different mechanisms of action was reported in Brazil, including synthetic auxins (2,4-D), 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS), protoporphyrinogen oxidase (PROTOX), photosystem I (PSI), and acetolactate synthase (ALS) (Pinho et al., 2019). For synthetic auxins, the identified resistance mechanism was associated with rapid necrosis (Souza et al., 2023), which led to the accelerated spread of these biotypes throughout several Brazilian regions, limiting the effectiveness of 2,4-D in controlling *Conyza* spp. (Lúcio et al., 2019).

Baccin et al. (2022) reported the infestation by 2,4-D-resistant *Conyza* spp. biotypes increased the soybean production costs due to the need to replace 2,4-D in pre-sowing desiccation with other auxinic herbicides and PROTOX inhibitors. The authors also emphasize that the situation may become even more critical when *Conyza* spp. and *D. insularis* infestations coexist in production areas with multiple resistance, as the herbicide costs may rise by up to 165% in soybean crops.

Thus, the presence of resistant *Conyza* spp. biotypes reduces the number of effective herbicide options for pre-sowing soybean desiccation (Albrecht et al., 2020). Therefore, in the search for alternative management approaches, auxinic products were initially used in three ways: (1) registered for pasture, with proven efficacy in controlling broadleaf weeds, such as fluroxypyr and triclopyr (Borges et al., 2025); (2) obsolete products that returned to the market, such as new formulations of dicamba; and (3) new auxinic products, such as halauxifen + diclosulam (Krenchinski et al., 2019).

Given the widespread occurrence of 2,4-D–resistant *Conyza* spp. biotypes and the resulting limitation of effective chemical options for their control require further research on alternative management strategies. Therefore, this study aimed to evaluate the efficacy of alternative herbicides for controlling *Conyza* spp. at two different growth stages.

Material and Methods

Two simultaneous field experiments were conducted in Dourados, Mato Grosso do Sul state, Brazil, in areas with natural infestation of *Conyza* spp. (22º 18′ 14.6″ S, 54º 37′ 14.2″ W), from September 12, 2021, to October 17, 2021. According to the Köppen classification, the climate is Cwa (humid mesothermal climate, hot summers, and dry winters), with an average annual temperature of 22.7 °C (Fietz et al., 2022).

Soil samples were taken from the 0-20 cm soil layer in the experimental area before the installation of the experiment in an Oxisol (Soil Survey Staff, 2022) which corresponds to a Latossolo Vermelho Distroférrico in the Brazilian Soil Classification System (SiBCS) (Santos et al., 2018), whose chemical and physical characteristics were determined according to methodologies recommended by Teixeira et al. (2017) and are presented in Table 1.

The temperature and rainfall data from the FAECA-UFGD weather station (Dourados-MS), located at 22º 16' 31" S, 54º 49' 06" W, are presented in Figure 1.

The experimental units consisted of plots of 15 m² (3 × 5 m). Both experiments were arranged in a randomized block design with four replicates. In the first experiment, 13 treatments were evaluated, consisting of different herbicide mixtures. In the second experiment, nine treatments were tested, including single herbicide applications and one sequential treatment in which glufosinate ammonium was applied 15 days after the first application. In both experiments, the density of *Conyza* spp. plants was determined before the installation of the experiment using a 1 m² quadrat randomly placed within the experimental area, followed by identification and quantification of the plants.

In the first experiment, the target area predominantly consisted of *Conyza* spp. plants with a density of 96 plants per m², distributed homogeneously across the field and with an average height of 8.73 cm, classified at phenological stages 30–39 of the BBCH scale (Hess et al., 1997). A single application of the herbicides was performed on 09/26/2021, either as a tank mixture or applied sequentially, as specified in Table 2.

In the second experiment, aiming at the control of *Conyza* spp. plants (density of 28.4 plants per m²) with an average

Table 1. Chemical and physical soil analysis performed at the experiment site

Clay	Silt	Sand	pH	OM	K⁺	Ca²⁺	Mg²⁺	Al³⁺	H⁺+Al³⁺	SB	CEC	BS
(g kg⁻¹)			($CaCl_2$)	(g dm⁻³)	(mg dm⁻³)	(cmol$_c$ dm⁻³)						(%)
661	207	132	5.08	27.74	18	4.56	2.08	0.12	1.96	24.64	26.6	48.8

Clay, silt, and sand were determined by the pipette method; pH measured in $CaCl_2$; OM – Organic matter - Determined by Walkley-Black method; K^+ extracted with Mehlich-1; Ca^{2+} and Mg^{2+} extracted with 1 M KCl; Al^{3+} and H^++Al^{3+} determined by SMP method; SB - Sum of bases; CEC - Effective cation exchange capacity; BS - Base saturation

