FILUS, A.; BARROSO, A. A. M.; ALBRECHT, A. J. P.; SILVA, A. F. M.; ALBRECHT, L. P.; RONCATTO, E. Application technology and effectiveness of auxin herbicides in controlling *Conyza sumatrensis* and *Commelina benghalensis* **Revista de Agricultura Neotropical**, Cassilândia-MS, v. 11, n. 1, e8319, Jan./Mar., 2024. ISSN 2358-6303. DOI: https://doi.org/10.32404/rean.v11i1.8319.

Application technology and effectiveness of auxin herbicides in controlling *Conyza sumatrensis* and *Commelina benghalensis*

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Received: 19/10/2023; Accepted: 10/01/2024.

ABSTRACT

The Sumatran fleabane (*Conyza sumatrensis* [Retz.] E.Walker) and Benghal dayflower (*Commelina benghalensis* L.) are among the most challenging weeds to control in agricultural crops. However, synthetic auxins present a potential solution. This study aimed to assess the efficacy of auxin herbicides in controlling *C. sumatrensis* and *C. benghalensis* using two spray volumes and two types of nozzles: Turbo TeeJet® Induction (TTI) and Extended Range (XR). The research comprised four experiments conducted in a greenhouse in Curitiba, Paraná, Brazil, from November 2019 to January 2020. For *C. sumatrensis*, no significant differences were observed between treatments at both stages of development. Consequently, it was not possible to identify the most effective herbicide, volume, or application nozzle. However, all treatments were found to be effective by the end of the evaluations. In contrast, for *C. benghalensis*, 2,4-D demonstrated higher efficacy than dicamba, irrespective of the developmental stages. The reduction in spray volume from 200 to 140 L ha^{-1}, and the use of the TTI nozzle did not impact the effectiveness of the herbicides. The stage of development did not influence the herbicide control. In this case, the target species was the predominant factor in determining the effectiveness of control.

Keywords: 2,4-D, Benghal dayflower, Dicamba, Sumatran fleabane, Spray nozzles.

Tecnologia de aplicação e eficácia de herbicidas auxínicos no controle de *Conyza sumatrensis* e *Commelina benghalensis*

RESUMO

As espécies buva (*Conyza sumatrensis* [Retz.] E.Walker) e trapoeraba (*Commelina benghalensis* L.) estão entre as mais importantes plantas daninhas nos cultivos agrícolas, sendo de difícil controle, mas tendo como opção o uso de auxinas sintéticas. Assim, o objetivo do trabalho foi avaliar a eficácia de herbicidas auxínicos no controle de *C. sumatrensis* e *C. benghalensis*, sob dois volumes de calda e pontas *Turbo TeeJet® Induction* (TTI) ou *Extended Range* (XR). Quatro experimentos foram conduzidos em casa-de-vegetação em Curitiba, PR, Brasil, entre novembro de 2019 e janeiro de 2020. Para *C. sumatrensis*, em ambas as etapas, não houve diferenças significativas nos tratamentos e por esse motivo, não foi possível determinar o herbicida, volume ou ponta de aplicação mais eficaz, sendo todos os tratamentos aplicados eficazes ao final das avaliações. Para *C. benghalensis* foi possível observar maior eficácia do 2,4-D em relação ao dicamba, independente dos estágios de desenvolvimento. A redução de 200 para 140 L ha^{-1} e o uso da ponta TTI não afetaram a ação dos herbicidas. O estádio de desenvolvimento não influenciou o controle observado pelos herbicidas. Neste caso, o fator predominante na eficácia do controlo foi a espécie alvo.

Palavras-chave: 2,4-D, Trapoeraba, Dicamba, Buva, Pontas de aplicação.

1. Introduction

Herbicides containing synthetic auxins primarily target broadleaf weeds, with limited effect on grasses due to reduced translocation via phloem and anatomical structures (Peterson et al., 2016). Over the years, various chemical classes of synthetic auxins, including phenoxycarboxylic acids, benzoic acids, pyridinecarboxylic acids, aromatic carboxymethyl derivatives, and quinolinocarboxylic acids, have been synthesized and are commercially available (Grossmann, 2010). The efficacy of these herbicides varies depending on the specific molecule used, the weed species (Silva et al., 2019), and the application technique. Synthetic auxins are commonly used in pre sowing applications for grain crops to control *Conyza* spp. (Hedges et al., 2018; Hedges et al., 2019) and *Commelina benghalensis* (Merchant et al., 2013).

However, *Conyza sumatrensis* exhibits resistances to chlorimuron, glyphosate, paraquat, and 2,4-D, as well as multiple resistance to glyphosate, paraquat, and chlorimuron, making control challenging (Santos et al., 2014; Zobiole et al., 2019; Queiroz et al., 2020; Albrecht et al., 2020). Similarly, *C. benghalensis* is difficult to control with glyphosate alone because of its tolerance to this herbicide (Dias et al., 2013). These cases of resistance or tolerance to herbicides make it difficult to control these weeds.

To make synthetic auxins work better, we need to pay attention to how we apply them. The spray nozzle can affect how well the herbicide sticks to the leaves of *C. benghalensis* (Contiero et al., 2016; Oliveira et al., 2019) or *C. bonariensis* (Oliveira et al., 2019), which affects how well the herbicide works. It is recommended to use thicker drops that will not drift as much, as drifting can make the herbicide less effective (Butts et al., 2019). Thus, the objective of this study was to evaluate the effectiveness of auxin herbicides in the control of *C. sumatrensis* and *C. benghalensis* using two volumes of spray and Turbo TeeJet® Induction (TTI) or extended range (XR) nozzles.

2. Material and Methods

Four experiments were conducted in a greenhouse with semi-controlled conditions in Curitiba, Paraná, Brazil (25°24′42″S 49°14′53″W, 935 m altitude) between November 2019 and January 2020. The greenhouse had daily irrigation (5 mm) by micro sprinkler, an average temperature of 22 °C, and natural daylight supplemented by high-pressure metallic vapor lamps (80 lm W^{-1}). Experiments one and two involved the application of herbicides on *C. sumatrensis* plants with heights of less than 10 cm (12 leaves) and more than 10 cm (30 leaves), respectively. Experiments three and four were conducted on *C. benghalensis* plants with heights of less than 20 cm and more than 20 cm, respectively. All plants were in the vegetative stage, without flowers. A completely randomized design was adopted with the treatments described in Table 1. Each experiment considered four replicates, and each replicate consisted of a 7-L pot with one plant.

