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HERBICIDES APPLIED ALONE AND IN ASSOCIATION FOR THE LATE POST-EMERGENCE CONTROL OF *Merremia aegyptia* AND *Urochloa decumbens*

HERBICIDAS APLICADOS ISOLADAMENTE E EM ASSOCIAÇÃO PARA O CONTROLE EM PÓS-EMERGÊNCIA TARDIA DE *Merremia aegyptia* E *Urochloa decumbens*

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Abstract

Weed interference is one of the main factors limiting sugarcane (*Saccharum officinarum* L.) performance, making chemical control an important practice for weed management. This study aimed to evaluate the efficacy of herbicides applied alone and in association for the late post-emergence control of *Merremia aegyptia* and *Urochloa decumbens*. The experiment was conducted under greenhouse conditions in pots using a completely randomized design in a two by six factorial arrangement, with four replications. The first factor consisted of the weed species *Merremia aegyptia* and *Urochloa decumbens*, and the second factor consisted of the herbicide treatments: untreated control, tebuthiuron, sulfentrazone, clomazone, tebuthiuron + atrazine, and tebuthiuron + sulfentrazone. The evaluated variables were visual control at 7, 14, 21, and 28 days after application (DAA) and shoot dry mass at 28 DAA. Significant effects of herbicides and of the interaction between weed species and herbicides were observed at all evaluation times. *Urochloa decumbens* showed greater initial control, whereas no significant differences between species were observed at 21 and 28 DAA. At the end of the experimental period, tebuthiuron, sulfentrazone, clomazone, and tebuthiuron + atrazine provided the highest control levels, whereas tebuthiuron + sulfentrazone showed lower performance. All herbicide treatments reduced shoot dry mass compared with the untreated control. Under the conditions of this experiment, tebuthiuron + atrazine, sulfentrazone, tebuthiuron, and clomazone were effective for the late post-emergence control of *Merremia aegyptia* and *Urochloa decumbens*.

Keywords: Chemical management, Sugarcane, Weed control.

Resumo

A interferência de plantas daninhas é um dos principais fatores que limitam o desempenho da cana-de-açúcar (*Saccharum officinarum* L.), tornando o controle químico uma prática importante para o manejo dessas plantas. Este estudo teve como objetivo avaliar a eficácia de herbicidas aplicados isoladamente e em associação para o controle em pós-emergência tardia de *Merremia aegyptia* e *Urochloa decumbens*. O

experimento foi conduzido em casa de vegetação, em vasos, utilizando delineamento inteiramente casualizado em esquema fatorial 2 x 6, com quatro repetições. O primeiro fator consistiu nas espécies de plantas daninhas *Merremia aegyptia* e *Urochloa decumbens*, e o segundo fator consistiu nos tratamentos herbicidas: testemunha sem aplicação, tebuthiuron, sulfentrazona, clomazona, tebuthiuron + atrazina e tebuthiuron + sulfentrazona. As variáveis avaliadas foram o controle visual aos 7, 14, 21 e 28 dias após a aplicação (DAA) e a massa seca da parte aérea aos 28 DAA. Efeitos significativos dos herbicidas e da interação entre espécies de plantas daninhas e herbicidas foram observados em todas as épocas de avaliação. *Urochloa decumbens* apresentou maior controle inicial, enquanto não foram observadas diferenças significativas entre as espécies aos 21 e 28 DAA. Ao final do período experimental, tebuthiuron, sulfentrazona, clomazona e tebuthiuron + atrazina proporcionaram os maiores níveis de controle, ao passo que tebuthiuron + sulfentrazona apresentou desempenho inferior. Todos os tratamentos herbicidas reduziram a massa seca da parte aérea em comparação com a testemunha sem aplicação. Nas condições deste experimento, tebuthiuron + atrazina, sulfentrazona, tebuthiuron e clomazona foram eficazes para o controle em pós-emergência tardia de *Merremia aegyptia e Urochloa decumbens*.

Palavras-chave: Cana-de-açúcar, Controle de plantas daninhas, Manejo químico.

INTRODUCTION

Weed management is one of the main practices associated with maintaining the productivity and longevity of sugarcane (*Saccharum officinarum* L.) fields, particularly in systems with mechanized harvesting and high infestation pressure. The presence of these species can impair the early development of the crop, hinder management operations, and reduce both the agricultural and industrial yield of sugarcane. Considering the economic relevance of this crop in Brazil, whose production in the 2025/26 season was estimated at 668.8 million tonnes cultivated on approximately 8.85 million hectares (Conab, 2025), efficient weed management remains one of the main challenges of sugarcane production systems.