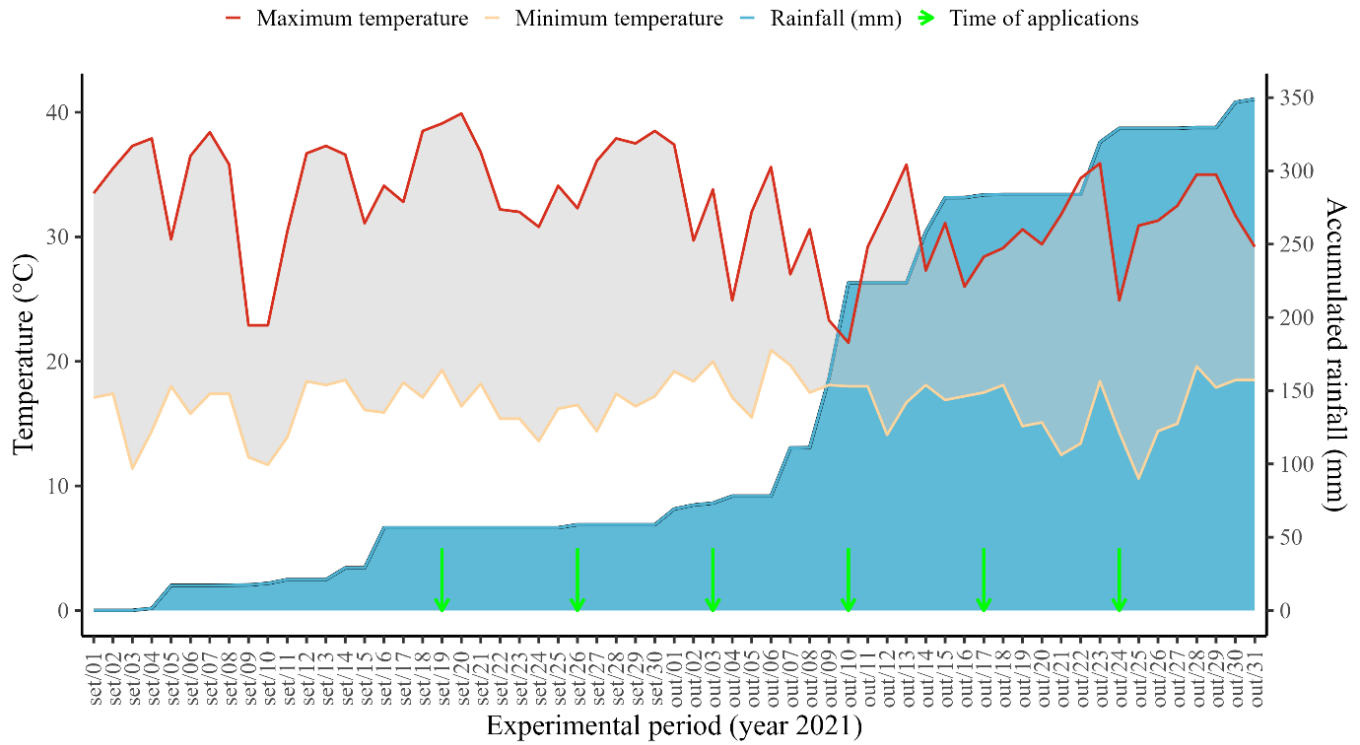


Figure 1. Historical series of rainfall and daily minimum and maximum temperatures in the municipality of Dourados, Mato Grosso do Sul state, Brazil, for the period from September 12, 2021, to October 17, 2021

Table 2. Treatments applied in first experiment 1 (*Conyza* spp. with ≤ 10 cm in height)

Treatments	1st Application[1,2]	Doses (g a.i. ha^{-1})
T1	Fluroxypyr + Clethodim + Glyphosate	250 + 175 + 1,000
T2	Dicamba + Glyphosate + Saflufenacil	288 + 1,000 + 28
T3	Triclopyr + Glyphosate + Saflufenacil	1,990 + 1,000 + 28
T4	Chlorimuron + Glyphosate + Saflufenacil	17.5 + 1,000 + 28
T5	Mesotrione + Atrazine + Glyphosate	100 + 1,000 + 1,000
T6	Fluroxypyr + Clethodim + Glyphosate	250 + 17.5 + 1,000
T7	Dicamba + Glyphosate	384 + 1,000
T8	Triclopyr + Glyphosate	1,190 + 1,000
T9	Chlorimuron + Glyphosate	17.5 + 1,000
T10	Mesotrione + Atrazine + Glyphosate + 2,4-D	100 + 1,000 + 1,000 + 1,209
T11	Halauxifen + Diclosulam + Glyphosate	4.85 + 25.52 + 1,000
T12	Tembotrione + Atrazine + Glyphosate	84 + 1,000 + 1,000
T13	Tembotrione + Atrazine + Glyphosate + 2,4-D	84 + 1,000 + 1,000 + 1,209

[1] All treatments, except the control, with the addition of glyphosate ;[2]Addition of mineral oil to saflufenacil - 0.2% v/v, as recommended by the manufacturer; a.i – Active ingredient

height of 13.8 cm, classified at phenological stages 40–49 of the BBCH scale (Hess et al., 1997), a sequential application was performed. All treatments, except the control (without herbicide application), received the sequential application 15 days after the first application, using glufosinate ammonium at a dose of 400 g a.i. ha^{-1}. The details of the treatments are presented in Table 3.

Herbicide applications were carried out using a CO_2-pressurized backpack sprayer at a pressure of 3.0 bar, equipped with a spray boom containing six Teejet 110.015 nozzles spaced 0.5 m apart, with an application volume of 150 L ha^{-1}. During the first experiment, environmental conditions were 70% relative air humidity, 28 °C air temperature (Figure 1), and 2.3 km h^{-1} wind speed. For the second experiment, conditions were 64.8% relative air humidity, 23.9 °C air temperature (Figure 1), and a 1.3 km h^{-1} wind speed.

