

## Herbicide association for simultaneous control of seeds and emerged plants of *Rottboellia exaltata* L.

Associação de herbicidas no controle simultâneo de plantas emergidas e sementes de *Rottboellia exaltata* L.

Asociación de herbicidas en el control simultáneo de semillas y plantas emergentes de *Rottboellia exaltata* L.

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### Abstract

The species *Rottboellia exaltata* L. (itchgrass) has become an important weed in cultivated areas, requiring management studies to enhance its control. This study aimed to evaluate the effectiveness of the herbicides pendimethalin (1200 g ha<sup>-1</sup>), clomazone (1000 g ha<sup>-1</sup>), indaziflam (100 g ha<sup>-1</sup>), and trifluralin (900 g ha<sup>-1</sup>) applied in pre-emergence in association with diquat (400 g ha<sup>-1</sup>) and glyphosate (1175 g ha<sup>-1</sup>), in addition to their isolated application, in the simultaneous control of emerged plants and seeds of *R. exaltata*. The experiments were conducted in a greenhouse in a completely randomized design, with four replications. Evaluations were performed at 7, 14, 21, 28, 35, and 42 days after application (DAA). The associations of diquat + pendimethalin, diquat + clomazone, diquat + indaziflam, diquat + trifluralin, glyphosate + pendimethalin, glyphosate + clomazone, glyphosate + indaziflam, and glyphosate + trifluralin controlled 100% of the species and prevented the germination of new fluxes of *R. exaltata*. Regarding isolated applications, only clomazone did not differ from herbicide associations in controlling the species. Thus, the interaction promoted by the association between desiccant and residual herbicides was the best option to control *R. exaltata*, consisting of an important management tool to control the species, considering the post-emergence control and the seed bank.

**Keywords:** Grasses; Herbicide association; Weed management; Itchgrass; Sugarcane.

### Resumo

A espécie *Rottboellia exaltata* (capim-camalote) tem se tornado importante planta daninha em áreas cultivadas, sendo necessários estudos de manejos que potencializem seu controle. O objetivo deste trabalho foi avaliar a eficácia dos herbicidas aplicados em pré-emergência pendimethalin (1200 g ha<sup>-1</sup>), clomazone (1000 g ha<sup>-1</sup>), indaziflam (100 g ha<sup>-1</sup>) e Trifluralin (900 g ha<sup>-1</sup>) em associação com diquat (400 g ha<sup>-1</sup>) e Glyphosate (1.175 g ha<sup>-1</sup>), além dos respectivos herbicidas isolados, no controle simultâneo de plantas emergidas e sementes de *R. exaltata*. Os experimentos foram conduzidos em casa-de-vegetação, em delineamento inteiramente casualizado, com quatro repetições. As avaliações foram realizadas aos 7, 14, 21, 28, 35, 42 dias após a aplicação (DAA). As associações de diquat+pendimethalin, diquat+clomazone, diquat+indaziflam, diquat+Trifluralin, Glyphosate+pendimethalin, Glyphosate+clomazone,

Glyphosate+indaziflam e Glyphosate+Trifluralin controlaram 100% da espécie e impediram a germinação de novos fluxos de *R. exaltata*. Em relação às aplicações isoladas, apenas o clomazone não diferiu das associações de herbicidas no controle da espécie. Os resultados do estudo permitem concluir que a interação promovida pela associação entre herbicidas dessecantes e residuais se mostrou como a melhor maneira para o controle de *R. exaltata*, sendo uma ferramenta de manejo importante no controle da espécie, considerando o controle pós-emergente e o banco de sementes.