This concern is justified because weed interference can affect sugarcane performance from the earliest stages of development. Competition for light, water, nutrients, and space can compromise the early growth of sugarcane and negatively affect the final yield of the crop. Beluci *et al.* (2018) reported that the coexistence of the crop with the weed community throughout the entire cycle reduced yield by 60%, while Amaral *et al.* (2019) showed that interference can occur early in pre-sprouted sugarcane seedlings.

In this context, chemical management remains one of the main strategies used to reduce weed interference in commercial sugarcane areas. However, herbicide performance varies according to the weed species, the developmental stage of the plants, the environmental conditions, and the timing of application. In addition, the efficiency of chemical management in sugarcane may vary with the amount of straw remaining after harvest, the herbicide used, and the weed species evaluated (Castro *et al.*, 2024). For this reason, comparative evaluations of active ingredients applied alone or in association are useful for guiding the management of weed communities composed of species from different botanical groups. Similarly, Gongka *et al.* (2025) observed that the efficiency of herbicides applied in pre- and post-emergence in sugarcane varied with the treatment, the weed community, and the location where the experiment was conducted, reinforcing the need for specific evaluations under different management conditions.

In sugarcane fields, the weed community often comprises species with different morphology, life cycle, and herbicide response, which makes it difficult to design control programs with a broad spectrum of action. Among broadleaf weeds, *Merremia aegyptia* deserves attention because it belongs to the Convolvulaceae family, whose climbing growth habit can favor entanglement around the stalks and hinder mechanized harvesting. Beyond this operational impact, the management of this species tends to be more complex when applications are made on well-developed plants. Correia (2016) demonstrated that the chemical control of morning glory species in sugarcane varies with the species and the harvest

condition, indicating that results obtained for one Convolvulaceae species should not be generalized to the entire group.

Among grasses, *Urochloa decumbens* is a relevant species in agricultural areas due to its high adaptability, establishment capacity, and biomass production. In areas of sugarcane renewal or expansion, especially when coming from systems previously occupied by pastures, its presence can increase the complexity of management because of the persistence of propagules and the rapid vegetative growth. In addition, the efficiency of chemical control of grasses in sugarcane can be affected by environmental factors, as demonstrated by Takano *et al.* (2018), as well as by the herbicide used and the soil type, as observed by Ghirardello *et al.* (2022) for species of the Poaceae family.

The simultaneous presence of species with distinct characteristics, such as *Merremia aegyptia* and *Urochloa decumbens*, makes chemical management more complex. This difficulty tends to be greater in late post-emergence, when broadleaf weeds and grasses may show different levels of tolerance to the treatments. Under this condition, the weeds already exhibit greater vegetative development, which can reduce the control provided by certain treatments and increase the need for alternatives with greater consistency. This variation in response among botanical groups has also been observed in studies with species associated with sugarcane (Correia, 2016; Ghirardello *et al.*, 2022).

The use of herbicides alone or in association is an alternative to broaden the control spectrum in areas infested by species from different groups. Active ingredients such as tebuthiuron, sulfentrazone, clomazone, and atrazine may show different responses depending on the weed species evaluated and the developmental stage at the time of application. Evaluating the control of *Merremia aegyptia* in sugarcane, Correia *et al.* (2010) found that the association of mesotrione with herbicides such as atrazine, metribuzin, and diuron + hexazinone was more effective than their application alone. These results reinforce that the use of associations should be evaluated specifically, considering the combination of products and the species present in the area.

Given this background, the present study aimed to evaluate the efficacy of herbicides applied alone and in association for the late post-emergence control of *Merremia aegyptia* and *Urochloa decumbens*.

MATERIAL AND METHODS

The study was conducted under greenhouse conditions at the Experimental Field of Faculdades ITES, located in the municipality of Taquaritinga, SP, Brazil, at the coordinates 21°24′22″ S and 48°30′20″ W. The region has a humid tropical climate with a well-defined dry season, an average annual rainfall of approximately 1,200 mm, and soil classified as Argissolo (Brazilian Soil Classification).