The percentage control of *Conyza* spp. plants was evaluated at 7, 14, 21, 28, and 35 days after application (DAA) for plants taller than 10 cm in height, and at 7, 14, 21, 28, 35, and 42 DAA for plants shorter than 10 cm in height. The visual assessment of herbicide efficacy was conducted according to the scale proposed by Alam (1974). In this scale, 0% corresponds to the absence of visible injury—indicating completely healthy plants—whereas 100% represents complete plant death. Intermediate values indicate the degree of phytotoxicity, such as chlorosis, necrosis, leaf deformation, stunting, and overall reduction in plant vigor, depending on the herbicide mode of action.

Generalized additive models for location, scale, and shape (GAMLSS) were used for the deviance analysis. The Beta distribution was applied to the *Conyza* spp. control variables, followed by the logit link function for the location (mean) and scale (dispersion of the data) parameters. In the location parameter, the factors block, treatment, DAA, and the treatment × DAA interaction were considered as fixed effects. The plot, formed by the combination of blocks and treatments, was also included as a random effect.

Table 3. Treatments applied in second experiment (*Conyza* spp. with > 10 cm in height)

Treatments	1st Application[1,2]	Doses (g a.i. ha^{-1})	2nd Application
T1	Fluroxypyr + Clethodim + Glyphosate	250 + 175 + 1,000	Glufosinate Ammonium
T2	Dicamba + Glyphosate	288 + 1,000	Glufosinate Ammonium
T3	Triclopyr + Glyphosate	384 + 1,000	Glufosinate Ammonium
T4	Chlorimuron + Glyphosate	1,190 + 1,000	Glufosinate Ammonium
T5	Mesotrione + Atrazine + Glyphosate	17.5 + 1,000	Glufosinate Ammonium
T6	Halauxifen + Diclosulam + Glyphosate	100 + 1,000 + 1,000	Glufosinate Ammonium
T7	Mesotrione + Atrazine + Glyphosate + 2,4-D	4.85 + 25.52 + 1,000	Glufosinate Ammonium
T8	Tembotrione + Atrazine + Glyphosate	84 + 1,000 + 1,000	Glufosinate Ammonium
T9	Tembotrione + Atrazine + 2,4-D + Glyphosate	84 + 1,000 + 1,000 + 1,209	Glufosinate Ammonium

[1] All treatments, except the control, with the addition of glyphosate; [2]Addition of mineral oil to glufosinate - 0.1% mineral oil in the spray mixture; saflufenacil – 0.2% v/v, as recommended by the manufacturer; a.i – Active ingredient

The Shapiro-Wilk test was used to assess the normality of model residuals. The F test from deviance analysis evaluated the significance of fixed effects, and Tukey's test compared treatment means. Response variables were modelled as a function of DAA using a logistic model. All tests were conducted at a 5% significance level. All analyses were performed in R (R Core Team, 2021) using the gamlss package (Rigby & Stasinopoulos, 2005).

Results and Discussion

In both experiments for controlling *Conyza* spp., the factors herbicide (H), days after application (DAA), and the interaction between H and DAA were considered significant at the 5% level according to the F-test of the deviance analysis (Table 4). The results of the Shapiro-Wilk normality test indicated that the normal distribution adequately fit the residuals produced by the GAMLSS regression, with p-values of 0.063 and 0.638 for *Conyza* spp. control in plants taller than 10 cm and shorter than 10 cm, respectively.

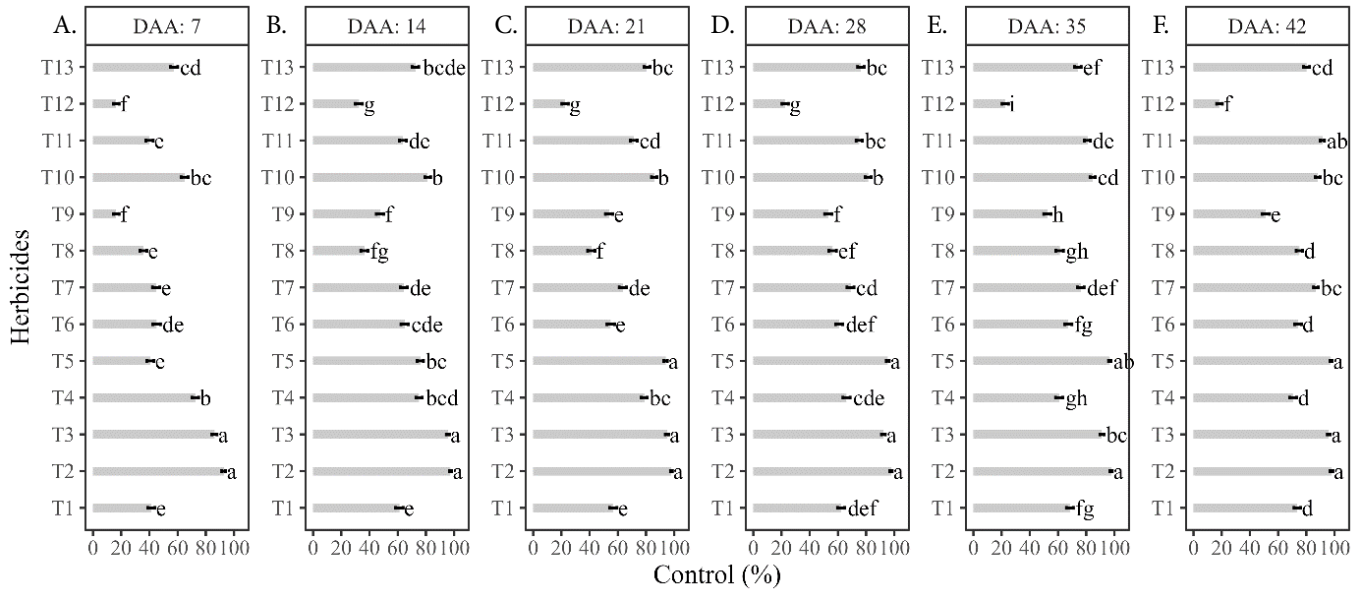
The coefficients of variation were 6.09 and 5.97% for *Conyza* spp. control in plants taller and shorter than 10 cm, respectively (Table 4). These values indicate low variability among repetitions, suggesting greater homogeneity in infestation and treatment application.

