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Control of hairy fleabane in sequential and pre-emergence applications in soybean crops

Controle de buva em aplicações sequenciais e em pré emergência na cultura da soja

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ABSTRACT - The control of *Conyza* spp. can be conducted at different times in the soybean crop. This study aimed to evaluate the efficiency of controlling *Conyza* spp. by positioning herbicides at different times and their selectivity in the soybean crop. The experiment was conducted under field conditions in a randomized block design with four replications. A first application of 2.4-D + glyphosate (975 + 1500 g of active ingredient [a.i.] ha^{-1}) was conducted, followed by the following treatments: glufosinate (500 g i.a. ha^{-1}), diquat (400 g a.i. ha^{-1}), and saflufenacil + glyphosate (50 + 1500 g a.i. ha^{-1}) and a third application of the pre-emergents flumioxazin + imazethapyr (60 + 127 g i. a. ha^{-1}), sulfentrazone + diuron (210 + 420 g a.i. ha^{-1}), diclosulam (35 g a.i. ha^{-1}), and s-metolaclhor (1440 g a.i. ha^{-1}), in addition to the control treatment. High percentages of control were obtained with saflufenacil + glyphosate and diquat. Glufosinate provided satisfactory control seven days after the treatment (DAT) application, with regrowth throughout the evaluations, except when diclosulam was applied. The pre-emergent herbicides reduced the emergence of *Conyza* spp. resulting in 0.25 plants m^{-2} when flumioxazin + imazethapyr was applied at 28 DAT. Regardless of the treatment, the soybean crop had no significant phytotoxicity. The management of *Conyza* spp. with the positioning of herbicides at different times proved to be more efficient when the sequential use of diquat and/or saflufenacil + glyphosate and flumioxazin + imazethapyr in pre-emergence was carried out.

Keywords: Desiccation. *Conyza* spp. Germination flow.

RESUMO - O controle de espécies de *Conyza* spp., pode ser efetuado em diferentes períodos na cultura da soja. O objetivo desse trabalho foi avaliar a eficiência no controle de *Conyza* spp. através do posicionamento de herbicidas em diferentes momentos, e sua seletividade na cultura da soja. O experimento foi realizado em campo no delineamento de blocos ao acaso, com quatro repetições. Foi realizada uma primeira aplicação de 2,4-D + glyphosate (975 + 1500 g de ingrediente ativo [i.a.] ha^{-1}) e na sequencial os tratamentos: glufosinate (500 g i.a. ha^{-1}), diquat (400 g i.a. ha^{-1}) e saflufenacil + glyphosate (50 + 1500 g i.a. ha^{-1}) e uma terceira aplicação dos pré-emergentes flumioxazin + imazethapyr (60 + 127 g i.a. ha^{-1}), sulfentrazone + diuron (210 + 420 g i.a. ha^{-1}), diclosulam (35 g i.a. ha^{-1}) e s-metolaclhor (1440 g i.a. ha^{-1}), além das testemunhas. Altas porcentagens de controle foram obtidas com saflufenacil + glyphosate ou diquat. O glufosinate, proporcionou controle satisfatório 7 dias após a aplicação dos tratamentos (DAT), com rebrotas ao longo das avaliações, exceto quando ocorreu aplicação do diclosulam. Os herbicidas pré-emergentes diminuíram a emergência de *Conyza* spp. resultando em 0,25 plantas m^{-2}, na aplicação de flumioxazin + imazethapyr aos 28 DAT. Não houve fitotoxicidade significativa na cultura da soja independente do tratamento. O manejo de *Conyza* spp. através do posicionamento de herbicidas em diferentes momentos, mostrou-se mais eficiente quando realizado a sequencial de diquat e/ou saflufenacil + glyphosate e flumioxazin + imazethapyr em pré-emergência.

Palavras-chaves: Dessecação. *Conyza* spp. Fluxo de germinação.

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INTRODUCTION

Conyza spp. belong to the Asteraceae family and are native to South America (KASPARY et al., 2017). The *Conyza* spp. complex (*Conyza sumatrensis* (Retz.) E. Walker; *Conyza bonariensis* (L.) Cronquist *and Conyza canadensis* (L.) Cronquist) infests around 11.8 million hectares in Brazil, occurring in all Brazilian states (ADEGAS et al., 2017). Soybean areas infested with 0.16 to 0.62 plants m^2 of *Conyza* spp. can have a yield reduction of 12.54 and 13.72%, respectively (ALBRECHT et al., 2019).

Conyza spp. plants have an annual cycle, are herbaceous, have a sparsely branched and very leafy stem, have non-toothed leaves, and are prolific. Depending on the species, *Conyza* spp. plants can produce more than 120,000 seeds with low or no dormancy (HAO et al., 2009; KASPARY et al., 2021; KASPARY et al., 2017; PIASECKI et al., 2019). The optimum germination temperature for *C. bonariensis* was 20 °C (ROLLIN ; TAN, 2004; WU et al., 2007). In Brazil, regardless of the *Conyza* spp. species, germination occurs in early fall and spring, with temperatures close to 20 °C (LAZAROTO; FLECK;

VIDAL, 2008).