The trial was set up in pots and conducted under a completely randomized design in a 2 × 6 factorial arrangement, with four replications. Treatments were formed by combining two weed species, *Merremia aegyptia* (L.) Urb. (Convolvulaceae) and *Urochloa decumbens* (Stapf) R.D.Webster (Poaceae), with six herbicide programs: an untreated control, tebuthiuron, sulfentrazone, clomazone, tebuthiuron + atrazine, and tebuthiuron + sulfentrazone (Table 1). A total of 48 pots were used, each constituting one experimental unit.

Table 1

Treatments, active ingredient, and doses of the herbicides applied in late post-emergence on Merremia aegyptia and Urochloa decumbens.

Treatment	Active ingredient	Dose L or kg ha^{-1}	
		c.p.	**a.i.**
T1	Untreated control	---	---
T2	tebuthiuron	2.4	1.2
T3	sulfentrazone	1.6	0.8
T4	clomazone	3.5	1.26
T5	tebuthiuron + atrazine	1.2 + 4.0	0.6 + 2.0
T6	tebuthiuron + sulfentrazone	1.2 + 0.8	0.6 + 0.4

c.p. = commercial product; a.i. = active ingredient; sulfentrazone = Boral® 500 SC; clomazone = Gamit® 360 CS; tebuthiuron = FortalezaBR®; atrazine = Atrazina Nortox®. Source: Own authorship (2026).

The pots were filled with soil from the Experimental Field of Faculdades ITES. Sowing was performed on November 28, 2018, using 15 seeds of the corresponding species per pot, distributed on previously moistened soil at a depth of approximately 2 cm. After emergence, no thinning was performed, and the population established in each experimental unit was maintained to provide sufficient plant cover to simulate a dense infestation.

During the experiment, the pots were irrigated daily to maintain soil moisture and were rotated at intervals of two to three days to reduce possible environmental effects associated with the position of the experimental units.

Applications were carried out under late post-emergence conditions, when *Urochloa decumbens* had five to six tillers per plant and *Merremia aegyptia* had four to six leaves with the onset of branching. At the time of spraying, the average air temperature was 27.8 °C, the relative humidity was 74.1%, and the wind speed was 1.69 km h^{-1}. Each treatment was applied separately, with the replications kept isolated from the other treatments to avoid drift and cross-contamination between experimental units.

Control was assessed at 7, 14, 21, and 28 days after herbicide application (DAA) using visual phytotoxicity scores. A percentage scale from 0 to 100% was used, in which 0% represented the absence of control and 100% corresponded to total plant death, following the scale proposed by Rolim (1989).

At 28 DAA, the shoot dry mass of the remaining plants was determined. To this end, all plant material in each pot was cut at the base, placed in a forced-air oven at 70 ± 2 °C until constant mass, and subsequently weighed on a precision digital balance.

The data obtained were subjected to analysis of variance using the F test. Before the analysis, the assumptions of normality of the residuals and homogeneity of variances were verified using the Shapiro-Wilk and Levene tests, respectively. When a significant effect was detected, the means were compared by Tukey's test at 5% probability, using the AgroEstat software (Barbosa and Maldonado, 2015).

RESULTS AND DISCUSSION

The visual control assessments indicated a differential response of the weeds to the herbicide treatments throughout the experimental period. Significant effects of herbicides and of the interaction between species and herbicides were detected at all evaluation times, while the effect of species was significant only at 7 and 14 DAA (Table 2).

Table 2

Summary of the analysis of variance for the control of Merremia aegyptia and Urochloa decumbens subjected to herbicides applied in late post-emergence, at 7, 14, 21, and 28 days after application (DAA).

Source of variation	7 DAA	14 DAA	21 DAA	28 DAA
Weeds (A)	174.75**	12.83**	2.05^{NS}	0.07^{NS}
Herbicides (B)	144.39**	131.35**	194.08**	175.61**
A × B	21.47**	3.44**	4.94**	5.38**
CV (%)	13.02	12.52	10.23	10.80
LSD (A)	3.74	4.72	4.42	4.79
LSD (B)	9.61	12.12	11.37	12.30

ns = not significant; ** significant at 1% probability by the F test. CV = coefficient of variation; LSD = least significant difference. Source: Own authorship (2026).

Considering the species means, *Urochloa decumbens* showed greater initial control, with 61.25% at 7 DAA and 68.54% at 14 DAA, differing from *Merremia aegyptia* in these assessments (Table 3). At 21 and 28 DAA, no significant differences between species were observed, indicating a convergence of control levels at the end of the experimental period.

Table 3

Control (%) of Merremia aegyptia and Urochloa decumbens at 7, 14, 21, and 28 DAA.