At 7 DAA, for *Conyza* spp. plants shorter than 10 cm, treatments T2 (dicamba + glyphosate + saflufenacil, 85%) and T3 (triclopyr + glyphosate + saflufenacil, 82%) did not differ statistically, both showing control above 80% (Figure 2). At 42 DAA, the final evaluation, treatments T2 (dicamba + glyphosate + saflufenacil), T3 (triclopyr + glyphosate + saflufenacil), T5 (mesotrione + atrazine + glyphosate), and T11 (halauxifen + diclosulam + glyphosate) did not differ

Table 4. Results of the deviance analysis in the two experiments

Experiment	F statistic			Shapiro-Wilk test	Coefficient of variation (%)
	Herbicide (H)	DAA (D)	H × D		
> 10 cm	6.339**	473.277**	4.400**	0.063^{ns}	6.085
≤ 10 cm	95.248**	184.067**	12.161**	0.638^{ns}	5.969

** - Significant according to the F-test ($p \leq 0.01$); ns - Not significant



T1 - Fluroxypyr + Clethodim + Glyphosate; T2 - Dicamba + Glyphosate + Saflufenacil; T3 - Triclopyr + Glyphosate + Saflufenacil; T4 - Chlorimuron + Glyphosate + Saflufenacil; T5 - Mesotrione + Atrazine + Glyphosate; T6 - Fluroxypyr + Clethodim + Glyphosate; T7 - Dicamba + Glyphosate; T8 - Triclopyr + Glyphosate; T9 - Chlorimuron + Glyphosate; T10 - Mesotrione + Atrazine + Glyphosate + 2,4-D; T11 - Halauxifen + Diclosulam + Glyphosate; T12 - Tembotrione + Atrazine + Glyphosate; T13 - Tembotrione + Atrazine + Glyphosate + 2,4-D. Treatments with the same letters do not differ from each other using the Tukey test ($p > 0.05$). Error bars represent standard deviation (±SD)

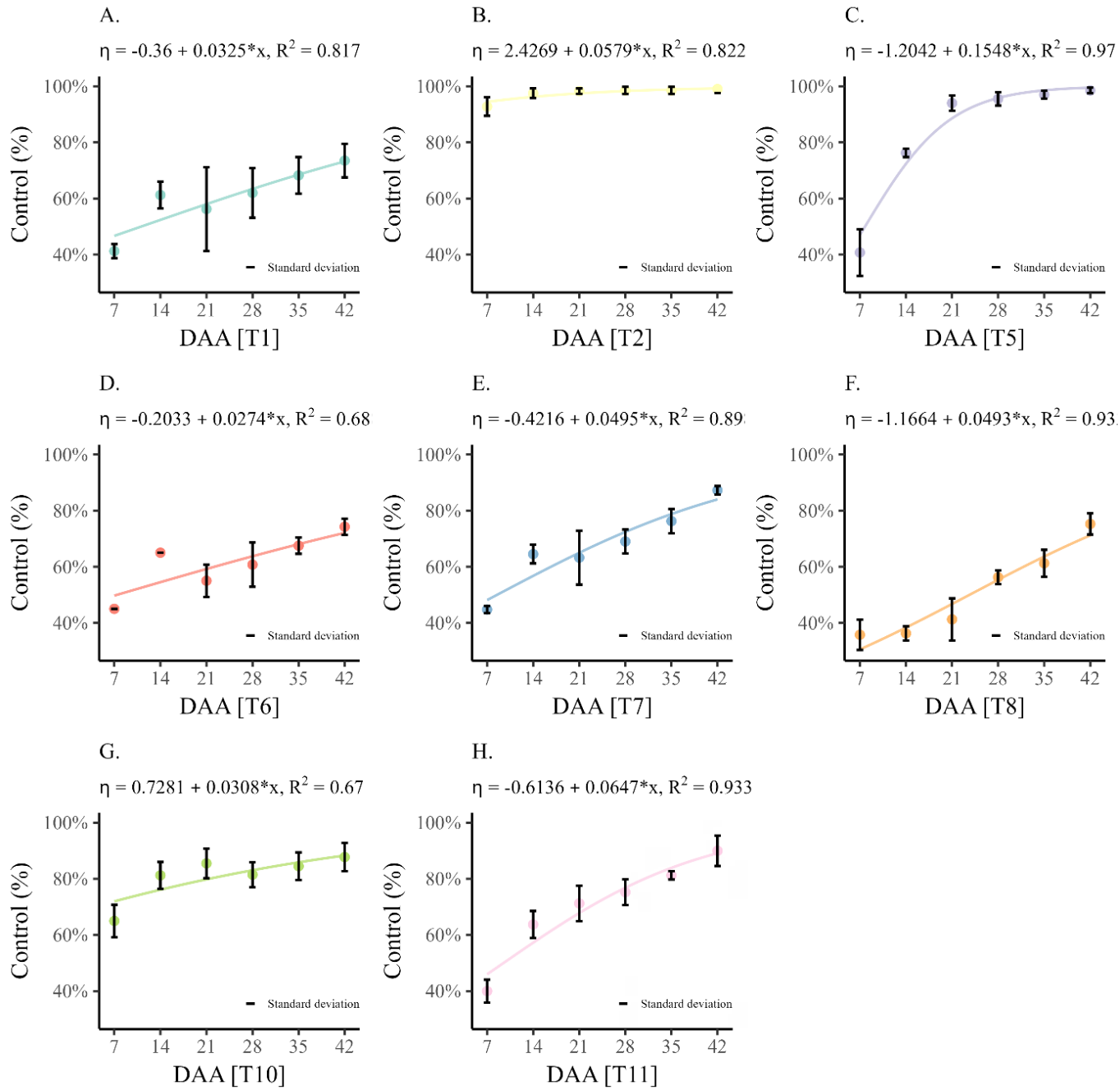
Figure 2. Evolution of weed control over the evaluation periods, with treatment comparisons within each evaluation date (days after application – DAA), in the first experiment with plants shorter or equal than 10 cm