In the south of Mato Grosso do Sul, average temperatures close to 20°C have been observed in June, July, and August in recent years (EMBRAPA, 2021). This period is conducive to the emergence of *Conyza* spp., which occurs in stages. In addition, field cultivation is often not conducted at this time due to the low temperatures and frost warning in the region (EMBRAPA, 2020), a fact that contributes to different germination flows of *Conyza* spp. culminating in high infestation at different phenological stages close to soybean sowing (CANTU, et al., 2021; ALBRECHT et al., 2019; ALBRECHT et al., 2020; ALBRECHT et al., 2021).

In areas cultivated with the soybean/maize succession system, the flow of emergence of *Conyza* spp. starts from the harvest of the second-crop corn until the sowing of the soybean, so the best time for action to control these weeds is in autumn management (fallow season), between crop successions (RUDELL et al., 2023; ALBRECHT et al., 2019). However, this pre-sowing management of the soybean crop should always be associated with the positioning of post and pre-emergence herbicides, aiming to control the infestation present in the field and reduce and/or eliminate new germination flows of weeds, thus avoiding the process of reinfestation and mitigating the competition between *Conyza* spp. with the soybean crop in summer (SCHNEIDER et al., 2022; ALBRECHT et al., 2020; FERRAZ et al., 2020).

Thus, given the difficulty in controlling *Conyza* spp., the use of pre-emergent herbicides in soybean cultivation is an essential tool in the management of weeds with a history of resistance (MUELLER et al., 2014), providing a reduction in initial infestation, mainly due to their residual effect (RIZZARDI et al., 2016). Therefore, this study aimed to evaluate the efficacy of herbicide applications to control *Conyza* spp. and their selectivity in the soybean crop, in post-emergence with sequential applications, and pre-emergence of the weed.

MATERIAL AND METHODS

The experiment was conducted under field conditions from September 27, 2020, to November 24, 2020, in Dourados, Mato Grosso do Sul (MS), Brazil (22°18'22"S 54°51'26"W, altitude 413 m). According to the Köppen climate classification, the climate of the region is Cwa-type (humid mesothermal climate, hot summers, and dry winters), with an average annual temperature of 22.7 °C (FIETZ; FISCH, 2008). When the experiment was set up, soil samples were collected in the 0-20 cm layer for chemical and particle-size analysis. The soil is classified as Latossolo Vermelho distroférrico (SANTOS et al., 2018), with a clayey texture whose chemical and particle-size properties are shown in Table 1.

Table 1. Soil chemical and particle-size properties in the experimental area at the 0-20 cm layer.

pH ($CaCl_2$)	Al	H + Al	P (mehl)	K	Ca	Mg	SB	CEC	BS	Sand	Silt	Clay
4.4	1.4	12.4	21.6	0.2	3.2	1.6	4.9	17.3	28.5	140	176	684

Units: Al, H + Al, K, Ca, Mg, SB, and CEC ($cmol_c$ dm^{-3}); P (mehl) (mg dm^{-3}); BS (%); Sand, Silt, and Clay (g. kg^{-1}).

Figure 1 presents the daily historical series of accumulated rainfall and maximum and minimum temperatures in the municipality of Dourados, Mato Grosso do Sul, Brazil, considering the period from September 1, 2020 to November 30, 2020. This information was collected at the weather station of Embrapa Agropecuária Oeste (Dourados-MS; 22º16'31"S, 54º49'06"W, and 408m of altitude), which is close to the experiment (EMBRAPA, 2021).

The experimental design was a randomized block design with four replications and 14 treatments, 12 managed with herbicides, and weeded and unweeded controls. The experimental units consisted of plots 3 meters wide x 5 meters long. Before sowing the soybeans, on 09/27/2020, a general treatment was carried out consisting of the application of 2.4-D (DMA 806 BR, 975 g a.i. ha^{-1}, Corteva) + glyphosate (Zapp QI 620, 1500 g a.i. ha^{-1}, Syngenta) in all treatments except the weeded and unweeded control. Subsequently, on 10/11/2020, the treatments consisting of the desiccant herbicides: glufosinate (Trunfo, 500 g a.i. ha^{-1}, UPL), diquat (Reglone, 400 g a.i. ha^{-1}, Syngenta), and saflufenacil (Heat, 50 g a.i. ha^{-1}, BASF) + glyphosate (Zapp QI 620, 1500 g a.i. ha^{-1}, Syngenta) were applied sequentially. Finally, on 10/25/2020, the soybean crop was sown, and then the pre-emergent herbicides were applied: flumioxazin + imazethapyr (Zethamaxx, 60 g a.i. ha^{-1} + 127g a.i. ha^{-1}, Summitomo Chemical), sulfentrazone + diuron (Stone, 210 g a.i. ha^{-1} + 420 g a.i. ha^{-1}, FMC), diclosulam (Spider, 35 g a.i. ha^{-1}, Corteva), and s-metolachlor (Dual Gold, 1440g a.i. ha^{-1}, Syngenta), and the controls without herbicide application (weeded and unweeded). When preparing the spray mixture, mineral oil was added, 0.2% v/v for glufosinate, 0.1% v/v for diquat, and 0.2% v/v for saflufenacil, as recommended by the manufacturer.

At the time of the first application (2.4-D + glyphosate), the area was infested with *Conyza* spp. at a density of 96 plants per m^2, with plants evenly distributed in the field, with an average height of 12.4 cm. According to the BBCH classification scale (HESS et al., 1997), the plants were at the 30-39 phenological stage.