Weed seeds, sourced from local field crops, were sown in trays filled with horticultural substrate. Once they developed two true leaves, they were transplanted into 7 L pots filled with clayey soil (14.7% sand, 25.3% silt, and 60% clay). This soil was collected from a field area with an annual soybean/maize succession, devoid of residues. Upon reaching the application stage, the weeds were treated with dicamba and 2,4-D herbicides using a CO_2 pressurized backpack sprayer at a constant pressure of 2 bar. The sprayer was equipped with a bar containing four nozzles (Teejet®), spaced at 0.5 m, and operated at an application speed of 1 m s^{-1}, producing ultra-thick droplets.

Table 1. Treatments comprised the postemergence application of dicamba or 2,4-D in two spray volumes and two types of nozzles in *Conyza sumatrensis* and *Commelina benghalensis*.

Herbicide	Commercial product	Herbicide rate	Spray volume	Nozzle[2]	Flow rate
		g ae[1] ha^{-1}	L ha^{-1}		L min^{-1}
Without application	-	-	-	-	-
Dicamba	Atectra®	560	140	TTI 110015	0.48
			140	XR 110015	0.48
			200	TTI 110020	0.65
			200	XR 110020	0.65
2,4-D	DMA® 806 BR	1,005	140	TTI 110015	0.48
			140	XR 110015	0.48
			200	TTI 110020	0.65
			200	XR 110020	0.65

[1]Acid equivalent; [2]TTI: Turbo TeeJet® Induction; XR: extended range.

Weed control was evaluated at 7, 21, and 35 days after application (DAA) through visual assessments of each plant (0% for no injury and 100% for plant death), considering visible symptoms (Velini et al., 1995). On these assessment dates, injuries related to the application of synthetic auxins were also evaluated. For *C. sumatrensis*, these included wrinkled leaves, epinasty and stem shriveling, and chlorosis and necrosis. For *C. benghalensis*, they included wrinkled leaves, leaves with altered margins, epinasty and stem shriveling, and chlorosis and necrosis. These injuries were assigned scores from 0 to 5 (0-absent, 1-mild, 2-mild to moderate, 3-moderate, 4-moderate to severe, and 5-severe) (Foster and Griffin, 2018).

At 35 DAA, the shoot dry mass of the weed was determined. The remaining plant material in each experimental unit was cut close to the ground level and dried in a forced ventilation oven at 60ºC until it reached a constant weight. After drying, the plant material was weighed on a scale with precision to two decimal places. Data were subjected to analysis of variance using the F-test ($p \leq 0.05$), and the means were compared by Tukey's test ($p \leq 0.05$). Analyses were performed using the Sisvar 5.6 program (Ferreira, 2011).

3. Results and Discussion

The statistical analysis of *C. sumatrensis* with heights <10 cm revealed a significant effect ($p \leq 0.05$) for all variables in experiment 1. At 7 DAA, only dicamba applied at 200 L ha^{-1} with nozzle TTI 110020 did not achieve at least 80% control, performing better than the untreated control. From 21 to 35 DAA, all herbicide treatments effectively controlled *C. sumatrensis* (≥91.3%), with no differences observed between herbicides, spray volumes, or nozzles used (Figure 1). Dry mass did not differ between treatments, showing an average reduction of 87.4% compared to the untreated control (data not shown).

The statistical analysis of *C. sumatrensis* with heights >10 cm indicated a significant effect ($p \leq 0.05$) for all variables in experiment 2. Dicamba applied at a spray volume of 140 L ha^{-1} with nozzle TTI 110015 was not among the most effective treatments in control assessments but still achieved 90% effectiveness at 35 DAA. Differences in control were observed between nozzles with and without air induction. Other herbicide treatments showed no differences at 35 DAA, with control ranging from 91.3% to 100% like it is above, in the Figure 2. Shoot dry matter did not differ between herbicide treatments, resulting in a reduction compared to the untreated control (data not shown).

For the control of *C. sumatrensis* at both heights, it was not possible to determine the most effective herbicide, volume, or nozzle. All treatments were effective at the end of assessments at 35 DAA (Figures 1 and 2). Dicamba and 2,4-D were equally effective in controlling *C. sumatrensis*. It can be suggested that differences in the effectiveness of these herbicides can generally be observed due to suspected cases of resistance.

It is likely that the plants in this study do not show resistance to 2,4-D due to the efficacy observed and the lack of the typical symptom of rapid necrosis in resistant plants. Other studies indicate the superiority of dicamba over 2,4-D in controlling this weed (Osipe et al., 2017; Albrecht et al., 2022), which can be explained by the resistance to 2,4-D in *C. sumatrensis* biotypes in Brazil (Pinho et al., 2019; Queiroz et al., 2020).

Importantly, Queiroz et al. (2020) observed no cross-resistance to dicamba in the biotype of *C. sumatrensis* resistant to 2,4-D. In combining 2,4-D and dicamba in weed control, differences in efficacy are observed. As already noted, there is a case of *C. sumatrensis* with resistance to 2,4-D (Queiroz et al., 2020). In this context, Osipe et al. (2017), in compiling dicamba and 2,4-D, observed greater effectiveness of the former in controlling *Conyza bonariensis* and greater effectiveness of 2,4-D in controlling *C. benghalensis*.

Other studies have also found equivalent efficacy of these two herbicides in controlling *Conyza* spp. (Flessner and Pittman, 2019; Sherman et al., 2020; Cantu et al., 2021). The differences may be due to plant height. Crose et al. (2020) observed the equivalent efficacy of dicamba and 2,4-D in controlling *Conyza canadensis* in plants with 10 or 15–20 cm, and superiority of dicamba in plants with 5 cm. McCauley and Young (2019) observed greater dicamba efficacy, compared to 2,4-D, in *C. canadensis* plants up to 20 cm.

The statistical analysis for *C. benghalensis* with <20 cm indicated a significant effect ($p \leq 0.05$) for all variables in experiment 3. At 7 and 21 DAA, some differences were found in the control of *C. benghalensis* plants, however, with scores of at most 30%. At 35 DAA, there was a clear superiority of 2,4-D in control (up to 92.5%). The application of dicamba provided less control, at most 26.3% (Figure 3). The shoot dry mass results follow those observed for control (Figure 4).

