Chilean J. Agric. Anim. Sci., ex Agro-Ciencia (2025) 41(1): 120-127.
https://doi.org/10.29393/CHJAAS41-11PMWR30011

ISSN 0719-3890 online

POST-MOWING AND SEQUENTIAL HERBICIDE APPLICATION IN THE MANAGEMENT OF SOURGRASS (Digitaria *insularis*)

Walison Gasparelo da Silva[1], Lia Mara Moterle[2*], and Renato Frederico dos Santos[3]

[1] Centro Universitário Ingá, Rod. PR 317, 6114| CEP 87035-510, Maringá, Paraná, Brazil
https://orcid.org/0009-0006-8588-2648
[2] Universidade Estadual de Maringá, Av. Colombo, 5790 - Jd. Universitário CEP 87020-900, Maringá, Paraná, Brazil
https://orcid.org/0000-0003-3425-7018
[3] Unicesumar, Avenida Guedner, 1610, Jardim Aclimação CEP 87050-390, Maringá, Paraná, Brazil
https://orcid.org/0000-0002-7188-2691
[*] Corresponding author: lmmsantos2@uem.br

ABSTRACT

The excessive use of glyphosate in crop production has led to the emergence of sourgrass (*Digitaria insularis*) populations resistant to this herbicide. The species has a high capacity for emergence and development throughout the year, making it difficult to control during the off-season. The objective of the this study was to evaluate the effectiveness of glyphosate application, alone or in mixture, integrated with post-mowing management or sequential herbicide application for the control of sourgrass in fallow areas in Paraná State, Brazil. The experiment was carried out in a 2 × 5 factorial scheme (with or without mowing × herbicides), under a complete block experimental design with randomized treatments, with four replications. Herbicide applications were made on the reshoots of the mowing management treatment when plants reached a height between 10 and 20 cm. In the unmowed plants, after the initial herbicide application (glyphosate + graminicides), a sequential application of paraquat was performed. Sourgrass control was determined at 7, 14, 21, 28 and 35 days after application, DAA). The results revealed that mowing *D. insularis* followed by the combined application of glyphosate and other herbicides is a good strategy for the management of this weed. The combined application of glyphosate + clethodim (1480 + 248 g a.i. ha^{-1}), followed by a sequential application of paraquat, was effective in controlling sourgrass and produced results comparable to mechanical management.

Keywords: weed, herbicides, control, clethodim.

INTRODUCTION

Glyphosate is one of the most important herbicides worldwide, being the most used active ingredient in the control of annual and perennial weeds in various production systems, with a broad spectrum of control (Diesel et al., 2018). Its site of action is the enzyme EPSP synthase, which is inhibited through competitive binding with the substrate phosphoenolpyruvate (PEP), thereby preventing the conversion of shikimate to corismate. Upon application, a significant reduction in the levels of aromatic amino acids (phenylalanine, tyrosine, and tryptophan) is observed, leading to growth cessation in treated plants (Heap, 2023).

The use of glyphosate has increased significantly due to technological innovations in

Recieved : October 23, 2024 Accepted : April 17, 2025

agriculture, such as the emergence of no-till and glyphosate-resistant genetically modified crops (Melo et al., 2012; Diesel et al., 2018). This fact, alongside its indiscriminate use, has contributed to the selection of weed biotypes resistant to this herbicide in Brazil (Silva et al., 2023).

Sourgrass (*D. insularis*) stands out among the weed species that exhibit resistance and greater control complexity (López-Ovejero et al., 2017). In recent decades, due to its aggressive characteristics, it has become the target species of studies. Among its characteristics are the ability to form rhizomes that, although short, are prominent and result in dense clump formation (Ferreira et al., 2018), as well as its capacity to spread and produce propagules (seeds) continuously throughout the summer (Lorenzi, 2014; Gomes et al., 2017). Once the perennial process occurs, this plant can flower and disseminate seeds with low dormancy levels over extended periods (Gemelli et al., 2013a).