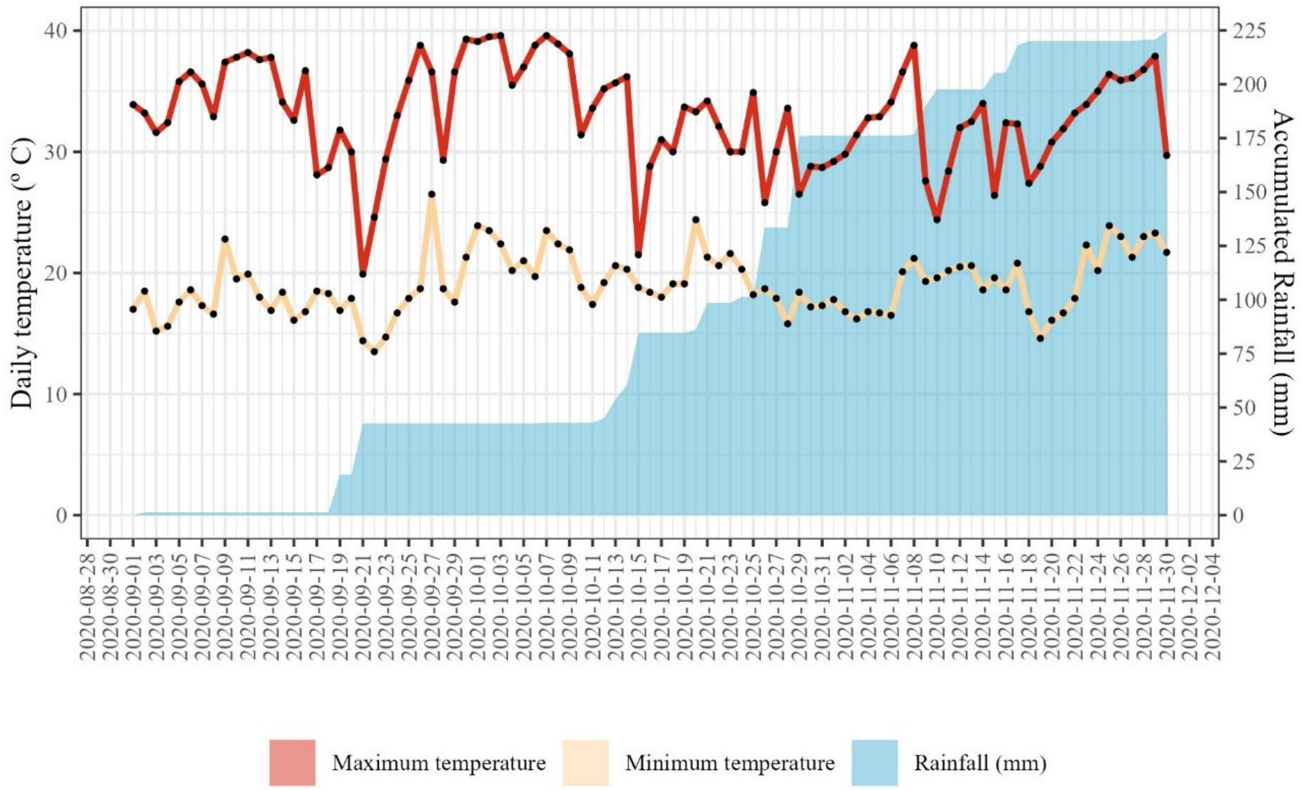


Figure 1. Daily historical series of accumulated rainfall and minimum and maximum temperatures in the municipality of Dourados, Mato Grosso do Sul, Brazil, for the period from September 1, 2020 to November 30, 2020.
Source: EMBRAPA (2021).

The soybeans were mechanically sown on 10/25/2020 with a spacing of 0.45 meters between rows and 14 seeds per meter to obtain a final population (stand) of approximately 305,000 plants per hectare. Pre-emergent herbicide treatments were applied immediately after soybean sowing (plant and apply system). The crop was monitored, and there was no need for fungicide or insecticide applications during the evaluation periods.

The herbicide treatments were applied with a CO_2 pressurized knapsack sprayer at a pressure of 2.0 bar, with a spray boom containing six Teejet 110.015 fan tips spaced 0.5 m apart and with a spray volume of 175 L ha^{-1}. At the time of each application, the climatic conditions (temperature, relative humidity, and wind speed) were checked. On the first application, the relative humidity was 70%, the temperature was 28°C, and the wind speed was 2.3 km h^{-1}. On the second application, the relative humidity was 64.8%, the temperature was 29.1°C, and the wind speed was 0.8 km h^{-1}. On the third application, the relative humidity was 69.9%, the temperature was 23.9°C, and the wind speed was 1.3 km h^{-1}.

The percentage control of *Conyza* spp. plants was assessed at 7, 14, 21, 28, 35, 42, and 49 days after the application of the treatments (DAT), based on the days after the initial application of 2.4 D + glyphosate, following the visual scale of ALAM (1974) in which 0% was attributed to the absence of herbicide symptoms and 100% to plant death. Phytotoxicity evaluations were carried out during the same periods, using a scale of phytotoxicity scores, where 0% was related to the absence of damage and 100% meant destruction of the plants (plant death) (EWRC, 1964).

Conyza spp. emergence rates were evaluated after pre-emergent herbicides were applied at 7, 14, 21, and 28 days after treatment (DAT) (relative to pre-emergent herbicide applications). These evaluations consisted of counting the *Conyza* spp. seedlings that emerged after the application of the pre-emergent herbicides. This count was conducted using a 1 m² square randomly launched once on each plot. This value was used to calculate the density of *Conyza* spp. plants for each treatment (*Conyza* spp. plants m^{-2}).