Weed species	7 DAA	14 DAA	21 DAA	28 DAA
Merremia aegyptia	36.88 b	60.21 b	75.42 a	76.04 a
Urochloa decumbens	61.25 a	68.54 a	72.29 a	75.42 a

Means followed by the same letter in the column do not differ from each other by Tukey's test at 5% probability. Source: Own authorship (2026).

This initial difference may be related to the morphological characteristics of the species and to the developmental stage at the time of application. *Merremia aegyptia*, due to its climbing habit and the onset of branching, tends to be more difficult to control in late applications, a behavior already associated with the variable response of morning glory species to chemical control in sugarcane (Correia, 2016). Although their study was carried out under pre-emergence conditions, Silva *et al.* (2024) also observed that the control of *Merremia aegyptia* may vary with the germination flux, the amount of straw, the simulated dry period, and the herbicide used, reinforcing the need for species-specific evaluations. In contrast, *Urochloa decumbens* responded more intensely in the first assessments, although this difference between species was no longer observed in the final evaluations.

Considering the herbicide treatments, the treatments differed from each other at all evaluation times (Table 4). At 7 DAA, sulfentrazone provided the highest initial control, with 71.88%, not differing statistically from tebuthiuron + atrazine and tebuthiuron + sulfentrazone. In this same assessment, clomazone showed the lowest initial control among the herbicides, with 35.00%, indicating a slower action compared with the other treatments.

Table 4

Control (%) of Merremia aegyptia and Urochloa decumbens as a function of the herbicides applied in late post-emergence, at 7, 14, 21, and 28 days after application (DAA).

Treatment	7 DAA	14 DAA	21 DAA	28 DAA
T1	0.00 d	0.00 c	0.00 c	0.00 c
T2	59.38 b	81.25 a	92.50 a	96.25 a
T3	71.88 a	81.25 a	93.75 a	97.50 a
T4	35.00 c	68.75 b	86.88 a	90.63 a
T5	63.75 ab	88.75 a	97.50 a	97.50 a
T6	64.38 ab	66.25 b	72.50 b	72.50 b

T1 = untreated control; T2 = tebuthiuron; T3 = sulfentrazone; T4 = clomazone; T5 = tebuthiuron + atrazine; T6 = tebuthiuron + sulfentrazone. Means followed by the same letter in the column do not differ from each other by Tukey's test at 5% probability. Source: Own authorship (2026).

At 14 DAA, tebuthiuron, sulfentrazone, and tebuthiuron + atrazine provided the highest control levels, with values between 81.25% and 88.75%, not differing statistically from each other. In this

assessment, clomazone and tebuthiuron + sulfentrazone showed lower performance than the treatments with the highest control. At 21 and 28 DAA, tebuthiuron, sulfentrazone, clomazone, and tebuthiuron + atrazine fell within the same statistical group, indicating satisfactory to high control at the end of the experimental period. In contrast, tebuthiuron + sulfentrazone maintained lower performance in the final assessments, with 72.50% control at 21 and 28 DAA.