The mechanisms that confer resistance of this species are related to the lower speed of absorption of glyphosate by resistant biotypes and the faster enhanced metabolism of glyphosate to AMPA, glyoxylate, and sarcosine (Gemelli et al., 2013b). Therefore, it is evident that once resistance becomes established in an area or region (López-Ovejero et al., 2017; Silva et al., 2023), the study of control alternatives becomes vital to ensure effective weed management. As herbicide alternatives for the control of sourgrass, photosystem I inhibitors and ACCase inhibitors are prominent (Adegas et al., 2017; Gomes et al., 2017; Gomes et al., 2020; Takano et al., 2020). Among the latter, clethodim is notable; its active ingredient acts by producing the characteristic symptom of necrosis in the growth zones by inhibiting lipid synthesis. Post-emergence application or use during the off-season has proven to be an effective alternative for managing glyphosate resistant plants (Barroso et al., 2014). However, in advanced development stages, such as pre-flowering, it is necessary to use sequential applications and product combinations and/or mowing as alternative strategies to control resistant plants (Gaspar et al., 2019).

It is noteworthy that, due to the challenges associated with the control of sourgrass, there is a clear need for integrated strategies aimed at the diversification of active ingredients and potential use of herbicide combinations (Gaspar et al 2019; Silva et al 2023), alongside cultural management practices (Krenchinski et al., 2019). In this context, mowing plants at an advanced development stages deserves special attention. For this approach to be effective, the plants must be fully perennial so that the aerial part of the plants can be removed, allowing herbicide application to target the regrowth of the clumps (Dantas et al., 2015).

We hypothesize that *D. insularis* plants exhibit differential response to glyphosate depending on the management approach, mechanical or sequential; and that, for effective control of adult plants, mowing should be performed followed by the application of glyphosate in combination with graminicides during regrowth. This study aimed to evaluate the effectiveness of glyphosate application, alone or in mixture, integrated with post-mowing management or sequential herbicide applications for the control of sourgrass in Paraná State, Brazil.

MATERIALS AND METHODS

The experiment was carried out between March and June 2016 in the municipality of Itambé, Paraná State (Brazil).

The experimental area is located at the geographic coordinates of 23º28′48.92′′S latitude and 51º 59′ 40.63′′W longitude, at an elevation of 403 meters above sea level. The soil had a water pH of 6.20; 4.28 $cmol_c$ of $H^{++}Al^{+3}$ dm^{-3} of soil; 8.19 $cmol_c$ dm^{-3} of Ca^{+2}; 4.13 cmolc dm^{-3} Mg^{+2}; 0.55 $cmol_c$ dm^{-3} K^{+}; 14.28 mg dm^{-3} of P; 18.8 g dm^{-3} of C; 31.17 g dm^{-3} of organic matter (OM); 18.0 % of fine sand; 14.0 % of silt and 68.0 % of clay.

The area was fallow, with plants in full bloom, indicating the presence of well-established perennial plants. This site has a documented history of difficulties in the control of *D. insularis*, resulting from repeated glyphosate applications, even at high doses. This suggests the probable resistance of the biotypes present. At the time of the experiment, the area was fully infested with weeds covering nearly the entire soil surface.

The work was conducted in a 2 × 5 factorial scheme (with or without mowing × herbicides) under a complete block experimental design with randomized treatments, with four replications, totaling ten different strategies for *D. insularis* management, in addition to the untreated control (without weeding). The plots measured 4.0 m in width and 4.0 m in length, totaling 16.0 m^2. The usable plot area was considered to be the central 4.0 m^2 (2.0 × 2.0 m).

The following herbicides were applied to mowed and whole (unmoved) plant: (1) glyphosate (1480 g a.i. ha^{-1}); (2) glyphosate (1480 g a.i. ha^{-1}) + clethodim (248 g a.i. ha^{-1}); (3) glyphosate (1480 g a.i. ha^{-1}) + haloxyfop-P-methyl (124 g a.i. ha^{-1}); (4) glyphosate (1480 g a.i. ha^{-1}) + fluazifop-P-butyl (375 g a.i. ha^{-1}, and (5) glyphosate (1480 g a.i. ha^{-1}) + quizalafop-P-methyl (103 g a.i. ha^{-1}). Mineral oil Assist® EC was added to all herbicide treatments at a concentration of 0.5 % v/v and the polyfunctional adjuvant U10® was included at 0.15 % v/v to improve the quality of the spray droplets.