statistically and achieved control levels near or equal to 100%. During the same period, treatment T12 (tembotrione + atrazine + glyphosate) differed from the other treatments, with control percentages below 20% (Figure 2).

Treatments T2 (dicamba + glyphosate + saflufenacil) showed high and consistent control, maintaining values above 95% throughout the entire evaluation period, with $R^2 = 0.82$ (Figures 2 and 3). Treatment T3 (triclopyr + glyphosate + saflufenacil) showed excellent control (>90%), whereas T12 (tembotrione + atrazine + glyphosate) resulted in poor control (<30%). Both exhibited low model fit ($R^2 < 0.25$) (Figure 2). Treatment T4 (chlorimuron + glyphosate + saflufenacil, $\eta = 1.2099 - 0.0139x$) demonstrated a downward curve with $R^2 = 0.35$, indicating an inadequate model fit and control below 80% across all DAAs (Figure 2).

Treatments T7 (dicamba + glyphosate), T10 (mesotrione + atrazine + glyphosate + 2,4-D), T11 (halauxifen + diclosulam + glyphosate), and T13 (tembotrione + atrazine + glyphosate + 2,4-D) showed upward curves, resulting in control percentages above 80% at 42 DAA (Figure 3).

Figure 4 shows the control of *Conyza* spp. plants taller than 10 cm over time. At 7 DAA, treatments T6 (halauxifen + diclosulam + glyphosate), T3 (triclopyr + glyphosate), T2 (dicamba + glyphosate), and T1 (fluroxypyr + clethodim + glyphosate) showed the highest control levels, reaching approximately 50–55%, and differed statistically from the



T1 - Fluroxypyr + Clethodim + Glyphosate; T2 - Dicamba + Glyphosate + Saflufenacil; T3 - Triclopyr + Glyphosate + Saflufenacil; T4 - Chlorimuron + Glyphosate + Saflufenacil; T5 - Mesotrione + Atrazine + Glyphosate; T6 - Fluroxypyr + Clethodim + Glyphosate; T7 - Dicamba + Glyphosate; T8 - Triclopyr + Glyphosate; T9 - Chlorimuron + Glyphosate; T10 - Mesotrione + Atrazine + Glyphosate + 2,4-D; T11 - Halauxifen + Diclosulam + Glyphosate; T12 - Tembotrione + Atrazine + Glyphosate; T13 - Tembotrione + Atrazine + Glyphosate + 2,4-D. The black line represents the fit of the beta regression with a logit link function, $1/\{1 + \exp[-\eta]\}$. Error bars represent standard deviation (±SD)

Figure 3. Regression analysis for the variable control with *Conyza* spp. ≤ 10 cm as a function of days after application (DAA)

other treatments (Figure 4A). Conversely, treatments T4 (chlorimuron + glyphosate), T5 (mesotrione + atrazine + glyphosate), and T9 (tembotrione + atrazine + 2,4-D + glyphosate) exhibited the lowest control levels, around 35–40% and did not differ significantly from each other (Figure 4A).