In the data analysis, the analysis of deviance was applied using the Generalized Additive Models for Location, Scale, and Shape (GAMLSS). The Beta distribution was used to analyze the *Conyza* spp control, followed by the logit link function for the parameters of location (related to the mean) and scale (related to the dispersion of the data). For the average number of plants per m², the number of plants per hectare was scaled, and the Negative Binomial distribution with a log link function was adjusted for both parameters of this distribution. Still, for the graphical presentation of the results of this variable, the original scale, plants per m², was used. In the location parameter, the factors Block, Treatment, DAT, and the interaction Treatment versus DAT were considered fixed effects. In addition, the plot, formed by the combination of Blocks and Treatment, was entered as a random effect.

The Shapiro-Wilk test was used to check that the model residuals conformed to the Normal distribution. The F-test from the analysis of deviance was used to check the significance of the factors inserted as fixed effects. Tukey test was used to compare the treatments. The logistic model was used to adjust the response variables according to the DAT. A 5% significance level was adopted for all tests.

All data analyses were performed in the R software (R Core Team) with the support of the gamlss (RIGBY; STASINOPOULOS, 2005), emmeans (LENTH, 2023), and ggplot2 (WICKHAM, 2016) libraries.

RESULTS AND DISCUSSION

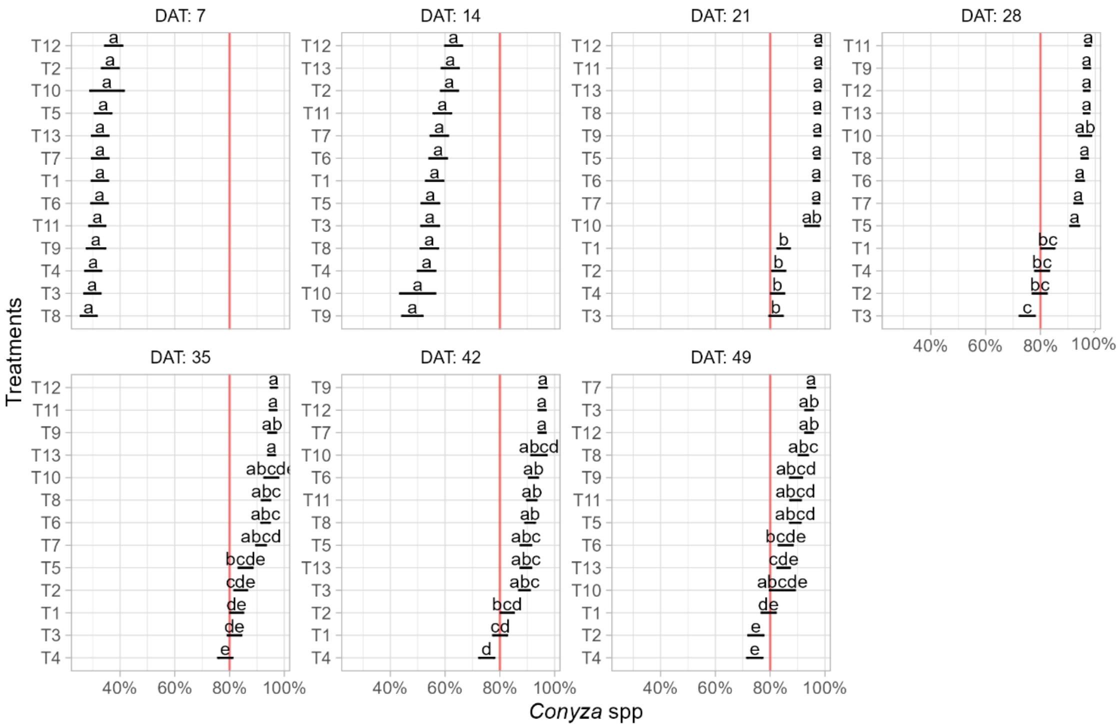
For the *Conyza* spp. variable, there was a significant effect (P < 0.05) of DAT (Table 2). Therefore, as the interaction was significant, comparisons were made between the treatments at each DAT, and the regression was adjusted for each treatment. There was also a significant DAT effect (P < 0.05) for the variable number of plants, and comparisons were made between the treatments at each DAT.

Table 2. Results of fitting the GAMLSS models to the percentage-related variables.

Variable	F Test				SH	CV
	Block	Treatment (T)	DAT (D)	T versus D		
Conyza spp.	0.28	0.39	657.39**	6.31	0.129	5.71%
Plants	1.32	22888**	14567**	1258.71**	0.000	6.22%

**, significant at 5% by the F-test of the analysis of Deviance; SH, p-value of the Shapiro-Wilk Normality test; CV, coefficient of variation.

Figure 2 shows the data on post-emergence control of *Conyza* spp. Seven days after the initial application, the treatments showed no statistical difference. At 14 DAI, the treatments also showed no statistical difference, with all the treatments obtaining control percentages of *Conyza* spp. lower than 70%.