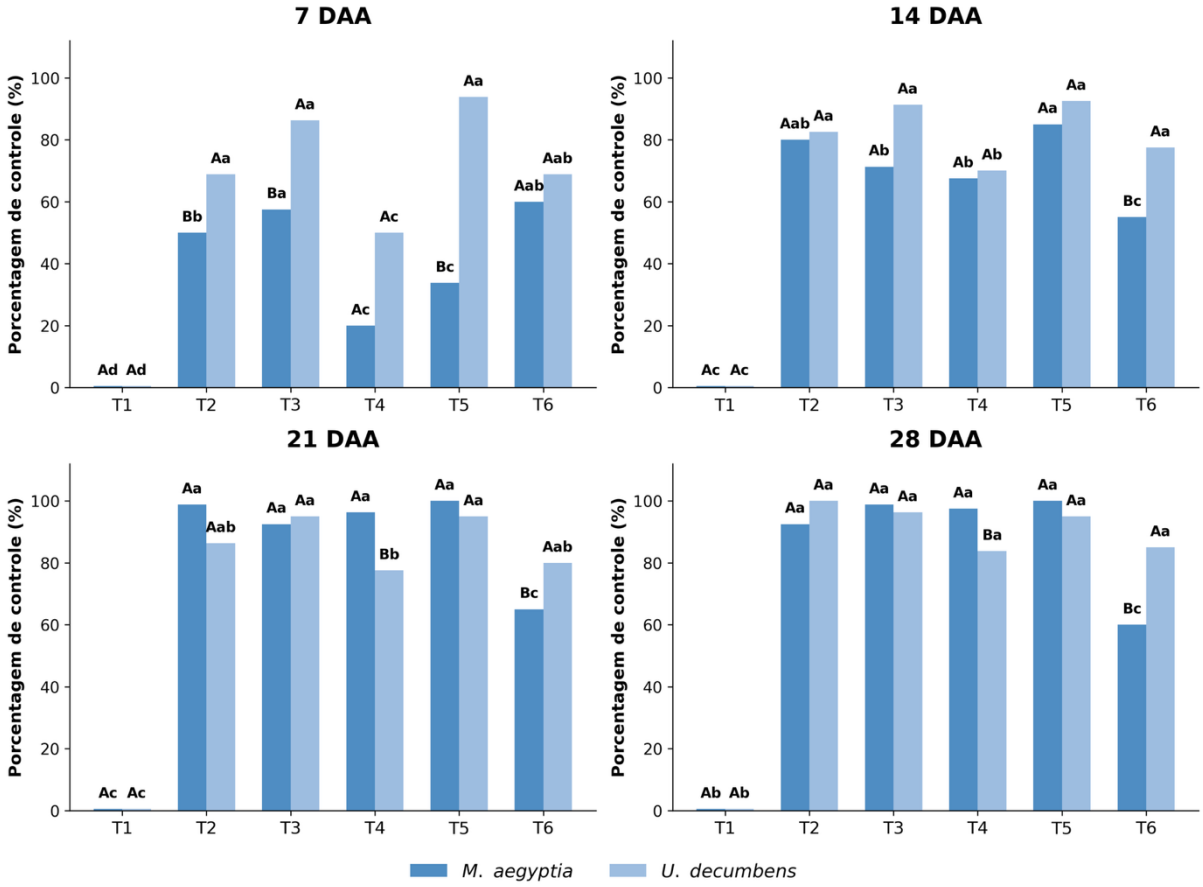
According to the control scale of Rolim (1989) cited in the Material and Methods section, tebuthiuron, sulfentrazone, and tebuthiuron + atrazine reached control levels classified between good and very good in the final assessments. Clomazone, although showing a slower initial response, reached 90.63% at 28 DAA, a value classified as sufficient control. The association tebuthiuron + sulfentrazone remained below the other treatments at the end of the experiment and was classified as insufficient control, indicating lower consistency under this application condition.

The differential response among treatments confirms that the efficiency of chemical management in sugarcane depends not only on the active ingredient, but also on the application conditions and the weed species evaluated. In recent studies, Castro *et al.* (2024) observed that the amount of straw remaining after harvest and the herbicides used influenced the control of *Digitaria* spp. in green-cane (unburned) sugarcane, while Gongka *et al.* (2025) reported variation in the efficiency of herbicides applied in pre- and post-emergence according to the treatment, the weed community, and the location where the experiment was conducted.

The significant interaction between species and herbicides indicates that the overall means should be complemented by the response of each species to the treatments. This behavior is presented in Figure 1, which illustrates the differences in the performance of the herbicides on *Merremia aegyptia* and *Urochloa decumbens* throughout the assessments.

Figure 1

Interaction between the control scores (%) of the treatments and the weed species (Merremia aegyptia and Urochloa decumbens) subjected to herbicides applied in late post-emergence at 7, 14, 21, and 28 days after application (DAA).



T1 = untreated control; T2 = 1.2 kg ha⁻¹ tebuthiuron; T3 = 0.8 kg ha⁻¹ sulfentrazone; T4 = 1.26 kg ha⁻¹ clomazone; T5 = 0.6 kg ha⁻¹ tebuthiuron + 2.0 kg ha⁻¹ atrazine; T6 = 0.6 kg ha⁻¹ tebuthiuron + 0.4 kg ha⁻¹ sulfentrazone. Uppercase letters compare species within each treatment, and lowercase letters compare treatments within each species, by Tukey's test at 5% probability. Source: Own authorship (2026).

The interaction between species and herbicides showed that the highest-performing treatments varied with the species and the evaluation time. At 7 and 14 DAA, there was greater variation among treatments, whereas at 21 and 28 DAA, tebuthiuron, sulfentrazone, clomazone, and tebuthiuron + atrazine provided the highest control levels for both species. In contrast, tebuthiuron + sulfentrazone showed lower performance in the final assessments, indicating lower consistency of control under the evaluated conditions.