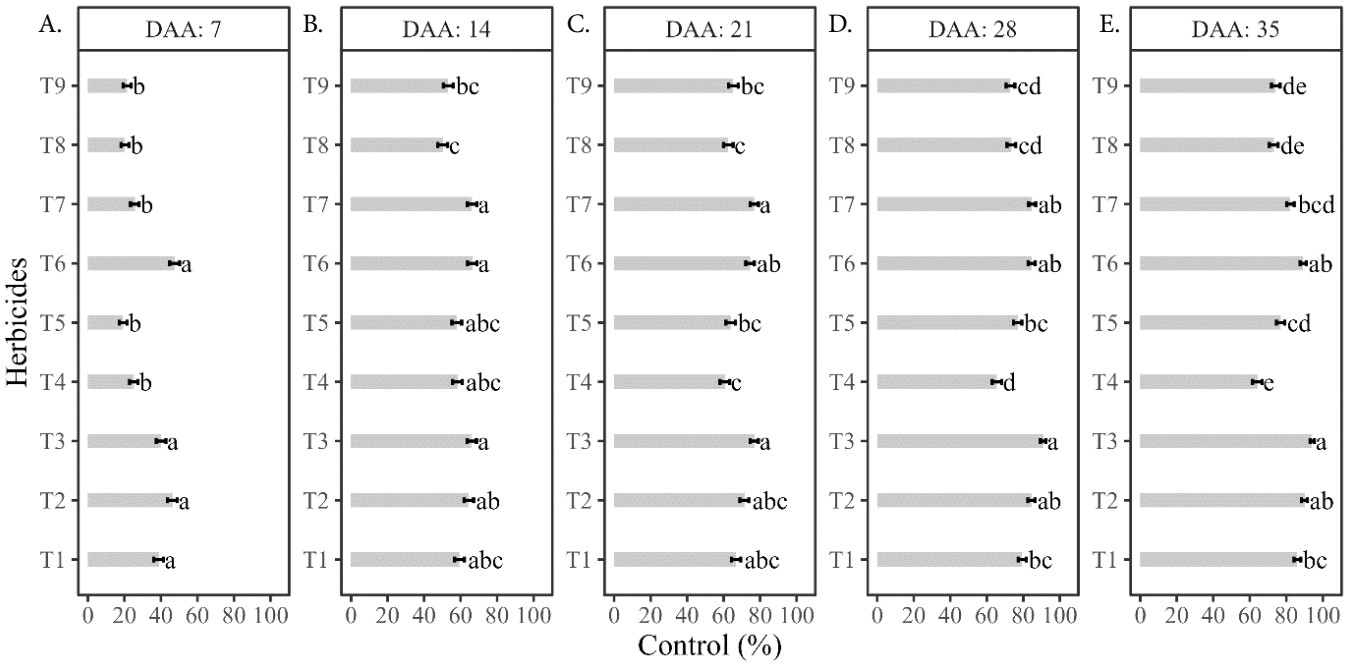
At 14 DAA, treatments T7 (mesotrione + atrazine + glyphosate + 2,4-D) and T6 (mesotrione + atrazine + glyphosate) achieved the highest control, around 70%, and were statistically equal. Treatments T2 (glyphosate + clethodim) and T3 (glyphosate + chlorimuron) showed control close to 65% and differed only from T8. Intermediate efficacy was observed for T5 (mesotrione + atrazine + glyphosate), T4 (chlorimuron + glyphosate), and T1 (fluroxypyr + clethodim + glyphosate), with 55–60% control and no significant differences among them. T9 (tembotrione + atrazine + 2,4-D + glyphosate) presented moderate control (~55%), differing from the best treatments but not from the intermediate group. The least effective treatment was T8 (tembotrione + atrazine + glyphosate), with about 50% control, statistically different from the top-performing treatments (Figure 4B).

At 21 DAA — the first evaluation after the sequential glufosinate application — no treatment achieved control above 80%. In the evaluation conducted at 28 DAA, treatments T2 (dicamba + glyphosate), T3 (triclopyr + glyphosate), T6 (halauxifen + diclosulam + glyphosate), and T7 (mesotrione + atrazine + glyphosate + 2,4-D) showed control above 80% and did not differ statistically among themselves (Figure 4D).

In the final evaluation (35 DAA), treatments T2 (dicamba + glyphosate), T3 (triclopyr + glyphosate), and T6 (halauxifen + diclosulam + glyphosate) achieved the highest control levels, exceeding 90%. In contrast, treatment T4 (chlorimuron + glyphosate) showed the lowest control, approximately 60% (Figure 4E). Treatments T7 (mesotrione + atrazine + glyphosate + 2,4-D) and T1 (fluroxypyr + clethodim + glyphosate) did not differ significantly from each other and provided moderate control (~80%).