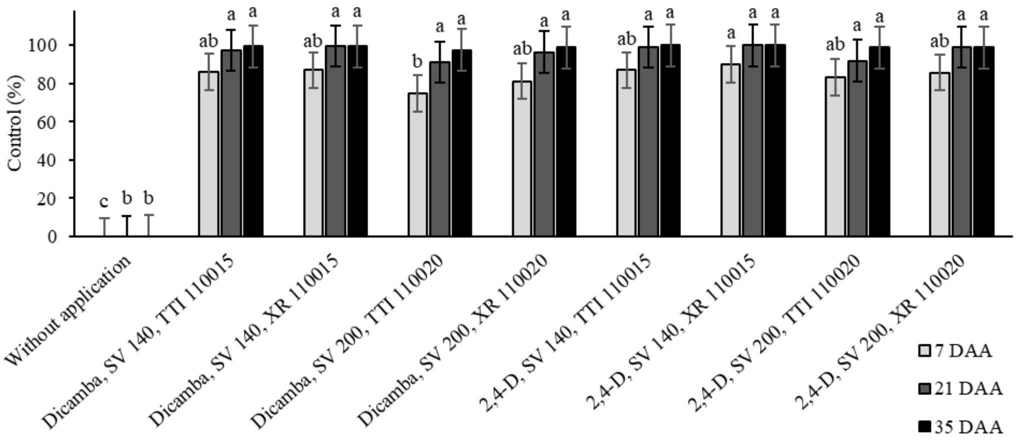

Figure 1. Visual control (%) of *Conyza sumatrensis* plants (<10 cm) at 7, 21, and 35 days after the application (DAA) of herbicides (experiment one). Means with the same letter, when comparing treatments on each evaluation date, do not differ according to Tukey's test ($p \leq 0.05$). Vertical bars, at means (n = 4), correspond to the standard error. TTI, Turbo TeeJet® Induction; XR, extended range; dicamba at 560 g acid equivalent (ae) ha^{-1}, 2,4-D at 1,005 g ae ha^{-1}; SV 140, spray volume of 140 L ha^{-1}; SV 200,spray volume of 200 L ha^{-1}.

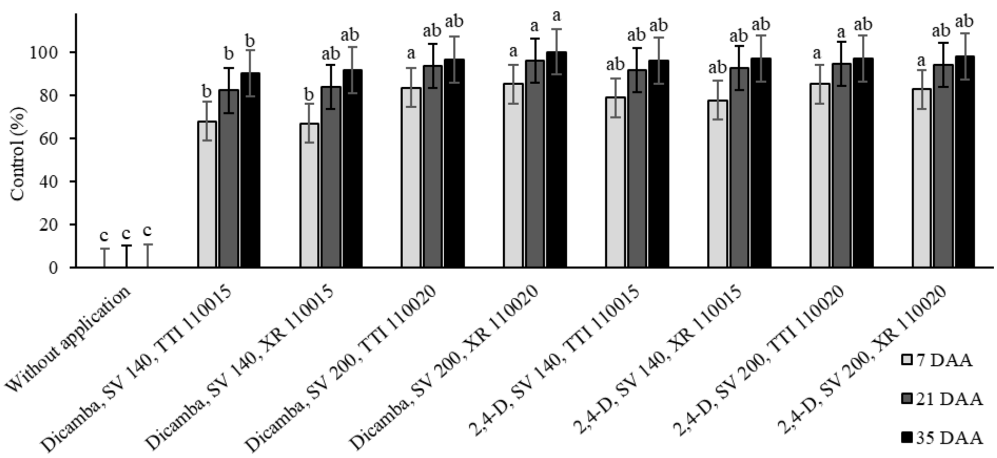

Figure 2. Visual control (%) of *Conyza sumatrensis* plants (>10 cm) at 7, 21, and 35 DAA of the herbicides (experiment two). Means with the same letter, when comparing treatments on each evaluation date, do not differ according to Tukey's test ($p \leq 0.05$). Vertical bars, at means (n = 4), correspond to the standard error. TTI, Turbo TeeJet® Induction; XR, extended range; dicamba at 560 g acid equivalent (ae) ha^{-1}, 2,4-D at 1,005 g ae ha^{-1}; SV 140, spray volume of 140 L ha^{-1}; SV 200, spray volume of 200 L ha^{-1}.

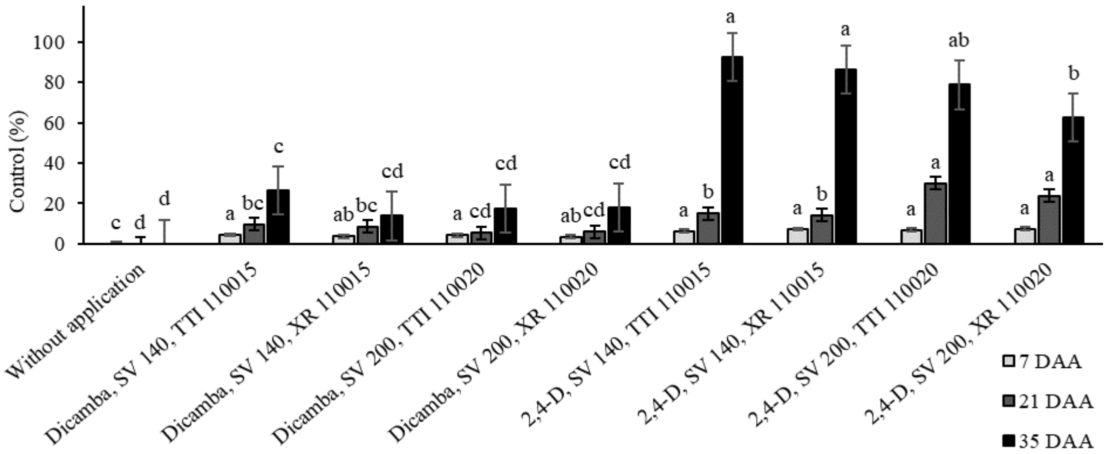

Figure 3. Visual control (%) of *Commelina benghalensis* plants (<20 cm) at 7, 21, and 35 DAA of the herbicides (experiment 3). Means with the same letter, when comparing treatments on each evaluation date, do not differ according to Tukey's test ($p \leq 0.05$). Vertical bars, at means (n = 4), correspond to the standard error. TTI, Turbo TeeJet® Induction; XR, extended range; dicamba at 560 g acid equivalent (ae) ha^{-1}, 2,4-D at 1,005 g ae ha^{-1}; SV 140, spray volume of 140 L ha^{-1}; SV 200, spray volume of 200 L ha^{-1}.