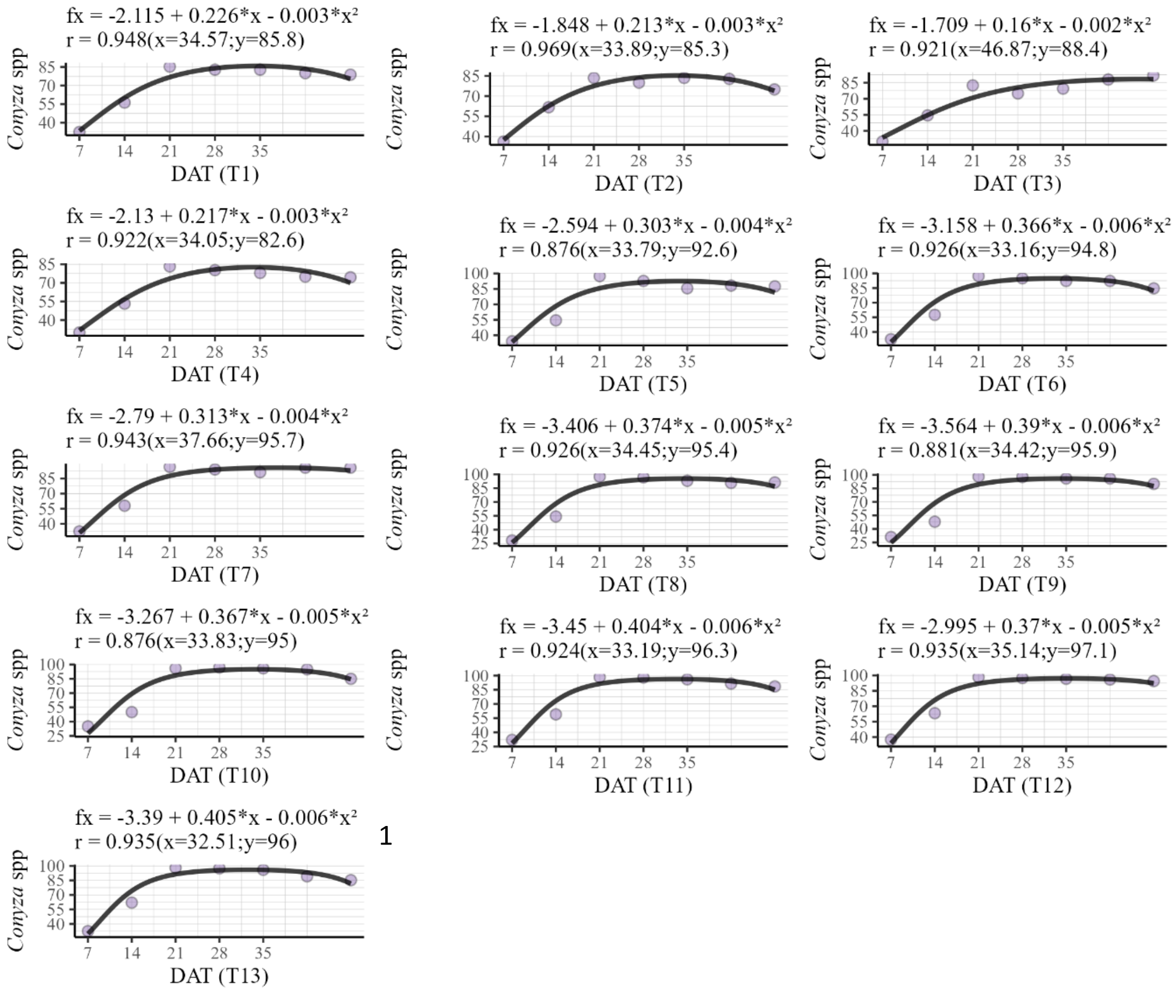


T1: 1º 2,4-D + Gly 2º GS 3º flumioxazin + imazethapyr; T2: 1º 2,4-D + Gly 2º GS 3º sulfentrazone + diuron; T3: 1º 2,4-D + Gly 2º GS 3º Diclosulam; T4: 1º 2,4-D + Gly 2º GS 3º S-metalachlor; T5: 1º 2,4-D + Gly 2º diquat 3º flumioxazin + imazethapyr; T6 1º 2,4-D + Gly 2º diquat 3º sulfentrazone + diuron; T7: 1º 2,4-D + Gly 2º diquat 3º Diclosulam; T8: 1º 2,4-D + Gly 2º diquat 3º S-metalachlor; T9: 1º 2,4-D + Gly 2º Saflufenacil 3º flumioxazin + imazethapyr; T10: 1º 2,4-D + Gly 2º Saflufenacil + Gly 3º flumioxazin + imazethapyr; T11: 1º 2,4-D + Gly 2º Saflufenacil + Gly 3º sulfentrazone + diuron; T12: 1º 2,4-D + Gly 2º Saflufenacil + Gly 3º Diclosulam; T13: 1º 2,4-D + Gly 2º Saflufenacil + Gly 3º S-metalachlor.

Figure 2. Percentage control of *Conyza* spp. by post and pre-emergent herbicides in the different evaluation periods (DAT).

An application of the 2.4-D + glyphosate on *Conyza* spp. plants taller than 10 cm were not enough to establish adequate control. Cesco et al. (2019) conducted a field experiment applying 2.4-D + glyphosate (1035 + 703.5 g ha^{-1}) on *Conyza* spp. plants and obtained 65.50% control and 100% regrowth, corroborating the data obtained in this study. These results reinforce the fact that, in *Conyza* spp. plants at a more advanced stage of development, an application of 2.4-D + glyphosate is not enough to promote effective control, with the consequent massive production of seeds and new germination flows. Similar data was also obtained by Silva et al. (2021), who, when applying 2.4 D + glyphosate (975 + 1025 g ha^{-1}) to control *Conyza* spp. plants over 20 cm tall obtained a maximum control of 55%.