**Palavras-chave:** Gramíneas; Associação herbicidas; Manejo plantas daninhas; Capim-camalote; Cana-de-açúcar.

### Resumen

La especie *Rottboellia exaltata* se ha convertido en una maleza importante en las áreas cultivadas, requiriendo estudios de manejo para mejorar su control. El objetivo de este trabajo fue evaluar la efectividad de los herbicidas aplicados en preemergencia pendimethalin (1200 g ha<sup>-1</sup>), clomazone (1000 g ha<sup>-1</sup>), indaziflam (100 g ha<sup>-1</sup>) y trifluralin (900 g ha<sup>-1</sup>), en asociación con diquat (400 g ha<sup>-1</sup>) y Glyphosate (1.175 g ha<sup>-1</sup>), además de los respectivos herbicidas aislados, en el control simultáneo de plantas emergidas y semillas de *R. exaltata*. Los experimentos se realizaron en invernadero, en un diseño completamente al azar, con cuatro repeticiones. Las evaluaciones se realizaron a los 7, 14, 21, 28, 35, 42 días después de la aplicación (DDA). Las asociaciones de diquat+pendimethalin, diquat+clomazone, diquat+indaziflam, diquat+trifluralin, glyphosate+pendimethalin, glyphosate+clomazone, glyphosate+indaziflam y glyphosate+trifluralin controlaron el 100% de las especies e impidieron la germinación de nuevos flujos de *R. exaltata*. En cuanto a las aplicaciones aisladas, solo la clomazone no difirió de las asociaciones de herbicidas en el control de la especie. Los resultados del estudio permiten concluir que la interacción promovida por la asociación entre desecante y herbicidas residuales demostró ser la mejor forma de control de *R. exaltata*, siendo una importante herramienta de manejo en el control de la especie, considerando la postemergencia, control y el banco de semillas.

**Palabras clave:** Pastos; Asociación de herbicidas; Manejo de malezas; Hierba camalote; Caña de azúcar.

## 1. Introduction

Weeds can cause a significant reduction in sugarcane productivity if adequate management is not applied to control the most critical phase (Oliveira & Freitas 2008; Victoria Filho & Christoffoleti, 2004), leading to productivity losses of up to 80% (Azania et al., 2006), decrease in sugarcane longevity, and difficulty in harvesting and transport operations (Kuva et al, 2003). Sugarcane starts sprouting approximately 40 days after the planting operation, and weeds emerge along with the crop when they are not controlled, starting the interference period (Zera, 2020).

Weeds of the family Poaceae, especially those with C4 metabolism, are more competitive under high temperatures, providing rapid space domination (Carvalho et al, 2005). *Rottboellia exaltata* (itchgrass) has stood out among the numerous weeds that occur in sugarcane fields, as it is a prolific plant with a high vigor and easy spreading, resulting in dissemination throughout the cultivated areas of Brazil (Oliveira & Freitas, 2008). Its structure is of an erect plant, with leaf sheaths densely covered by rigid bristles, reaching between 1.0 and 2.5 m in height, with propagation only by seeds (Lorenzi, 2000).

*R. exaltata* can emit up to 100 tillers and produce more than 16,000 seeds (Hall & Patterson, 1992; Smith et al, 2001). Lorenzi (2000) observed that the seeds of this species can remain dormant in the soil for up to four years. Furthermore, the cold is a dormancy-inducing agent for its seeds (Bridgemohan et al, 1991). Thus, the seeds in the soil seed bank, among the greatest depths, may persist for a longer time, generating future infestations (Hijano, 2016).

Success in weed management in sugarcane, considering the use of herbicides and pre-emergence applications, is related to ensuring a broad spectrum of control of the infesting weed community, with a residual period of sufficient control to meet the critical period of crop competition (Miller et al, 1995). In this sense, the association of different active ingredients becomes an important tool in weed management (Santos et al, 2011).

To improve application positioning and have weed-free crop planting, a good practice would be pre-plant desiccation combined with a pre-emergent herbicide with higher residual (Carbonari et al, 2010). This association allows improving and/or complementing the action of both molecules, making the control spectrum broader and even reducing herbicide doses (Ronchi et al, 2002).

There is little information in the literature on the chemical control of *R. exaltata* in the sugarcane crop, mainly for herbicides applied in pre-emergence, although it is costly management (Oliveira & Freitas, 2009). Research aimed at better chemical management of *R. exaltata* has become necessary due to the increase in its infestation in the sugarcane sector.

Thus, this study aimed to evaluate the effectiveness of the association of the herbicides diquat or glyphosate with pre-emergent herbicides in the simultaneous control of emerged plants and seeds of *R. exaltata*.

## 2. Methodology

The experiment was set up and evaluated from November 2022 to February 2023 in a greenhouse belonging to the Department of Natural Resources and Environmental Protection (DRNPA) of the Federal University of São Carlos, Center for Agricultural Sciences, Campus Araras, SP, Brazil. It is a quantitative study, whose methodology was based on Silva et al. (2021) and Ratier et al. (2015).