Plants subjected to mechanical management were mowed on March 27, at an approximate height of 10 cm, using a manual Sthil model brush cutter with gasoline combustion operation and equipped with a nylon wire cutting mechanism. In this treatment, once plant regrowth reached a height of 10 to 20 cm, 14 days after mowing, an initial herbicide application (hereafter referred to as Application A) was carried out.

In the unmoved treatment, and after Application A, a sequential application of paraquat (hereafter referred to Application B) was carried out at a dose of 413 g a.i. ha^{-1}, except in the untreated control. Application A was applied on April 9 to both whole plants and mowed plants. Application B, conducted only in unmoved treatments, was performed on April 23.

All treatments were evaluated at seven-day intervals after Application A (DAA). For mowing treatments, the evaluations were conducted at 7, 14, 21, 28 and 35 DAA, while for the unmoved treatments, the evaluations were at 7 DAA, 14 DAA, 21 DAA (or 7 days after Application B; DAB), 28 DAA (or 14 DAB) and 35 DAA (or 21 DAB). All herbicide treatments were applied using a constant pressure knapsack sprayer (maintained by compressed CO_2) of 40 psi was used, equipped with a bar with 4 empty cone jet tips, Magnumjet brand, model (M054-MAG 02 black color) spaced at 0.50 m with an application volume equivalent to 120 L ha^{-1}. For all applications, the operator wore the appropriate personal protective equipment recommended for the conditions and types of products applied.

The climatic conditions at the time of Application A were: 27 ºC of air temperature; 60% of relative humidity; 5.5 km h^{-1} of wind speed. For Application B, the climatic conditions were: 28 ºC of air temperature; 58% relative humidity; 8.0 km h^{-1}. A digital thermo-hygro-anemometer device was used to obtain the data.

For weed control evaluations, the infestation of the area was used as a reference based on the weed samples existing in the control without herbicide. The weed control evaluations followed the criteria of the visual scale, where 0% means no symptoms and 100% necrosis of all tissues of the aerial part. However, as it is a perennial plant, the scale used classified only the symptoms observed in the leaf area at the time of evaluation, since it was not possible to predict future regrowth. It is important to note, for example, that a control index of 50% indicated tissue necrosis in half of the leaf area (including stems), and not that 50% of the plants within the plot had died (Gemelli et al.,2013b).

Data collected from each evaluation period were submitted to analysis of variance (ANOVA) and interaction unfolding. For comparison of management strategies, the F-test was used. For comparing the means of the herbicide treatments, the Scott-Knott clustering test was applied at a 5% probability level.

RESULTS AND DISCUSSION

Table 1 presents the control of *D. insularis* at 7 and 14 DAA, with and without mechanical control. In the untreated control (no herbicide application or mowing), neither the control index nor the regrowth index was evaluated; this treatment served solely as a visual reference for comparison with the evaluated parameters.

Sourgrass plants exhibited resistance to glyphosate, as even when at a high dose of glyphosate (1480 g a.i. ha^{-1}), they showed a low control index at 7 DAA (Table 1). The control of sourgrass with glyphosate (1480 g a.i. ha^{-1}) at 7 days without mowing was only 31.25%, which was significantly lower than all the other treatments at a 0.05 significance level. During the same period, Treatment (2) consisting of glyphosate + clethodim (1480 + 248 g a.i. ha^{-1}), achieved the highest effectiveness, with a control rate of 53.75%.

Regarding mechanical management, the use of mowing prior to the application of all herbicide treatments was significantly more efficient when compared to treatments without mowing (Table 1). A similar study conducted by Dantas et al. (2015) revealed that the use of mowing is a highly interesting management tool for weed suppression as it increases control effectiveness. According to the authors, the use of graminicides at the doses used (glyfosate 4 l p.c. ha^{-1} +clethodim 0.8 l p.c. ha^{-1}, glyfosate 4 l p.c. ha^{-1} +haloxyfop 0,8 l p.c. ha^{-1} and glyphosate 4 l p.c. ha^{-1} + sethoxydim 0,8 l p.c. ha^{-1}), presents selectivity for soybeans and, when managed correctly, provides control of more than 90%.