The statistical analysis for *C. benghalensis* with heights >20 cm revealed a significant effect ($p \leq 0.05$) for all variables in experiment 4. In all control evaluations, 2,4-D emerged as one of the most effective treatments. At 35 DAA, treatments could be categorized into three groups based on effectiveness: those achieving ≥90% control included 2,4-D applied at 140 L ha^{-1} (with both nozzles) and 2,4-D applied at 200 L ha^{-1} (TTI 110020), surpassing all other treatments; those achieving 77.5% control comprised 2,4-D applied at 200 L ha^{-1} (XR 110020); finally, all dicamba treatments and the untreated control showed no significant differences among them, with maximum control reaching only 6.8% (Figure 5).

Regarding shoot dry mass, all 2,4-D treatments resulted in similar reductions, outperforming all other treatments. Dicamba treatments followed a similar pattern, with no significant differences observed among different spray volumes or nozzles used, except for higher dry mass values compared to the untreated control (Figure 6). For controlling *C. benghalensis*, greater efficacy of 2,4-D compared to dicamba was observed in both experiments with this weed. Osipe et al. (2017) also noted the higher efficacy of 2,4-D in controlling *C. benghalensis*.

Other studies have highlighted the effectiveness of 2,4-D, either alone or in mixtures with other herbicides, in controlling *Commelina* spp. (Campos et al., 2013; Freitas et al., 2018). Despite dicamba's satisfactory control level, reaching 84% efficacy in controlling *C. benghalensis* (560 g acid equivalent [ae] ha^{-1}), the superiority of 2,4-D was evident with 99% efficacy at the same application rate (Merchant et al., 2013).

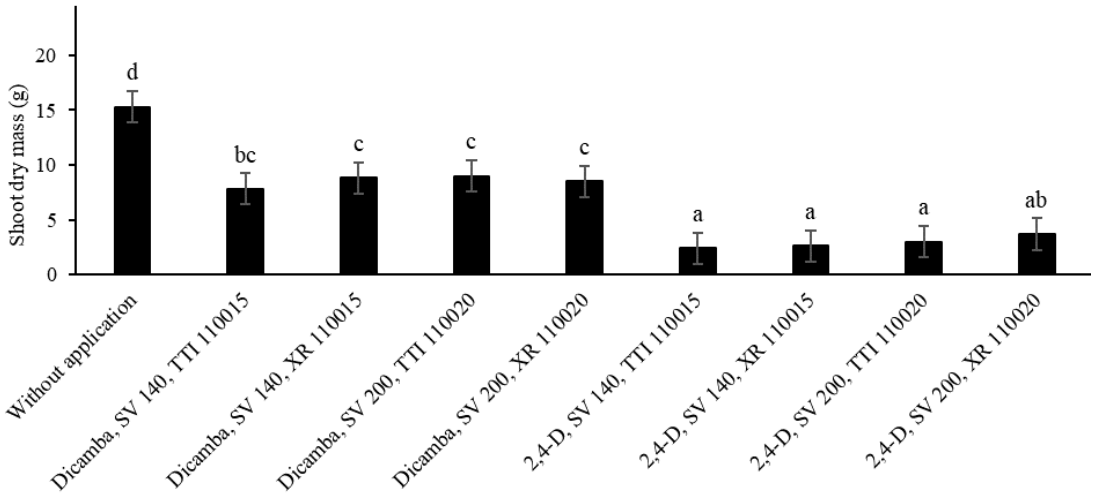

Figure 4. Shoot dry mass (g) of *Commelina benghalensis* plants (<20 cm) 35 DAA of the herbicides (experiment 3). Means with the same letter do not differ according to the Tukey test ($p \leq 0.05$). Vertical bars, at means (n = 4), correspond to the standard error. TTI, Turbo TeeJet® Induction; XR, extended range; dicamba at 560 g acid equivalent (ae) ha^{-1}, 2,4-D at 1,005 g ae ha^{-1}; SV 140, spray volume of 140 L ha^{-1}; SV 200, spray volume of 200 L ha^{-1}.