These results indicate that the association of tebuthiuron and atrazine provided high and consistent control throughout the evaluation period, particularly in the final assessments. By contrast, the tebuthiuron + sulfentrazone association did not show the same performance, indicating that herbicide mixtures do not necessarily improve efficiency. Therefore, the response of the associations should be interpreted considering the target species, the dose used, and the application conditions.

The differential response among herbicide associations has also been observed in other studies with sugarcane. Correia *et al.* (2010) reported greater efficacy in the control of *Merremia aegyptia* when mesotrione was associated with other herbicides, compared with application alone. In turn, Sandaniel *et al.* (2008), evaluating herbicides in ratoon sugarcane, observed that the performance of mixtures may vary with the weed species. These results reinforce that the choice of treatment should consider the composition of the weed community and the developmental stage of the plants at the time of application.

The shoot dry mass, evaluated at 28 DAA, complemented the visual control assessments by allowing verification of the final effect of the treatments on weed biomass accumulation. For this variable, there were significant effects of species and of herbicides, while the interaction between these factors was not significant (F = 2.00 ns), indicating that the main effects can be interpreted separately. Considering the species means, *Merremia aegyptia* showed greater dry mass accumulation than *Urochloa decumbens*, with 1.54 g and 0.66 g, respectively (Table 5).

Table 5

Shoot dry mass of Merremia aegyptia and Urochloa decumbens at 28 days after the application of herbicides in late post-emergence.

Treatment	Dry mass (g)
Weeds (A)	
Merremia aegyptia	1.54 a
Urochloa decumbens	0.66 b
F	21.33**
CV (%)	35.00
LSD	0.38

Means followed by the same letter, within each factor, do not differ from each other by Tukey's test at 5% probability. CV = coefficient of variation; LSD = least significant difference. Source: Own authorship (2026).

The greater dry mass observed for *Merremia aegyptia* confirms the lower biomass suppression of this species compared with *Urochloa decumbens*, consistent with the lower initial sensitivity observed in the visual control assessments. The absence of a significant interaction for dry mass indicates that the effect of the herbicides on biomass accumulation can be discussed from the overall treatment means (Table 6).

Table 6

Shoot dry mass as a function of the herbicides at 28 days after application in late post-emergence.

Treatment	Dry mass (g)
Herbicides (B)	
Untreated control	3.37 a
tebuthiuron (1.2 kg ha^{-1})	0.49 b
sulfentrazone (0.8 kg ha^{-1})	0.49 b
clomazone (1.26 kg ha^{-1})	0.80 b
tebuthiuron + atrazine (0.6 + 2.0 kg ha^{-1})	0.31 b
tebuthiuron + sulfentrazone (0.6 + 0.4 kg ha^{-1})	0.91 b
F	24.14**
CV (%)	35.00
LSD	0.98

Means followed by the same letter, within each factor, do not differ from each other by Tukey's test at 5% probability. CV = coefficient of variation; LSD = least significant difference. Source: Own authorship (2026).

All herbicide treatments reduced dry mass compared with the untreated control, demonstrating an effect on the biomass accumulation of the species evaluated. Although there was no statistical difference among the herbicides, the lowest numerical value was observed for tebuthiuron + atrazine, with 0.31 g, followed by tebuthiuron and sulfentrazone, both with 0.49 g. These results complement the visual control assessments, in which these treatments were among the most efficient at the end of the experimental period, indicating that greater control intensity was also reflected in lower shoot biomass production.

Overall, the results of visual control and dry mass indicate higher performance of tebuthiuron + atrazine, sulfentrazone, tebuthiuron, and clomazone in the late post-emergence control of the species evaluated. The tebuthiuron + sulfentrazone association, despite showing initial control close to that of some treatments, exhibited lower performance in the final assessments, indicating lower consistency under the evaluated conditions.

CONCLUSION

Under the conditions in which the experiment was conducted, the treatments tebuthiuron + atrazine, sulfentrazone, tebuthiuron, and clomazone showed greater efficiency in the late post-emergence control of *Merremia aegyptia* and *Urochloa decumbens*. The tebuthiuron + sulfentrazone association showed lower performance in the final assessments, indicating lower consistency of control compared with the other herbicide treatments. The reduction in dry mass relative to the untreated control confirmed the effect of the herbicides on the biomass accumulation of the species evaluated.

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