The sequential application of glufosinate resulted in a lower control of *Conyza* spp. than the other desiccants (saflufenacil + glyphosate and diquat) (Figure 2). Glufosinate also showed decreased control over the evaluation days, indicating regrowth (Figure 3). The climatic conditions in the Grande Dourados region during the experiment were high temperatures, low relative air humidity, and high wind speed (EMBRAPA, 2021), which meant that the sequential post-emergence applications were conducted in the late afternoon, exposing the *Conyza* spp. plants to only a few hours of light after the herbicides were applied.



T1: 1º 2,4-D + Gly 2º GS 3º flumioxazin + imazethapyr; T2: 1º 2,4-D + Gly 2º GS 3º sulfentrazone + diuron; T3: 1º 2,4-D + Gly 2º GS 3º Diclosulam; T4: 1º 2,4-D + Gly 2º GS 3º S-metalachlor; T5: 1º 2,4-D + Gly 2º diquat 3º flumioxazin + imazethapyr; T6 1º 2,4-D + Gly 2º diquat 3º sulfentrazone + diuron; T7: 1º 2,4-D + Gly 2º diquat 3º Diclosulam; T8: 1º 2,4-D + Gly 2º diquat 3º S-metalachlor; T9: 1º 2,4-D + Gly 2º Saflufenacil 3º flumioxazin + imazethapyr; T10: 1º 2,4-D + Gly 2º Saflufenacil + Gly 3º flumioxazin + imazethapyr; T11: 1º 2,4-D + Gly 2º Saflufenacil + Gly 3º sulfentrazone + diuron; T12: 1º 2,4-D + Gly 2º Saflufenacil + Gly 3º Diclosulam; T13: 1º 2,4-D + Gly 2º Saflufenacil + Gly 3º S-metalachlor.

Figure 3. GAMLSS regression with Beta distribution and *logit* link function adjusted for *Conyza* spp. control (%) concerning DAT. The dots are the average values, and the smoothed lines represent the fit of the logistic model, 1/[1+exp(-fx)]. The coefficient of determination (r) value is followed in parentheses of the points that maximize the function.

In this sense, herbicides can vary in their control of weeds depending on the time of day they are applied due to variations in temperature and relative air humidity (MONTGOMERY et al., 2017). Aliverdi, Ahmadvand, and Emami-Namivandi (2020) obtained a control of *Solanum nigrum* L. treated with glufosinate (1000 g a.i. ha^{-1}) of 77.1 and 50.6%, before sunrise and after sunset (exposure in the dark for 9 hours). The authors claim that a dark period after the herbicide application can temporarily prevent the activation of glufosinate.

According to Takano et al. (2020), glufosinate applications are usually recommended in direct sunlight, warm temperatures, and high relative air humidity because when these are followed by a dark period (sunset), the plants may compartmentalize the glufosinate somewhere in the cell (e.g., vacuole, apoplast) where it can no longer bind to glutamine synthetase (GS) even after sunrise the next morning; consequently, the plants can recover GS activity within 24 hours, allowing survival and regrowth in the following days.

At 7 DAT, i.e. the first assessment after the sequential post-emergence application, all the treatments that included the application of the herbicide glufosinate and consequently the pre-emergence herbicides (flumioxazin + imazethapyr, sulfentrazone + diuron, diclosulam, and s-metolachlor) resulted in lower control efficacy of *Conyza* spp., although with percentages above 80% (Figure 2). In the same period, the herbicides saflufenacil + glyphosate and diquat resulted in excellent control of *Conyza* spp. in sequential positioning, regardless of which pre-emergent herbicide was applied afterward (Figure 2). Other authors have already verified this increase in the control of *Conyza* spp. (GONÇALVES et al., 2016; ALBRECHT et al., 2019; ALBRECHT et al., 2020; ALBRECHT et al., 2021; SILVA et al., 2021). These results are explained by the mechanisms of action of these herbicides, saflufenacil related to the inhibition of the PROTOX enzyme and diquat to the action of photosystem I (RODRIGUES; ALMEIDA, 2018), which result in rapid and expressive control effects on *Conyza* spp. plants after application.

The treatments with saflufenacil + glyphosate in sequence and s-metolaclhor in pre-emergence showed a gradual decrease in control percentages, i.e. from 97.5% at 21 DAT to 85.3% at 49 DAT (Figure 3). In contrast, the sequential application of glufosinate resulted in control of less than 80% at 49 DAT, except the sequential application of glufosinate and the pre-emergent diclosulam, where 91.8% control was observed due to the application of the pre-emergent herbicide diclosulam after the sequential application of glufosinate (Figure 3).

These results corroborate Krenchinski et al. (2019), who reported rapid absorption of diclosulam when applied in the post-emergence period of weeds, around 67% in two hours, which can lead to increased weed control. Albrecht et al. (2020) applied the treatment glyphosate + diclosulam (1500 + 670 g a.i. ha^{-1}) with a sequential application of glufosinate (400 g a.i. ha^{-1}) on *Conyza* ssp. plants over 15 cm tall and observed 96% control five weeks after the sequential application. Silva et al. (2021) also found a post-emergent effect of diclosulan on the control of *Conyza* spp. through synergism in association with the herbicide carfentrazone.