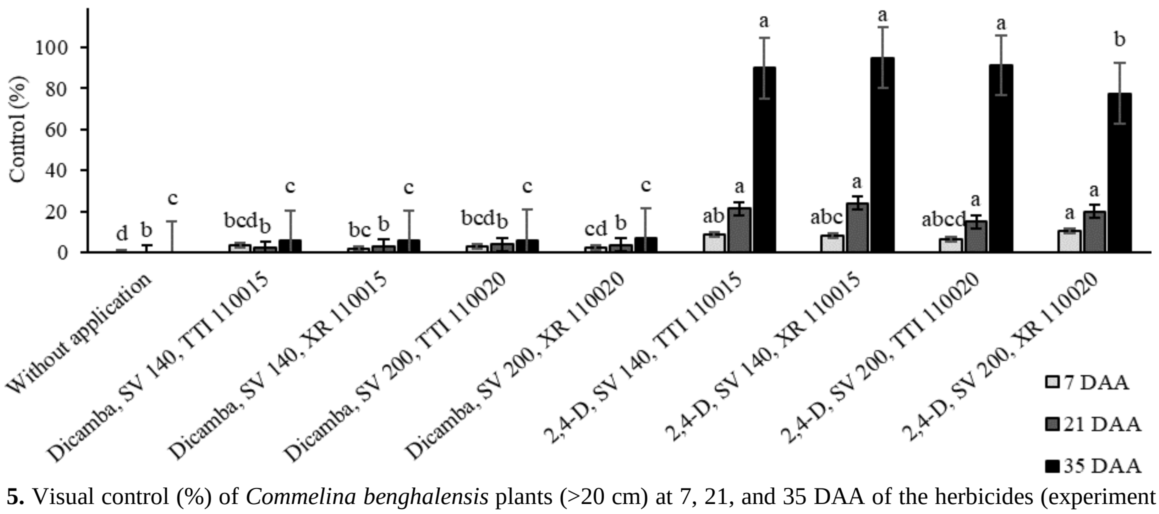

Figure 5. Visual control (%) of *Commelina benghalensis* plants (>20 cm) at 7, 21, and 35 DAA of the herbicides (experiment four). Means with the same letter, when comparing treatments on each evaluation date, do not differ according to Tukey's test ($p \leq 0.05$). Vertical bars, at means (n = 4), correspond to the standard error. TTI, Turbo TeeJet® Induction; XR, extended range; dicamba at 560 g acid equivalent (ae) ha^{-1}, 2,4-D at 1,005 g ae ha^{-1}; SV 140, spray volume of 140 L ha^{-1}; SV 200, spray volume of 200 L ha^{-1}.

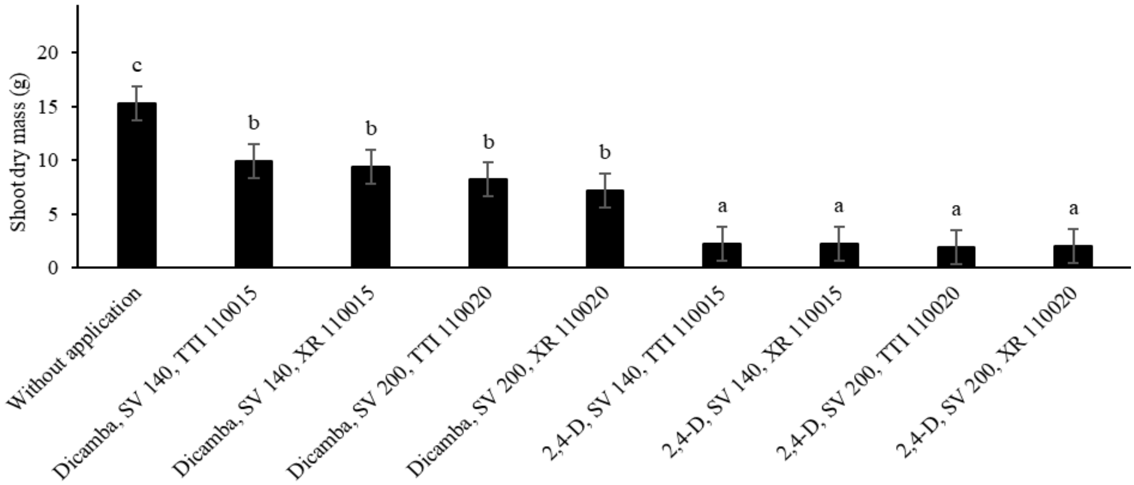

Figure 6. Shoot dry mass (g) of *Commelina benghalensis* plants (>20 cm) 35 DAA of the herbicides (experiment four). Means with the same letter do not differ according to the Tukey's test ($p \leq 0.05$). Vertical bars, at means ($n = 4$), correspond to the standard error. TTI, Turbo TeeJet® Induction; XR, extended range; dicamba at 560 g acid equivalent (ae) ha^{-1}, 2,4-D at 1,005 g ae ha^{-1}; SV 140, spray volume of 140 L ha^{-1}; SV 200, spray volume of 200 L ha^{-1}.

When combined with glufosinate, dicamba's control efficacy was complemented, reaching 94%. However, the results of this study and many others indicate the superiority of 2,4-D over dicamba in controlling *C. benghalensis* and other species of the family Commelinaceae. Regarding the injury scale for *C. sumatrensis* (<10 cm), wrinkled leaves (Figure 7A), and symptoms of chlorosis and necrosis (Figure 7C), no differences were observed between herbicide treatments on the three evaluation dates, consistently higher than the treatment without application.

In the analysis of epinasty and stem shriveling, at 7 DAA for 2,4-D applied at a volume of 140 L ha^{-1} with nozzle TTI 110015, a score of five was assigned, surpassing dicamba applied at the same volume and nozzle or at a volume of 140 L ha^{-1} with both nozzles. In subsequent evaluations, no differences were observed for epinasty between herbicides, spray volumes, or nozzles (Figure 7B). For epinasty and stem shriveling, dicamba applied at a volume of 140 L ha^{-1} with nozzle TTI 110015 caused more injury than the untreated control at 7 DAA. In subsequent evaluations, no differences were observed between herbicides, volumes, or application nozzles for epinasty and stem shriveling (Figure 8A).

For wrinkled leaves, no differences were found between herbicide treatments for *C. sumatrensis* (>10 cm) at 7 and 35 DAA. However, at 21 DAA, dicamba applied at a volume of 200 L ha^{-1} with nozzle XR 110020 resulted in more injuries (score 5) compared to dicamba applied at 140 L ha^{-1} with both nozzles (Figure 8B). Furthermore, dicamba applied at a volume of 140 L ha^{-1} with nozzle TTI 110015 caused more injury than the untreated control for chlorosis and necrosis at 21 and 35 DAA. On these dates, scores for other herbicide treatments were 4.5–5, with no differences between them (Figure 8C).

For *C. benghalensis* plants < 20 cm in height, injury assessments showed higher scores for the application of 2,4-D. At 35 DAA, 2,4-D demonstrated greater injury potential for application with a volume of 140 L ha^{-1} when assessing wrinkled leaves (Figure 9B). In other injury assessments, it was not possible to identify a superior volume or nozzle. However, it should be noted that in all these assessments, more significant injuries were observed for 2,4-D compared to dicamba (Figures 9A, 9C, and 9D).

For *C. benghalensis* plants taller than 20 cm, the symptoms generally followed the percentage control assessments. Greater injuries were observed for 2,4-D applications, but it was not possible to indicate a higher volume or nozzle (Figure 10A, 10B, 10C, and 10D). In relation to injury assessments for both species, the scores corresponded with the percentage control values and the final dry mass. Generally, for *C. sumatrensis*, the most pronounced symptom was epinasty and stem shriveling.