When evaluated at 14 DAA, the control percentage resulting from the use of glyphosate + graminicides was higher, both in mowed and unmowed plants. Furthermore, the most effective control without mowing was observed in Treatment (2) glyphosate + clethodim, i.e., reaching a control of 70%. Additionally, the treatment resulting in the lowest performance when using combined herbicides in whole plants was observed in Treatment (5) glyphosate + quizalafop-P-methyl (1480 + 103 g a.i. ha^{-1}), which presented a control rate of 46.25% at 14

Table 1. Control percentage of *D. insularis* plants at 7 and 14 days after initial herbicide application (Application A; DAA), with and without mowing, including the untreated control. Itambé, Paraná State, Brazil (2016).

Herbicides	Control methods			
	7 DAA		14 DAA	
	Mowing	No mowing	Mowing	No mowing
(1)	94.75aA	31.25dB	87.25bA	25.25eB
(2)	97.75aA	53.75aB	98.75aA	70.00aB
(3)	97.00aA	46.25bB	98.00aA	61.75bB
(4)	96.25aA	45.00bB	95.50aA	54.50cB
(5)	96.50aA	40.00cB	96.50aA	46.25dB
Witness	0,00		0,00	
CV (%)	6.06		4.87	

(1) glyphosate (1480 g a.i. ha^{-1}); (2) glyphosate (1480 g a.i. ha^{-1}) + clethodim (248 g a.i. ha^{-1}); (3) glyphosate (1480 g a.i. ha^{-1}) + haloxyfop-P-methyl (124 g a.i. ha^{-1}); (4) glyphosate (1480 g a.i. ha^{-1}) + fluazifop-P-butyl (375 g a.i. ha^{-1} and (5) glyphosate (1480 g a.i. ha^{-1}) + quizalafop-P-methyl (103 g a.i. ha^{-1}).
Means followed by the same letter, uppercase in the row and lowercase in the column, do not differ from each other by the F-test and the Scott-Knott clustering test, respectively, at a 5% probability level.

DAAS. According to the Ministry of Agriculture, Livestock and Supply, an average control level of 80% is required for the registration of a viable herbicide (Mapa, 2023). Therefore, the evaluation conducted at 14 DAA serve as an initial control parameter; however, this period is insufficient for drawing definite conclusions regarding the control of *D. insularis*.

Table 2 shows the data on the control percentage of *D. insularis* plants at 21, 28 and 35 DAA of herbicides with and without mechanical control. It should be noted that in the treatments without mowing, a sequential application (second application) was carried out using the product paraquat.

At 21, 28 and 35 DAA (or 7, 14 and 21 DAB), whole-plant control increased significantly (Table 2), possibly due to Application B of paraquat at a dose of 413 g a.i. ha^{-1}, given its mode of action as a contact herbicide. Regarding sourgrass mowed at 7 DAA (Table 1), there was no significant difference in plant control among the herbicide treatments. However, in the other periods evaluated (Tables 1 and 2), the treatment with glyphosate alone (1480 g a.i. ha^{-1}) presented a lower control rate (ranging from 74.50 to 87.50%), compared to the other herbicide combinations. This indicates that, for mowed grass, all herbicide mixtures were more effective in controlling the weed than glyphosate applied alone. These results align to those of Vidal et al. (2010), Melo et al. (2012), Correia et al. (2015) and Scalcon (2020).

Vidal et al. (2010) observed that the application of glyphosate alone was inefficient for the control of adult plants of *D. insularis*, suggesting the need for mixtures, using herbicides such as haloxyfop-methyl and clethodim to increase efficacy. Correia et al. (2015) not only observed lower efficacy of glyphosate when applied alone for the control of sourgrass, but also reported that, even with sequential applications of glyphosate, satisfactory control of adult plants was not achieved in areas with a history of resistance. Scalcon (2020) reinforced confirmed these findings, pointing out that in more advanced stages of development (with tillered plants), glyphosate alone showed low efficiency, even when used in high doses. The author suggests that the combined use of glyphosate with other mechanisms of action, as well as early management of the infestation, are crucial for successful control of the species.