The experimental units consisted of polyethylene pots with a volumetric capacity of 6 L and an area of 0.05088 m<sup>2</sup>. The pots were filled with Oxisol from the arable layer (0–20 cm). Chemical and physical analyses of soil samples were performed by the Laboratory of Soil Chemistry and Fertility at CCA/UFSCar (Table 1).

**Table 1** - Results of chemical analysis of a clay-textured Oxisol sample (0–20 cm).

Oxisol									
P	O.M.	pH	K	Ca	Mg	H+Al	SB	CTC	V
mg/dm <sup>3</sup>	g/dm <sup>3</sup>	Ca/Cl <sub>2</sub>				mmolc/dm <sup>3</sup>			%
15	38	5.6	5.4	53	13	26	71.4	97.4	73

Source: Laboratory of chemistry and soil fertility (2023).

The experiment was conducted in a greenhouse in a completely randomized design, with four replications. Fifteen treatments consisting of pre-and post-emergence herbicides applied alone or associated, in addition to the control without herbicide application, were evaluated (Table 2).

The seeds of the weed species *R. exaltata* were acquired from a company specialized in the production of weed seeds (Agrococosmos) for research purposes. The company analyzed seed germination analysis and informed the number of seeds required to obtain 25 plants. Sowing was carried out in two seasons aiming to obtain simultaneously emerged plants and seeds without emergence.

The first sowing was conducted with 20 seeds at a depth of 0.5 cm at 20 days before the post-emergence herbicide application, obtaining four plants per pot. Twenty seeds of the species were sown in the same pot the day before the application to evaluate the interaction of the herbicides in the emergence flux. Therefore, there were emerged plants and seeds of *R. exaltata* at the application time.

Post-emergence applications were performed on plants with three completely expanded leaves, using a CO<sub>2</sub>-pressurized knapsack sprayer equipped with a boom with four flat fan spray tips (Teejet 110.02) spaced at 0.5 m. The application was carried out at 0.5 m from the target, with a spray volume of 200 L ha<sup>-1</sup> and pressure of 40 Psi. Meteorological conditions at the application time were measured using the Kestrel weather station, with a temperature of 28 °C, relative humidity of 40%, and wind speed of 3 km/h.

**Table 2** - Treatments with herbicides used to control the species *Rottboellia exaltata*.

Treatment	Herbicide	Commercial name	Dose (g ai or ae ha <sup>-1</sup> )
T1	Control	-----	-----
T2	Diquat	Reglone	400
T3	Glyphosate	Roundup Transorb R	1176
T4	Glyphosate + Pendimethalin	Roundup Transorb R + Herbadox	1176 + 1200
T5	Glyphosate + Clomazone	Roundup Transorb R + Gamit	1176 + 1000
T6	Glyphosate + Indaziflam	Roundup Transorb R + Alion	1176 + 100
T7	Glyphosate + Trifluralin	Roundup Transorb R+ Trifluralin Gold	1176 + 900
T8	Diquat + Pendimethalin	Reglone + Herbadox	400 + 1200
T9	Diquat + Clomazone	Reglone + Gamit	400 + 1000
T10	Diquat + Indaziflam	Reglone + Alion	400 + 100
T11	Diquat + Trifluralin	Reglone + Trifluralin Gold	400 + 900
T12	Pendimethalin	Herbadox	1200
T13	Clomazone	Gamit	1000
T14	Indaziflam	Alion	100
T15	Trifluralin	Trifluralin Gold	900

Source: Authors (2023).

The control evaluations were performed at 7, 14, 21, 28, 35, and 42 days after the herbicide application (DAA) by visual scores based on the criteria by ALAM (1974), consisting of a percentage score scale, where 0 corresponds to no control and 100% to total control.

The weeds were cut close to the soil at 42 DAA and taken to a forced-air circulation oven at 65 °C until reaching a constant shoot dry mass weight. The reduction of the dry biomass into a percentage (%) was performed relative to the control (without herbicide application) to obtain the data referring to the shoot dry biomass.