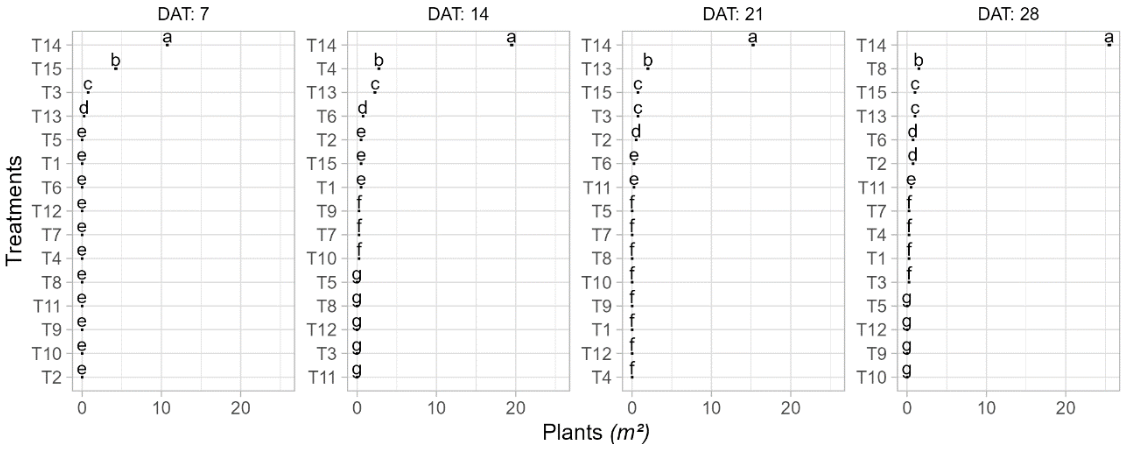
In this study, diclosulam also acted post-emergently because when this herbicide was applied pre-planting to the soybean crop, it increased the percentages of control of *Conyza* spp. while simultaneously resulting in pre-emergent activity, controlling new emergence flows, and reducing weed density. According to Albrecht et al. (2021), diclosulam is one of the most widely used herbicides for pre-sowing soybeans to control *Conyza* spp. and other weeds, as it provides broad-spectrum control (RODRIGUES; ALMEIDA, 2018).

About the analysis of *Conyza* spp. emergence flows at 7 DAT, only the treatments with glufosinate sequential and diclosulam pre-emergent, sequential saflufenacil + glyphosate and pre-emergent s-metolachlor, unweeded control, and weeded control showed the emergence of *Conyza* spp., and differed statistically with 0.75, 0.25, 10.75, and 4.25 plants m^{-2}, respectively (Figure 4).

At 14 DAT evaluation, only the treatments with glufosinate sequential and diclosulan pre-emergent, diquat sequential with s-metolachlor pre-emergent, and saflufenacil + glyphosate sequential with sulfentrazone + diuron and diclosulam pre-emergent, did not differ from each other, and did not show germination flow (Figure 4). At 21 DAT, the highest emergence percentages were 15.25 and 2.00 plants m^{-2}, which differed from each other statistically, respectively being the unweeded control and the sequential saflufenacil + glyphosate with s-metolaclim application (Figure 4). Also, at 21 DAT, the weeded control and glufosinate with sequential diclosulam did not differ in statistical analysis and showed a germination rate of 0.75 plants m^{-2}.

At 28 DAT, the treatments with flumioxazin + imazethapyr resulted in seedling emergence of 0.00, 0.00, and 0.25 plants m^{-2}, respectively, in the treatments with the following herbicides applied post-emergence: glufosinate, diquat (which did not differ statistically), and saflufenacil + glyphosate, which differed statistically from the others (Figure 4). The herbicide diclosulam resulted in the emergence of 0.25, 0.25, and 0.00 plants m^{-2} in the sequential post-emergence applications of glufosinate, diquat (which did not differ statistically), and saflufenacil + glyphosate, respectively (which differed from the previous two).

The application of s-metolachlor, depending on the sequential product, differed statistically, with *Conyza* spp. emergence of 0.25, 1.50, and 1.00 plants m^{-2} in the sequential applications of glufosinate, diquat, and saflufenacil + glyphosate, respectively. The unweeded control differed from the other treatments with an emergence of *Conyza* spp. of 28 plants m^{-2}.



T1: 1º 2,4-D + Gly 2º GS 3º flumioxazin + imazethapyr; T2: 1º 2,4-D + Gly 2º GS 3º sulfentrazone + diuron; T3: 1º 2,4-D + Gly 2º GS 3º Diclosulam; T4: 1º 2,4-D + Gly 2º GS 3º S-metalachlor; T5: 1º 2,4-D + Gly 2º diquat 3º flumioxazin + imazethapyr; T6 1º 2,4-D + Gly 2º diquat 3º sulfentrazone + diuron; T7: 1º 2,4-D + Gly 2º diquat 3º Diclosulam; T8: 1º 2,4-D + Gly 2º diquat 3º S-metalachlor; T9: 1º 2,4-D + Gly 2º Saflufenacil 3º flumioxazin + imazethapyr; T10: 1º 2,4-D + Gly 2º Saflufenacil + Gly 3º flumioxazin + imazethapyr; T11: 1º 2,4-D + Gly 2º Saflufenacil + Gly 3º sulfentrazone + diuron; T12: 1º 2,4-D + Gly 2º Saflufenacil + Gly 3º Diclosulam; T13: 1º 2,4-D + Gly 2º Saflufenacil + Gly 3º S-metalachlor.