In the evaluations carried out at 28 DAA and 35 DAA, plots that received both mowing and combined herbicide applications showed absence of tissues in the clumps, resulting in a visual evaluation of 100% control for all such treatments. This demonstrates that mowing prior to herbicide application enhances the effectiveness of plant control. This improvement is likely due to the stress caused by mowing, which eliminates aerial tissues such as leaves and stems, forcing the plant to demand a greater consumption of its reserves, particularly in the rhizomes and stalks, to initiate regrowth. The excessive expenditure of reserve tissues weakens the plant, and when herbicides are subsequently applied, the plant does not have

Table 2. Control pertentage of *D. insularis* plants at 21, 28 and 35 days after application (DAA) of herbicides, with and without mowing, including the untreated control. Itambé, Paraná State, Brazil (2016).

	Control methods					
	21 DAA		28 DAA		35 DAA	
Herbicides	Mowing	Without Mowing	Mowing	Without Mowing	Mowing	Without Mowing
(1)	87.50bA	75.00cB	84.00 bB	94.75 bA	74.50 bA	70,00 bB
(2)	99.00aA	96.25aA	100.00 aA	98.50 aA	100.00 aA	98.25 aA
(3)	99.00aA	93.75aB	100.00 aA	98.25 aB	100.00 aA	97.50 aB
(4)	99.00aA	91.25aB	100.00 aA	98.25 aB	100.00 aA	98.25 aA
(5)	98.50aA	86.25bB	100.00 aA	96.75 aB	100.00 aA	96.25 aB
Witness	0.00		0.00		0.00	
CV (%)	2.85		1.09		2.09	

(1) glyphosate (1480 g a.i. ha^{-1}); (2) glyphosate (1480 g a.i. ha^{-1}) + clethodim (248 g a.i. ha^{-1}); (3) glyphosate (1480 g a.i. ha^{-1}) + haloxyfop-P-methyl (124 g a.i. ha^{-1}); (4) glyphosate (1480 g a.i. ha^{-1}) + fluazifop-P-butyl (375 g a.i. ha^{-1} and (5) glyphosate (1480 g a.i. ha^{-1}) + quizalafop-P-methyl (103 g a.i. ha^{-1}).
Means followed by the same letter, uppercase in the row and lowercase in the column, do not differ from each other by the F-test and the Scott-Knott clustering test, respectively, at a 5% probability level.

sufficient energy to produce new shoots, thereby resulting in a highly effective plant control. These results corroborate those found by Raimondi et al. (2019), who observed that mowing at heights of less than 20 cm associated with herbicides can be an important tool for the management of sourgrass. Similarly, Pavan (2018) demonstrated that mechanical mowing of adult plants, followed by the application of herbicides, was effective in controlling glyphosate-tolerant D. insularis. The author concluded that the practice facilitates the contact of the herbicide with younger and more active tissues of the plant, increasing the effectiveness of the control. Thus, in agreement with previous studies, the present study indicates that while mowing alone does not result in total control, it plays an important role in the management of adult *D. insularis* plants, particularly as a complementary strategy to the use of selective and systemic herbicides.

In the comparison of management methods at 21, 28 and 35 DAA (7, 14 and 21 DAB) (Table 2), a similar control percentage was observed for Treatment (2) consisting of glyphosate + clethodim (1480 + 248 g a.i. ha^{-1}) in both mowed or mowed plants

For the control of tree weeds in pastures, the application of systemic herbicide on the stem immediately after cutting the aerial part provides the translocation of herbicides by the phloem (Mendes et al., 2016). Similarly, probably with the mixture with clethodim, a systemic herbicide, there was an increase in absorption and translocation of herbicides by stalks and roots, which reflected in a higher control rate of sourgrass. Raimondi et al. (2019) reported similar results when applying mixtures of clethodim and glyphosate, demonstrating that the strategy is effective at 15 days after mowing and even in its absence. The same authors also found that sequential application with and without mowing was more efficient when compared to treatments with applications of clethodim or glyphosate alone. This indicates that the use of this mixture is an efficient practice for controlling both mowed and unmowed sourgrass.