For *C. benghalensis*, the symptoms included wrinkled leaves (curled up or down) and leaves with altered margins, resulting in a narrowing of the limbus. It was not possible to observe a distinct pattern of symptoms for each herbicide, with the level of each symptom related to percentage control. Epinasty of the stem and changes in the leaves are common symptoms in plants susceptible to synthetic auxins (Al-Khatib and Peterson, 1999; Nunes et al., 2023).

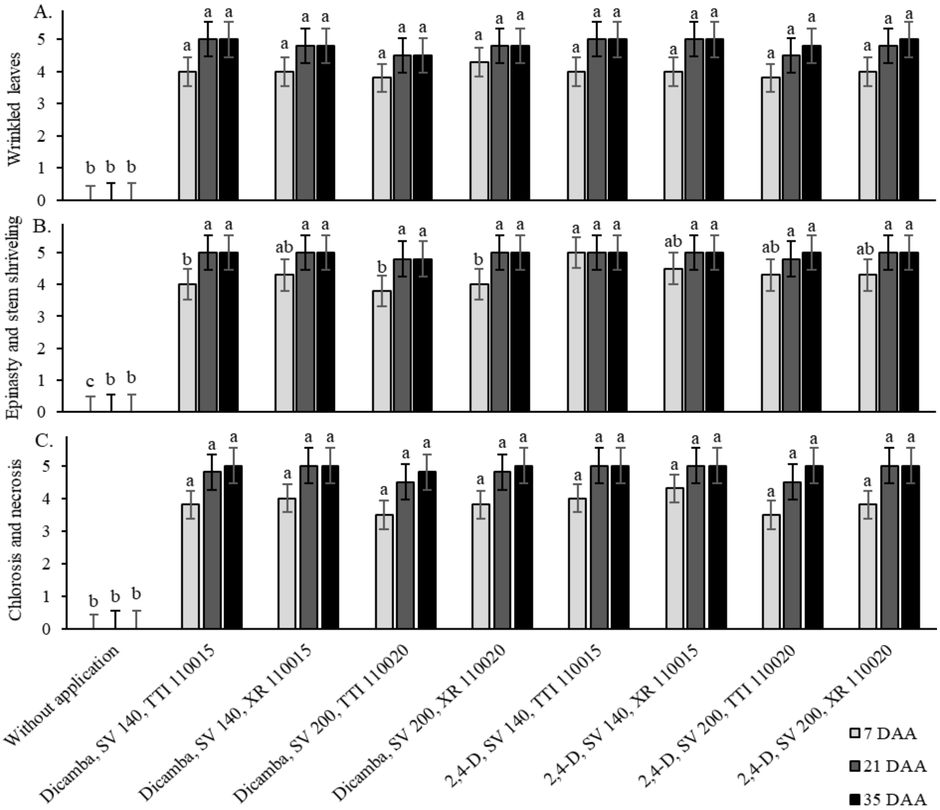

Figure 7. Symptoms of wrinkled leaves (A), epinasty and stem shriveling (B), and chlorosis and necrosis (C) in *Conyza sumatrensis* plants (<10 cm) at 7, 21, and 35 DAA of the herbicides (experiment 1). Means with the same letter, when comparing treatments on each evaluation date, do not differ according to Tukey's test ($p \leq 0.05$). Vertical bars, at means (n = 4), correspond to the standard error. TTI, Turbo TeeJet® Induction; XR, extended range; dicamba at 560 g acid equivalent (ae) ha^{-1}, 2,4-D at 1,005 g ae ha^{-1}; SV 140, spray volume of 140 L ha^{-1}; SV 200, spray volume of 200 L ha^{-1}.

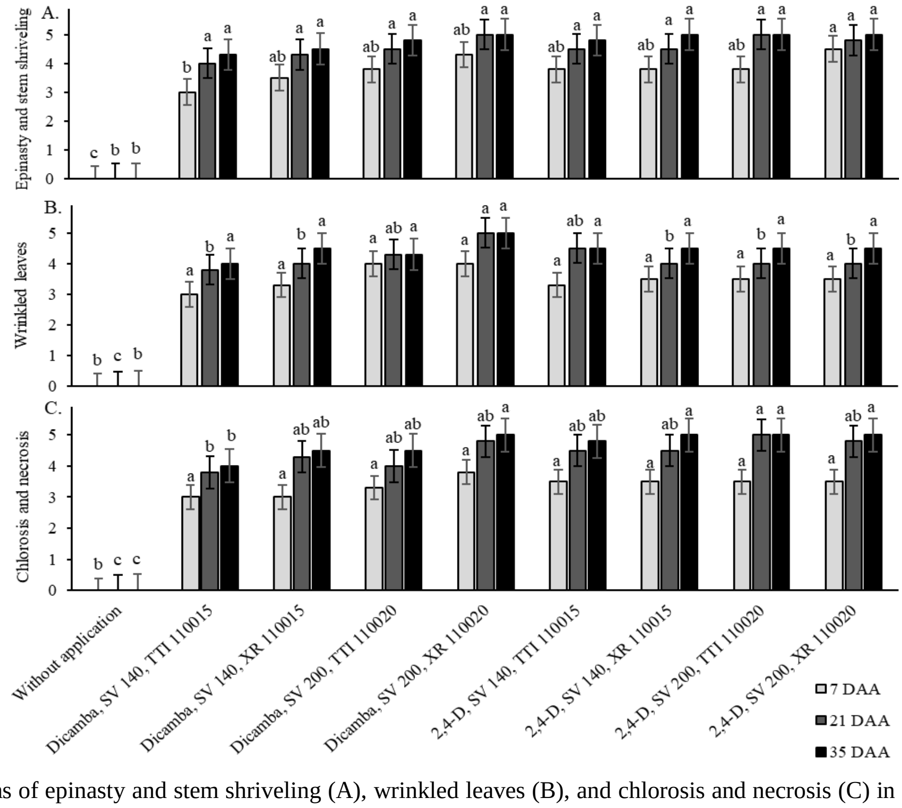

Figure 8. Symptoms of epinasty and stem shriveling (A), wrinkled leaves (B), and chlorosis and necrosis (C) in *Conyza sumatrensis* plants (>10 cm) at 7, 21, and 35 DAA of the herbicides (experiment two). Means with the same letter, when comparing treatments on each evaluation date, do not differ according to Tukey's test ($p \leq 0.05$). Vertical bars, at means (n = 4), correspond to the standard error. TTI, Turbo TeeJet® Induction; XR, extended range; dicamba at 560 g acid equivalent (ae) ha^{-1}, 2,4-D at 1,005 g ae ha^{-1}; SV 140, spray volume of 140 L ha^{-1}; SV 200, spray volume of 200 L ha^{-1}.