The evaluations of the pre-emergence control were performed daily for 42 days. Subsequently, we calculated the percentage of germination (G%), which corresponds to the total number of seeds germinated in the last evaluation, and the

germination speed index (GSI), calculated using the equation proposed by Maguire (1962):

$$GSI = \frac{N_1}{D_1} + \frac{N_2}{D_2} + \dots + \frac{N_n}{D_n} \quad (1)$$

where GSI is the germination speed index, N is the number of seedlings observed on the day of counting, and D is the number of days after sowing in which the count was performed.

Control effectiveness and dry mass data were subjected to the normality test. The data were analyzed using the F-test, comparing the means of treatments using the Scott-Knott test at the 5% level ( $p \leq 0.05$ ).

### 3. Results and Discussion

Table 3 shows the percentage of simultaneous control of emerged plants and seeds of *R. exaltata* (itchgrass) as a function of herbicides and different evaluation times. This table shows the importance of associating herbicides with different forms of application for the control of emerged weeds and seeds. Importantly, the seeds had not germinated in the two initial evaluations, which occurred only from 21 DAA. Therefore, the evaluations at 7 and 14 DAA had only plants with three expanded leaves at the application time. Thus, in the first two evaluations, the treatments with the herbicides diquat and glyphosate alone or associated provided effective control of *R. exaltata*. Only the treatment with glyphosate + trifluralin showed control of lower than 80% in the evaluation at 7 DAA.

The pre-emergent herbicides applied alone showed unsatisfactory control and caused phytotoxicity in the established plants in the initial evaluations, which was due to their mode of action, directed at controlling seeds. This seed control was observed from 21 DAA, as it was at this time that the beginning of germination of *R. exaltata* was observed in the control without herbicide.

The results corroborate those of other studies, such as Freitas et al. (2004), who found that herbicides belonging to the bipiryridyl group controlled over 90% of the *R. exaltata* species when used in association with pre-emergent herbicides.

The application of diquat alone led to 90 and 93% controls of the species in the evaluations at 7 and 14 DAA, respectively. This herbicide has a high contact action, resulting in wilting and desiccation after 24 hours, but it is inactive when in contact with the soil (Rodrigues, Almeida 2018). Thus, there was a decrease in the control means in the following evaluations due to seed germination. The lowest control index (40%) was observed at 42 DAA in comparison with the other herbicide treatments. A similar pattern was observed with the use of glyphosate alone, with control levels above 80% in the initial evaluations, not preventing seed germination because it has no residual effect, culminating in a loss of control over time. Silva et al. (2021) observed that diquat, saflufenacil and ammonium glufosinate, associated with pre-emergent herbicides (diclosulam, sulfentrazone + diuron and flumioxazim + imazethapyr), resulted in a control greater than 80% of *Conyza* sp.

Treatment with clomazone alone showed maximum control of 67.5% up to 14 DAA, as it was not effective in controlling established plants. However, the treatments showed controls higher than 90% at 35 and 42 DAA due to the control of the new emergence fluxes. These data corroborate those found by Correia and Gomes (2014), who observed that the herbicide clomazone at the dose of 1200 g ha<sup>-1</sup> controlled over 95% of different populations of itchgrass at 42 DAA. This herbicide is recommended to control itchgrass, especially for the sugarcane crop, allowing its use both in pre-planting and pre-emergence after planting (Tropaldi et al, 2021).

The herbicide trifluralin showed low control rates when applied alone, with values of 20 and 30% at 7 and 14 DAA, respectively. Therefore, these values are lower than those observed for clomazone. Similar to trifluralin, the herbicide pendimethalin is a pre-emergent graminicide. The control levels using pendimethalin were 38.7 and 37.5% at 7 and 14 DAA, respectively. However, both herbicides showed controls above 80% after the beginning of seed germination at 42 DAA.

According to Rodrigues and Almeida (2018), both herbicides inhibit the formation of microtubules in the mitotic process of cell division, impairing the germination process. The herbicides pendimethalin (2000 g ha<sup>-1</sup>), trifluralin (3600 g ha<sup>-1</sup>) alone or associated, and amicarbazone (1400 g ha<sup>-1</sup>) applied in pre-emergence provided 100% control over *R. cochinchinensis* plants (Zera et al, 2018).