The results obtained in the present study regarding the effectiveness of sequential control in whole plants agree with those of Melo et al. (2012), who found that the use of glyphosate 1,440 g ha^{-1} combined with clethodim at 108 g ha^{-1} is a viable alternative, with control percentages of 95.8, 95.0, 93.8 and 91.8% at 14, 21, 28 and 35 DAA, respectively. However, the same authors found that complementing this treatment with sequential application of paraquat + diuron at 400 + 200 g ha^{-1} represented a control percentage of 100% in the four periods evaluated. While control percentages of 96.3, 98.8, 100 and 100% at 14, 21, 28 and 35 DAA, respectively, were obtained by sequential application with glufosinate ammonium at 600 g ha^{-1} 7 days later. These results demonstrate the effectiveness of the mixtures in controlling sourgrass regardless of whether it is mowed or not. Additionally, Zobiole et al. (2016) found that the sequential application of glyphosate + clethodim at 14 DAA resulted in an increase in the control of perennial sourgrass plants compared to the sole application of glyphosate. The authors indicated that sequential herbicide application is an effective strategy for weed control, particularly in cases of increased herbicide resistance or advanced weed growth stage.

The other herbicide treatments of glyphosate at 1,480 g ha^{-1} in mixture with haloxyfop-p-methyl 124 g ha^{-1}, glyphosate at 1,480 g ha^{-1} in mixture with fluazifop-p-butyl at 375 g ha^{-1} and glyphosate at 1,480 g ha^{-1} in mixture with quizalafop-P-methyl (103 g a.i. ha^{-1}) resulted in control rates above 95 % at 28 and 35 DAA. These results agree with those observed by Melo et al. (2012), but using slightly lower doses.

The present study found that the use glyphosate combined with other herbicides demonstrated effective control of sourgrass under the two management strategies evaluated, representing a good alternative for the management of this difficult-to-control plant. ACCase - inhibiting herbicides, such as clethodim, haloxifop-p-methyl, and fluazifop-p-buthyl also exhibited good control rates under both management systems from the beginning of the evaluations. These results partially agree with those observed by Adegas et al. (2017), Raimondi et al. (2019), Dantas et al. (2015) and Takano et al. (2020), who noted that the herbicide clethodim, in mixture with glyphosate, stands out as an effective treatment for sourgrass management.

In general, when evaluating all treatments and control management strategies, mowing followed by the application of herbicides provided effective control of sourgrass clumps during the experimental period, except for Treatment (1) glyphosate (1480 g a.i. ha^{-1}), which was considered the least effective, and differed statistically from the other treatments.

An enhanced metabolism of 87.25% was observed at 14 DAA (Table 1), which later increased to 74.50% control at 35 DAA (Table 2). This lower control rate, compared to other treatments, can be explained by the fact that the plants are resistant to the herbicide, allowing them to resprout after a certain period of time following application. This situation was not observed in treatments that included mixtures of glyphosate + graminicides, which showed a high control index from the first evaluation, with increasing effectiveness over time. This is supported by the high level of control found at 28 DAA, where all treatments showed absence of living tissues and achieved a control level of 100%.

It is also noteworthy that, in the management without mowing, the most effective treatment at 7 and 14 DAA was Treatment (2) glyphosate (1480 g e.a ha^{-1}) and clethodim (248 g a.i. ha^{-1}), being the only combined treatment that, as early as 21 DAA (7 DAB), showed no statistical differences in effectiveness between the management strategies evaluated. In unmowed plants, the most ineffective treatment was the sole application of glyphosate (1480 g a.i. ha^{-1}), resulting in the lowest control index in all evaluations performed. Under the same condition (without mowing), the mixture (5) glyphosate (1480 g a.i. ha^{-1}) and quizalafop-P-methyl (103 g a.i. ha^{-1}) showed the lowest control index up to 21 DAA (7 DAB).