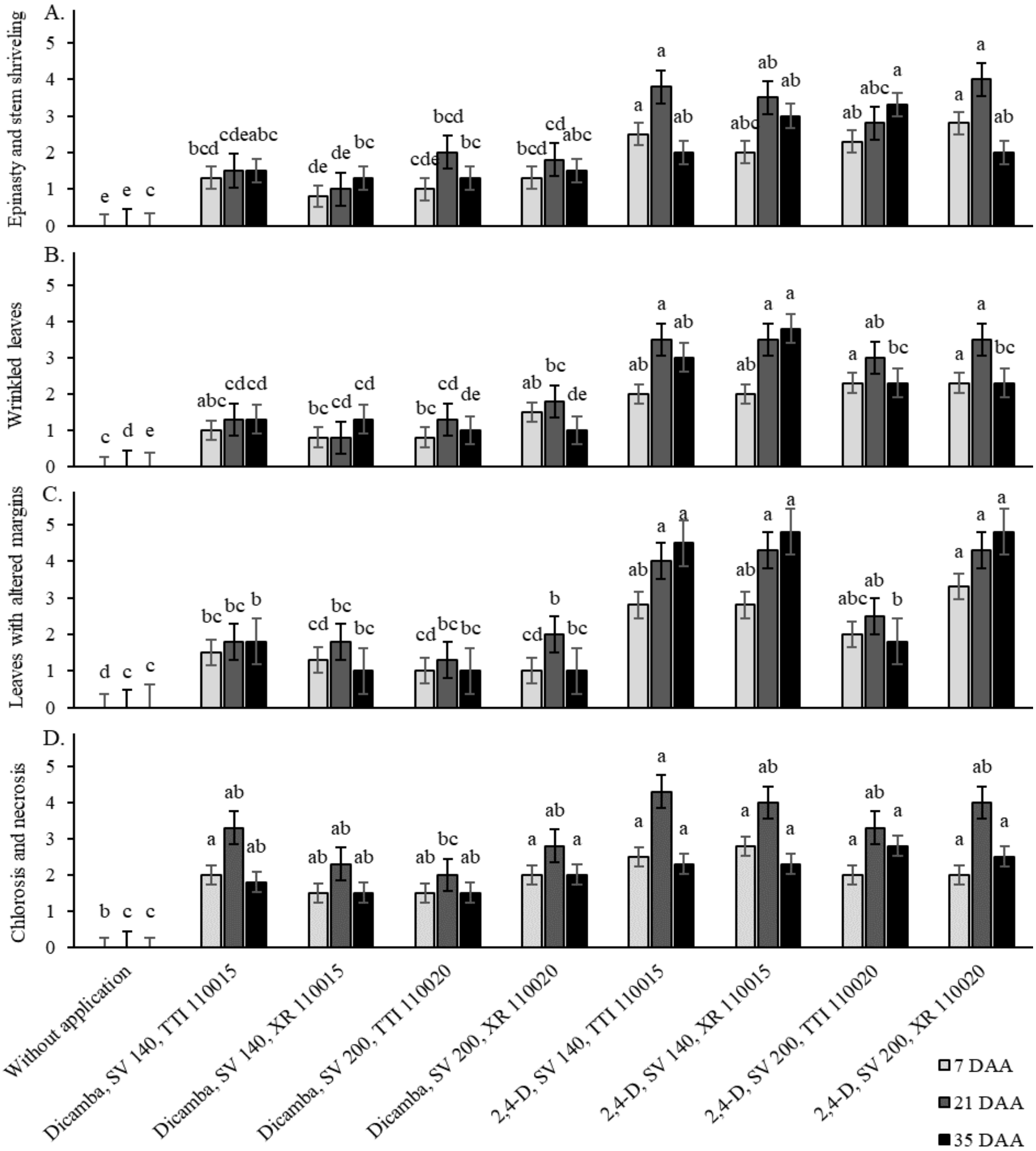

Figure 9. Symptoms of epinasty and stem shriveling (A), wrinkled leaves (B), leaves with altered margins (C), and chlorosis and necrosis (D) in *Commelina benghalensis* plants (<20 cm) at 7, 21, and 35 DAA of the herbicides (experiment three). Means with the same letter, when comparing treatments on each evaluation date, do not differ according to Tukey's test ($p \leq 0.05$). Vertical bars, at means ($n = 4$), correspond to the standard error. TTI, Turbo TeeJet® Induction; XR, extended range; dicamba at 560 g acid equivalent (ae) ha^{-1}, 2,4-D at 1,005 g ae ha^{-1}; SV 140, spray volume of 140 L ha^{-1}; SV 200, spray volume of 200 L ha^{-1}.

Subsequently, as other metabolic functions are affected, general metabolism and normal cellular functions are disrupted, causing other symptoms to appear, such as deformations in the veins and leaf blade (Griffin et al., 2013), growth arrest, and thickening of roots, which may lead to the appearance of adventitious roots. Tumors along the plant stem, linked to obstruction of phloem flow, may also appear (Grossmann, 2010; Peterson et al., 2016). The death of susceptible plants occurs slowly, generally between 3 and 5 weeks after application (Oliveira Junior et al., 2021).

No influence of volume or application nozzle was observed on the effectiveness of herbicides in controlling *C. sumatrensis*. For *C. benghalensis* plants less than 20 cm high, better performance was observed for the volume of 140 L ha^{-1} in the application of 2,4-D, with no differences between nozzles. For *C. benghalensis* plants taller than 20 cm, some differences between nozzles and volumes were observed, but no pattern was discernible. For *C. benghalensis*, the herbicide was the most important factor for effectiveness, with 2,4-D showing superiority.

Contiero et al. (2016) observed greater deposition of 2,4-D on the leaves of *C. benghalensis* when applied with nozzles with larger spray volumes, but the authors did not evaluate weed control. Even so, this study, for both species, and Souza et al. (2011), for C. benghalensis, did not observe the effect of the spray volume on control effectiveness.