Indaziflam also showed a low control in the initial evaluations, with values of 33.7 and 45.0% at 7 and 14 DAA, respectively. Similar to the other pre-emergent herbicides, an increase in control was observed over the course of the evaluations, with a 70% control of *R. exaltata* plants at 35 and 42 DAA. Similarly, Rodrigues et al. (2022) found that the herbicide indaziflam at doses of 75 and 150 g ha<sup>-1</sup> promoted control higher than 95% of *R. exaltata* at 35 and 49 DAA.

**Table 3** - Simultaneous control (%) of emerged plants and seeds of *Rottboellia exaltata* (itchgrass) at 7, 14, 21, 28, 35, and 42 days after treatment application.

Treatment	% Control (Emerged plants and seeds)					
	7	14	21	28	35	42
Control	0.0 dA	0.0 dA	0.0 dA	0.0 eA	0.0 dA	0.0 dA
Diquat	90.0 aA	93.7 aA	42.5 cC	43.7 dC	46.2 cC	40.0 cC
Glyphosate	88.0 bA	87.5 bA	72.5 bA	63.7 cA	65.0 bA	63.7 bA
Diquat+Clomazone	100.0 aA	100.0 aA	100.0 aA	100.0 aA	100.0 aA	100.0 aA
Diquat+Indaziflam	100.0 aA	98.7 aA	98.7 aA	98.7 aA	98.7 aA	98.7 aA
Diquat+Pendimethalin	100.0 aA	100.0 aA	100.0 aA	100.0 aA	100.0 aA	100.0 aA
Diquat+Trifluralin	100.0 aA	100.0 aA	100.0 aA	100.0 aA	100.0 aA	100.0 aA
Glyphosate+Clomazone	98.7 aA	100.0 aA	100.0 aA	100.0 aA	100.0 aA	100.0 aA
Glyphosate+Indaziflam	96.2 aA	100.0 aA	100.0 aA	100.0 aA	100.0 aA	100.0 aA
Glyphosate+Pendimethalin	95.0 aA	100.0 aA	100.0 aA	100.0 aA	100.0 aA	100.0 aA
Glyphosate+Trifluralin	77.5 bB	100.0 aA	100.0 aA	100.0 aA	100.0 aA	100.0 aA
Trifluralin	20.0 cC	30.0 cB	61.2 cB	61.2 cB	72.5 bA	81.2 bA
Pendimethalin	38.7 bC	37.5 cC	53.7 cB	50.0 dB	75.7 bA	83.7 bA
Clomazone	62.5 bC	67.5 bC	80.0 bB	77.5 bB	92.5 aA	91.2 aA
Indaziflam	33.7 bB	45.0 bB	77.5 bA	68.7 bA	70.0 bA	70.0 bA
CV (%)	13.75					
F	A= 158.16** B= 4.63** AxB= 3.28**					

Beginning of seed emergence at 21 DAA. CV (%): coefficient of variation. A: treatments. B: days after application. \*Significant and <sup>NS</sup> not significant at the 1%\*\* probability level by the F-test. Means followed by equal lowercase letters in the column and uppercase letters in the row do not differ from each other by the Scott & Knott test at a 5% significance. Source: Authors (2023).

Table 4 shows the results of the germination of *R. exaltata* seed for the different treatments as a function of the evaluation times. In this table shows how the correct choice and use of pre-emergent herbicides is important to prevent weed germination. Treatments with pre-emergent herbicides showed excellent control of the species. There was practically no emergence of plants treated with these herbicides during the evaluations.

Diquat and glyphosate showed no difference relative to the control without herbicide at the evaluation times. According to Dalcin (2019), the herbicides glyphosate and diquat are absorbed only by the green parts of the plants, which means that they do not have a seed control effect, as they are strongly adsorbed to soil colloids.

Importantly, the seeds of this species can remain dormant in the soil for up to four years (Lorenzi, 2000; Monquero et al, 2012). Thus, pre-emergent herbicides, such as those in the present study, can act on seeds and present a prolonged residual effect, becoming relevant to control this species, especially considering aspects such as uneven germination, dormancy, and high seed durability. The treatment with trifluralin allowed a 7.5% germination of the species in the first evaluations, but total emergence control was observed after 35 DAA.