The main reasons why the herbicide quizalafop-P-methyl does not adequately control sourgrass include plant resistance, water stress, and antagonism with other herbicides. Its continuous use in previous seasons, both in mixtures or applied alone as an aryloxphenoxypropionates may contribute to the development of resistance. According to previous reports, herbicides from the aryloxphenoxypropionate (FOPs) group, whose site of action is the ACCase enzyme, have demonstrated resistance in *D. insularis* (Takano et al., 2020; Heap, 2022). Resistance may be caused by the lack of rotation of the mechanisms of action (Rosa et al., 2023). Gaines et al. (2020) indicated that the harmful dynamics of continuous herbicide use enhances three key mechanisms of weed resistance: i) reduced sensitivity to the target enzyme; ii) increased herbicide metabolism; and iii) herbicide accumulation at the site of action, long with altered absorption and translocation, which irreversibly contribute to resistance through mutation and gene amplification.

Chemical and physiological antagonism may have possibly been the cause of the poor performance of Treatment (5) consisting of glyphosate (1480 g a.i. ha^{-1}) + quizalafop-P-methyl (103 g a.i. ha^{-1}). They are inhibitors of different enzymes, but glyphosate is more saline and aggressive in the initial absorption, which may have interfered with the absorption and translocation of quizalafop in the plants. In addition, as both use similar foliar absorption pathways, their presence may have decreased the penetration of one or both. Correia and Gomes (2015) also observed a 30-40% reduction in the efficacy of quizalafop-P-teturyl when applied with glyphosate, in the control of sourgrass. Regarding the differences in severity observed between the herbicides Aryloxphenoxypropionates (FOPs) and Cyclohexanediones (DIMs), it is possible that, although both inhibit the same site of action (ACCase enzyme), their differing chemical structures result in variations in their affinity with the active site of the target enzyme (Liu et al., 2007). Thus, it is common to observe differences in the effectiveness of grass control between these chemical groups (Powles and Yu, 2010). This may explain the superior performance of clethodim and the comparatively lower performance of quizalafop-P-methyl.

CONCLUSION

Mowing *D. insularis* followed by application of mixtures is a viable alternative for controlling this weed. The mixture glyphosate + clethodim (1480 + 248 g a.i. ha^{-1}) with sequential application of paraquat was effective in controlling sourgrass and produced results comparable to mechanical management.

Author contributions

Active participation in the bibliographic review: Walison Gasparelo da Silva and Lia Mara Moterle

Active participation in the development of the methodology: Walison Gasparelo da Silva, Lia Mara Moterle and Renato Frederico dos Santos

Active participation in the discussion of the results: Walison Gasparelo da Silva, Lia Mara Moterle and Renato Frederico dos Santos

4. Review and approval of the final version of the article: Lia Mara Moterle and Renato Frederico dos Santos.

LITERATURE CITED

Adegas, F.S., L. Vargas, D.L.P. Gazziero, D. Karam, A.F. Silva e D. Agostinetto. 2017. Impacto econômico da resistência de plantas daninhas a herbicidas no Brasil. Embrapa Soja: Londrina, Paraná, Brasil. Available at https://www.infoteca.cnptia.embrapa.br/infoteca/bitstream/doc/1074026/1/CT132OL.pdf (Accessed Ago 2024).

Barroso, A.A.M., A.J.P. Albrecht, F.C. Reis e R.V. Filho. 2014. Interação entre herbicidas inibidores da ACCase e diferentes formulações de glyphosate no controle de capim-amargoso. Planta Daninha 32(3):619-627. https://dx.doi.org/10.1590/s0100-83582014000300018

Correia, N.M., J.C. Durigan e G.J. Leite. 2015. Manejo químico e cultural de *Digitaria insularis* resistente ao glyphosate na cultura da soja. Pesquisa Agropecuária Brasileira 50(2):99-106.