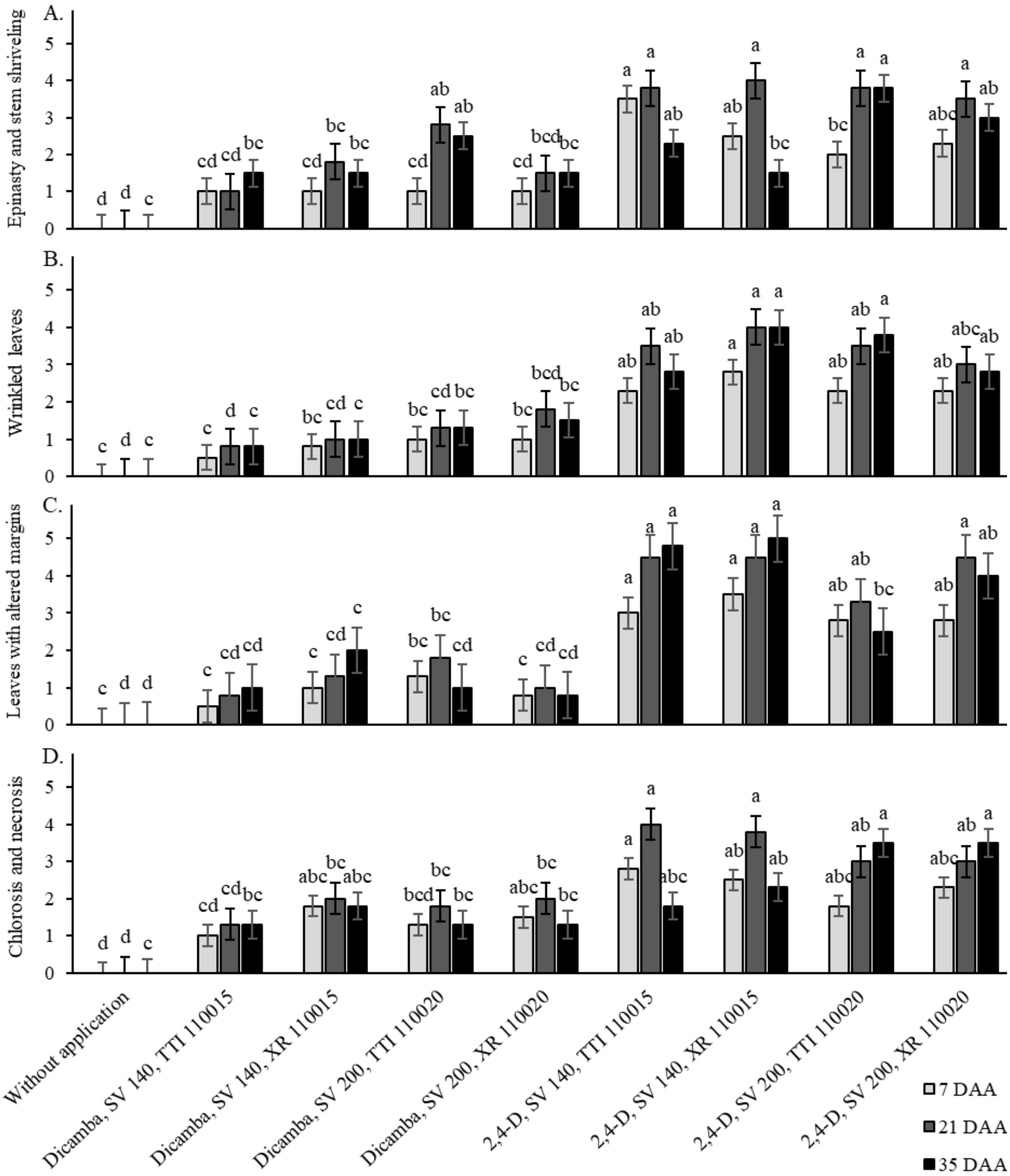

Figure 10. Symptoms of epinasty and stem shriveling (A), wrinkled leaves (B), leaves with altered margins (C), and chlorosis and necrosis (D) in *Commelina benghalensis* plants (>20 cm) at 7, 21, and 35 DAA of the herbicides (experiment four). Means with the same letter, when comparing treatments on each evaluation date, do not differ according to Tukey's test ($p \leq 0.05$). Vertical bars, at means ($n = 4$), correspond to the standard error. TTI, Turbo TeeJet® Induction; XR, extended range; dicamba at 560 g acid equivalent (ae) ha^{-1}, 2,4-D at 1,005 g ae ha^{-1}; SV 140, spray volume of 140 L ha^{-1}; SV 200, spray volume of 200 L ha^{-1}.

Studies comparing the effectiveness of dicamba and 2,4-D are gaining importance in the current Brazilian context. In addition to off-season use, the advent of transgenic soybeans tolerant to dicamba or 2,4-D should intensify the use of these herbicides. With the possibility of using them on the same day as soybean sowing or even in the postemergence of the crop, it is important to characterize the performance of these herbicides on significant weeds in soybean.

4. Conclusions

The application of either dicamba or 2,4-D effectively controls *C. sumatrensis*, irrespective of the spray volume, the spray nozzle, or the plant's stage of development. The application of 2,4-D is effective and superior to dicamba in controlling *C. benghalensis*. For 2,4-D, using a lower spray volume or an air induction nozzle did not affect weed control. Despite the observed difference in control, the control of *C. benghalensis* using auxin herbicides was inferior to that observed for *C. sumatrensis.*

Authors' Contribution

Alexandre Filus contributed to the conceptualization of the study, execution of the experiment, data collection, and writing of the manuscript. Arthur Arrobas Martins Barroso contributed to the conceptualization of the study, supervision, execution of the experiment, and final correction of the manuscript. Alfredo Junior Paiola Albrecht contributed to the conceptualization of the study, supervision, execution of the experiment, and final correction of the manuscript.

André Felipe Moreira Silva contributed to the analysis and interpretation of results, writing of the manuscript and final correction of the manuscript. Leandro Paiola Albrecht contributed to the conceptualization of the study and final correction of the manuscript. Eduardo Roncatto contributed to the execution of the experiment, data collection, and final correction of the manuscript.

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