**Table 4 - Germination (%) of *Rottboellia exaltata* (itchgrass) at 7, 14, 21, 28, 35, and 42 days after treatment applications.**

Treatment	Days after application					
	7	14	21	28	35	42
Control	20.0 aC	50.0 aB	100.0 aA	100.0 aA	100.0 aA	100.0 aA
Diquat	10.0 aC	60.0 aB	100.0 aB	100.0 aA	100.0 aA	100.0 aA
Glyphosate	10.0 aD	50.0 aC	100.0 aB	100.0 aA	100.0 aA	100.0 A
Diquat+Clomazone	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA
Diquat+Indaziflam	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA
Diquat+Pendimethalin	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA
Diquat+Trifluralin	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA
Glyphosate+Clomazone	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA
Glyphosate+Indaziflam	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA
Glyphosate+Pendimethalin	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA
Glyphosate+Trifluralin	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA
Trifluralin	5.0 bB	7.5 bA	7.0 bA	7.0 bA	0.0 bB	0.0 bB
Pendimethalin	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA
Clomazone	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA
Indaziflam	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA	0.0 bA
CV (%)	40.79					
F	A= 1096.27** B= 6.63** AxB= 3.60**					

CV (%): coefficient of variation. A: treatments. B: days after application. \*Significant and <sup>NS</sup> not significant at the 1%\*\* probability level by the F-test. Means followed by equal lowercase letters in the column and uppercase letters in the row do not differ from each other by the Scott & Knott test at a 5% significance. Source: Authors (2023).

Table 5 shows the results referring to the reduction of the shoot dry mass of *R. exaltata* plants relative to the control, evaluated at 42 DAA. This table shows how the correct association between herbicides can prevent the presence of the weed in the field. The most effective treatments for the simultaneous control of emerged plants and seeds of *R. exaltata* consisted of the associations of diquat and glyphosate with pre-emergent herbicides. The total control of the species was observed regardless of the association. Importantly, the associations did not differ from the treatment with clomazone applied alone. The herbicides trifluralin, pendimethalin, and indaziflam did not differ from each other in reducing the dry mass of the species, showing a lower control compared to the associations of herbicides, with control values ranging from 70.0 to 85.8%. The results obtained for the treatment of indaziflam applied alone agree with those found by Rodrigues et al. (2022), who found a higher reduction in dry matter of *R. exaltata* when applied at a dose of 75 g ha<sup>-1</sup>.

The least effective treatments in controlling the species consisted of the isolated applications of diquat and glyphosate, with less than 60% reduction in dry mass, as only emerged plants were controlled at the application time.

These data are consistent with those observed in the control of *R. exaltata* plants. Importantly, the dry mass observed in the treatments with pre-emergent herbicides comes from plants established at the application time, as they controlled 100%

of seed germination.

**Table 5** - Reduction (%) of shoot dry mass (SDM) of *Rottboellia exaltata* (itchgrass) evaluated at 42 DAA.

Treatment	SDM (%)
Diquat	57.4 c
Glyphosate	55.1 c
Diquat+Clomazone	100.0 a
Diquat+Indaziflam	100.0 a
Diquat+Pendimethalin	100.0 a
Diquat+Trifluralin	100.0 a
Glyphosate+Clomazone	100.0 a
Glyphosate+Indaziflam	100.0 a
Glyphosate+Pendimethalin	100.0 a
Glyphosate+Trifluralin	100.0 a
Trifluralin	85.8 b
Pendimethalin	78.3 b
Clomazone	95.2 a
Indaziflam	70.0 b
CV (%)	12.62
F	5.78**

CV (%): coefficient of variation. A: treatments. B: days after application. \*Significant and <sup>NS</sup> not significant at the 1%\*\* probability level by the F-test. Means followed by equal lowercase letters in the column and uppercase letters in the row do not differ from each other by the Scott & Knott test at a 5% significance. Source: Authors (2023).

#### 4. Conclusion

The association of the post-emergent herbicides glyphosate and diquat with the pre-emergent herbicides clomazone, pendimethalin, indaziflam, and trifluralin showed a high simultaneous control of seeds and emerged plants of the species *R. exaltata*.

The herbicides applied alone showed lower control of *R. exaltata* than the associations, except for the herbicide clomazone, which stood out relative to isolated applications, with high control of the species.

It would be interesting to work with other soil textures, especially with regard to the use of pre-emergent herbicides.

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