Figure 4. Number of plants per m² according to treatments and the number of days after the treatment (DAT) application.

In this sense, taking the 28 DAT evaluation as a parameter, we can say that the emergence of *Conyza* spp. according to the treatments was in the following order (from highest to lowest percentage): unweeded control > weeded control > s-metolachlor > sulfentrazone + diuron > diclosulam > flumioxazin + imazethapyr.

The unweeded control showed emergence of *Conyza* spp. in all evaluation periods with densities of more than 10 plants m^{-2}, always with a higher emergence of seedlings followed by a decrease (7 DAT to 14 DAT and 21 DAT to 28 DAT), thus representing a continuous flow of emergence of *Conyza* spp. This behavior is related to the temperature during the germination flow evaluation period when minimum temperatures were lower than and/or very close to 20°C (Figure 1). In the analysis of Figure 1, it can be seen that the temperatures showed a decrease, especially in the period of evaluation of the germination flows, since the emergence of *Conyza* spp. in the field is directly associated with decreasing temperature conditions (SOARES et al., 2017).

Regarding selectivity, the herbicide showed no significant phytotoxic effects on the soybean crop. When positioning post-emergent herbicides, the absence of phytotoxic effects was expected due to the time interval between the application of the herbicides and the sowing of the crop, which was 28 days for 2.4-D + glyphosate and 14 days for the sequential products. The 30 mm of rainfall shortly after the application of the pre-emergents (Figure 1) also contributed to mitigating the phytotoxic effects on the soybean crop, allowing plants to suffer less water stress and providing greater solubilization and transport of the herbicides in the soil solution.

Nunes et al. (2018) found that the herbicides glyphosate and glyphosate + 2.4-D did not affect soybean crop yields. Albrecht et al. (2020) found that all the treatments with only pre-sowing application of the herbicides: glyphosate, 2.4-D, saflufenacil, and glufosinate, without the addition of pre-emergent herbicides, showed soybean phytotoxicity of less than 1.5%, five weeks after the application of treatments.

Albrecht et al. (2021), working with the pre-emergent herbicides sulfentrazone + diuron, imazethapyr + flumioxazin, and diclosulam, found phytotoxic symptoms in soybeans that were more significant for diclosulam with up to 10.3%, the other pre-emergents showed lower percentages of phytotoxicity, in this experiment in the week following the applications there was no record of rainfall. The authors found that, for all herbicide treatments, there was a recovery of the symptoms with no effect on agronomic performance, proving the selectivity of the soybean crop to these herbicides.

Thus, during the experiment, environmental conditions were favorable for the emergence of *Conyza* spp., and new flows were observed in the post-emergence of soybeans, even in a period that is often not observed due to higher temperatures (EMBRAPA, 2021), resulting in a high density of infestation of *Conyza* spp. at the flowering stage during the soybean harvest in areas of southern Mato Grosso do Sul in 2021. This is because at lower temperatures and with a decreasing photoperiod, *Conyza* spp. can accumulate biomass but show slow development, and when there is an increase in temperature and photoperiod, there is less biomass accumulation, and flowering induction is faster (STRECK et al. 2020).

The associations between environmental conditions and germination flows represent a predictive tool and decision -making strategy for the chemical control of *Conyza* spp. The results indicate that the focus of *Conyza* spp. management should not only be on pre-sowing desiccation but also the positioning of pre-emergent herbicides, as the decrease in temperatures can stimulate a new flow of *Conyza* spp. emergence and these emerged plants can find favorable conditions for fast development and flowering due to the higher spring/summer temperatures culminating in high densities of *Conyza* spp. in already established soybean crops.

Thus, an important way of managing weeds is by applying pre-emergent herbicides (NUNES et al., 2018), which can reduce infestation and delay the occurrence of new emergence flows. In this context, in the present experiment, all the pre-emergent herbicides reduced the germination flow of *Conyza* spp. in the field compared to the control.

This high efficacy in controlling new flows using pre-emergent herbicides is related to the rainfall of more than 30 mm, which occurred the day after the treatments were applied, contributing to the transportation and incorporation of these products into the soil profile (MONQUERO et al., 2011). According to Maciel and Velini (2005), rainfall of 20 mm is essential to transport the herbicide to the soil solution. However, the period of drought and/or rainfall of less than 20 mm after the application of the pre-emergent herbicide can promote its interception and adsorption to the straw, and when the rains begin in greater quantities, the reversibility of the process (desorption) does not occur, and consequently, the transport of the herbicide from the straw and/or soil surface to the first 10 cm of the soil profile also does not occur, which reduces the effectiveness of these products in weed control (SILVA et al., 2020; CLARK et al., 2019).

CONCLUSION

Applications of diquat and saflufenacil + glyphosate were excellent at controlling *Conyza* spp. At the same time, glufosinate decreased control percentages over the evaluation periods, regardless of the pre-emergent herbicide. The application of diclosulam resulted in synergism in the control of *Conyza* spp. All the pre-emergent herbicides reduced the emergence of *Conyza* spp. in the field; the most efficient was flumioxazin + imazethapyr, and the least efficient was s-metolachlor.

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