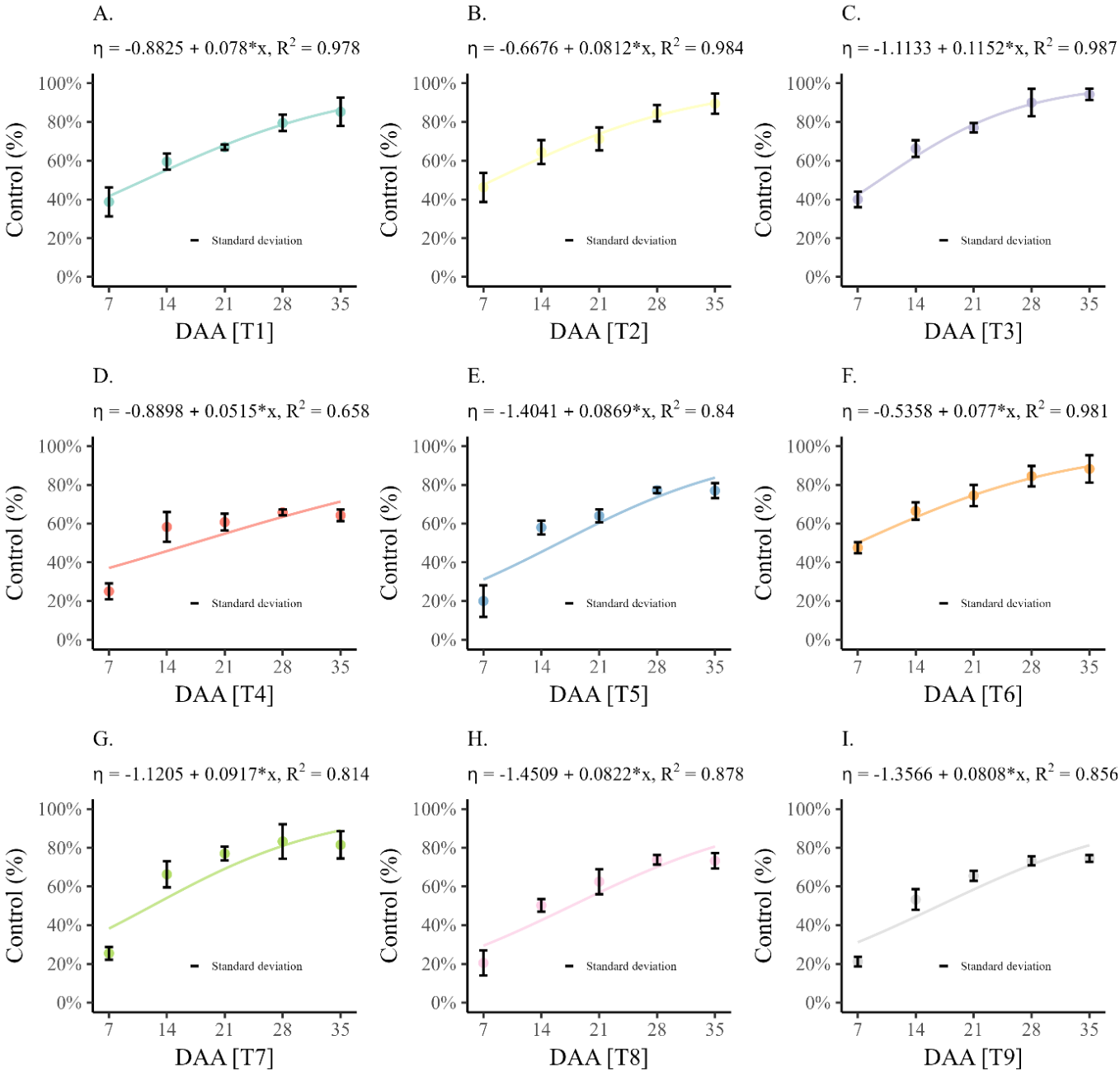
By comparison, treatments T9 (tembotrione + atrazine + 2,4-D + glyphosate), T8 (tembotrione + atrazine + glyphosate), and T5 (mesotrione + atrazine + glyphosate) showed no significant differences and exhibited lower control levels, below 80%. This reduced efficacy can be attributed to the limited activity of HPPD inhibitors (tembotrione and mesotrione) on *Conyza* spp. at more advanced growth stages, particularly when combined with atrazine, which primarily functions as a photosystem II inhibitor with limited effect on this species. Furthermore, the absence of systemically mobile auxinic herbicides in some treatments, or the use of suboptimal doses (as in the case of 2,4-D in treatment T9), may have restricted herbicide translocation, resulting in reduced overall control (Figure 4E).

Figure 5 shows the control of *Conyza* spp. plants taller than 10 cm. All treatments exhibited upward trajectories, reflecting progressive increases in control throughout the evaluation period. The most effective treatments were T1 (fluroxypyr + clethodim + glyphosate), T2 (dicamba + glyphosate), T3 (triclopyr + glyphosate), and T6 (halauxifen + diclosulam + glyphosate), achieving control consistently above 90% throughout the evaluation period. In contrast, treatments T5 (mesotrione + atrazine + glyphosate), T7 (mesotrione + atrazine + glyphosate + 2,4-D), T8 (tembotrione + atrazine + glyphosate), and T9 (tembotrione + atrazine + 2,4-D + glyphosate) showed slower increases in control, with maximum values below 80%. Treatment T4 (chlorimuron + glyphosate) exhibited the lowest control, reaching approximately 60% by the final evaluation.



T1 - Fluroxypyr + Clethodim + Glyphosate; T2 - Dicamba + Glyphosate; T3 - Triclopyr + Glyphosate; T4 - Chlorimuron + Glyphosate; T5 - Mesotrione + Atrazine + Glyphosate; T6 - Halauxifen + Diclosulam + Glyphosate; T7 - Mesotrione + Atrazine + Glyphosate + 2,4-D; T8 - Tembotrione + Atrazine + Glyphosate; T9 - Tembotrione + Atrazine + 2,4-D + Glyphosate. Treatments with the same letters do not differ from each other using the Tukey test ($p > 0.05$). Error bars represent standard deviation (±SD)

Figure 4. Evolution of weed control over the evaluation periods in the second experiment, with treatment comparisons within each evaluation date (days after application – DAA) in plants taller than 10 cm



T1 -Fluroxypyr + Clethodim + Glyphosate; T2 - Dicamba + Glyphosate; T3 - Triclopyr + Glyphosate; T4 - Chlorimuron + Glyphosate; T5 - Mesotrione + Atrazine + Glyphosate; T6 - Halauxifen + Diclosulam + Glyphosate; T7 - Mesotrione + Atrazine + Glyphosate + 2,4-D; T8 - Tembotrione + Atrazine + Glyphosate; T9 - Tembotrione + Atrazine + 2,4-D + Glyphosate. The black line represents the fit of the beta regression with a logit link function, 1/{1 + exp[-η]}. Error bars represent standard deviation (±SD)

Figure 5. Evaluating control in the second experiment with plants taller than 10 cm as a function of days after application - DAA

The results for the control of plants taller than 10 cm suggest that, despite the introduction of new strategies and/or mechanisms of action for managing *Conyza* spp., the use of synthetic auxin herbicides such as dicamba, triclopyr, and halauxifen remains essential to achieve control levels above 90% without regrowth, regardless of plant height.

It is worth noting that, although dicamba, triclopyr, and halauxifen are synthetic auxins, they belong to distinct chemical groups, differing from 2,4-D, an herbicide of the aryloxyalkanoic acid group. This difference is relevant for the management of *Conyza* spp. in the southern region of Mato Grosso do Sul state, where the experiment was conducted, due to the widespread presence of 2,4-D–resistant biotypes (HRAC, 2025), whose resistance mechanism is non-target-site resistance (NTSR) and associated with rapid plant necrosis (Leal et al., 2022). The chemical differences among these herbicides result in different control efficiencies.

Soares et al. (2012), using dicamba for control of *C. bonariensis* resistant to glyphosate, reported over 90%, with plants between 12 and 15 cm. Braz et al. (2017) observed control levels above 80% in *C. sumatrensis* plants taller than 10 cm with diclosulam and halauxifen mixtures. Duarte et al. (2024) also reported control >95% of *Conyza* spp. taller and shorter than 10 cm using diclosulam + triclopyr + saflufenacil.

Thus, the effectiveness of auxinic herbicides in controlling *Conyza* spp. is well established, but the timing of field application must be considered to avoid significant phytotoxic effects on soybean crops (Borges et al., 2025). Dicamba, halauxifen, and triclopyr require a minimum interval of 60, 14, and 10 days, respectively, between application and soybean

planting (AGROFIT, 2025). For example, in the 2022/2023 growing season in the state of Mato Grosso do Sul, soybean planting began on September 15, 2022. In this particular year, delays in corn harvesting reduced the interval between herbicide application and soybean planting in many fields, highlighting the challenges of sequential cropping under tight planting windows.

According to FAMASUL (2023), approximately 80% of the areas designated for soybean cultivation were already planted by the end of October. Thus, there would not have been enough time between application and soybean planting for dicamba to avoid phytotoxic effects on the crop. Francischini et al. (2020) reported soybean injuries caused by glyphosate + dicamba + saflufenacil, which persisted up to 120 days after herbicide application, in both single and sequential applications.

Fluroxypyr + clethodim + glyphosate was effective in controlling *Conyza* spp. regardless of height. This combination is a viable alternative for managing this species (Queiroz et al., 2020). However, despite these positive results, several studies have highlighted a relatively lower efficacy of fluroxypyr compared to other herbicides acting through the same synthetic-auxin mechanism of action. In this context, additional strategies may be considered to maximize the efficacy of fluroxypyr, such as combining it with other products in single or sequential applications, e.g., PROTOX inhibitors.

The treatment chlorimuron + glyphosate was not effective in controlling *Conyza* spp. taller than 10 cm (Figures 4 and 5). Therefore, its application is recommended for plants smaller than 10 cm in post-emergence soybean, as younger plants show higher susceptibility due to lower biomass and more active growth points, offering an additional management option with different mechanisms of action and enabling the control of escapes from pre-sowing desiccation (Miller et al., 2025). These results align with Zobiole et al. (2018), who observed the poor efficacy of chlorimuron + glyphosate + 2,4-D in controlling *Conyza* spp. 50–60 cm tall, which can be attributed to the size of the plants.

Another synergism was in combining auxinic herbicides with PROTOX inhibitors (saflufenacil). However, it is important to emphasize that for *Conyza* spp. at 42 DAA, the final evaluation, dicamba and triclopyr, regardless of the presence of saflufenacil, were effective in controlling *Conyza* spp., indicating a faster rate of control without changes in final efficacy. This synergism occurs because saflufenacil inhibits the PROTOX enzyme, resulting in cellular damage and eventual weed death (Baccin et al., 2022). Thus, when combined with other herbicides, such as the auxinics mentioned above, saflufenacil can enhance the treatment's efficacy, leading to faster weed control with quicker suppression (Chapeta et al., 2023).

An important factor to consider is that although some herbicides have demonstrated efficacy in controlling *Conyza* spp. shorter than 10 cm, it is recommended to avoid single applications and always opt for sequential management. This recommendation is based on the germination flushes that begin at the end of the maize cycle and continue until close to soybean planting in the state of Mato Grosso do Sul. It is common to find *Conyza* spp. plants of varying heights in the field, and using single herbicide applications may result in uneven control, leading to control failures or plant escapes.

Moreover, it is important to emphasize using products from other crops for *Conyza* spp. control must be done cautiously, especially when there is no clear information and/or recommendation on the label regarding plant-back restrictions.

Conclusions

1. For *Conyza* spp. plants taller than 10 cm, the combinations dicamba + glyphosate, triclopyr + glyphosate, and halauxifen + diclosulam + glyphosate provided above 90% control at 35 days after application, indicating that sequential applications or herbicide mixtures are essential for the effective management of taller plants.

2. For *Conyza* spp. plants shorter than 10 cm, at 42 DAA, the combinations dicamba + glyphosate + saflufenacil, triclopyr + glyphosate + saflufenacil, mesotrione + atrazine + glyphosate, and halauxifen + diclosulam + glyphosate achieved control close to 100%, with no significant differences among them. These results indicate that younger plants are more susceptible and can be effectively managed with a single application.

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