Correia, N.M. e L.A.A. Gomes. 2015. Antagonismo da mistura de herbicidas inibidores da ACCase e do 2,4-D no controle de gramíneas. Revista Brasileira de Herbicidas 14(2):146–154.

Dantas, G., D.K. Meschede, V.C. Samabatti, G. Azevedo, L.Vanzella, J. Denadai et al. 2015. Roçada como ferramenta no controle do capim amargoso (*Digitaria insularis*) resistente ao glyphosate na cultura da soja. p.1-3. In VII Congresso Brasileiro de Soja. Mercosoja. Reunião de Pesquisa de Soja. Florianópolis, SC. Available at https://www.alice.cnptia.embrapa.br/alice/bitstream/doc/1018507/1/R.309ROCADACOMOFERRAMENTANOCONTROLEDOCAPIMAMARGOSO.PDF (Accessed Jun 2023)

Diesel, F., M.M. Trezzi, M. Gallon, J.R.A.A. Balbinot and F.B. Pagnoncelli. 2018. Tolerance to glyphosate in broadleaf buttonweed and white-eye biotypes. Planta Daninha 36:1-14. https://dx.doi.org/10.1590/S0100-83582018360100137

Ferreira, S.D., V. Exteckoetter, A.M. Gibbert, J.A. Barbosa and N.V. Costa. 2018. Biological cycle of susceptible and glyphosate-resistant sourgrass biotypes in two growth periods Planta Daninha 36: e018175923. https://doi.org/10.1590/S0100-83582018360100077

Gaines, T.A., S.O. Duke, S. Morran, , C.A.G. Rigon, P.J. Tranel, A. Küpper et al. 2020. Mechanisms of evolved herbicide resistance. J. Biol. Chem. 295(30):10307-10330. doi: 10.1074/jbc.REV120.013572.

Gaspar, S.L.L., M. Ecco, E. Martini, M.E. Hennig, F.C. Perondi e L. Schneider. 2019. Controle do capim amargoso em diferentes manejos e associações de agroquímicos. Revista cultivando o saber 12(3): 280-291.

Gemelli, A., R.S. Oliveira Jr e J. Constantin. 2013a. Informe Técnico PGA-UEM 2013, 2 (2):1-5 Available at http://www.pga.uem.br/uploads/informe-tecnico-pga-uem-004.pdf (Accessed Abr 2024).

Gemelli., A., R.S. Oliveira Jr, J. Constantin, G.B.P. Braz, T.M.C. Jumes, E.A.A. Gheno et al. 2013b. Estratégias para o controle de capim-amargoso (*Digitaria insularis*) resistente ao glyphosate na cultura milho safrinha. Revista Brasileira de Herbicidas 12(2):162-170.

Gomes, H.L, V.C. Sambatti and G. Dalazen. 2020. Sourgrass control in response to the association of 2,4-D to ACCase inhibitor herbicides. Bioscience Journal 36(4):1126-1136. https://doi.org/10.14393/BJ-v36n4a2020-47895

Gomes, L.J.P., J.I. Santo, E.C. Gasparino and N.M. Correia. 2017. Chemical control and morphoanatomical analysis of leaves of diferente populations of sourgrass. Planta Daninha 35: e017158021. https://doi.org/10.1590/S0100-83582017350100008

Heap, I. 2023 The international herbicide-resistant weed database. Available at https://www.weedscience.org/Home.aspx (Accessed Set 2024).

Heap, I. 2022 Current Status of the International Herbicide-Resistant Weed Database. Available at https://www.weedscience.org/Home.aspx (Accessed Ago 2024).

Krenchinski, F.H., V.G.C. Pereira, L.H.S. Zobiole, A.J.P. Albrecht, L.P. Albrecht and M. Peterson. 2019. Halauxifen-methyl+diclosulam: New option to control *Conyza* spp. prior soybean sowing. Planta Daninha 37:1-10. https://dx.doi.org/10.1590/S0100-83582019370100059

Liu, W., D.K. Harrison, D. Chalupska, P. Gornicki, C.C, O'Donnell, S.W. Adkins et al. 2007. Williams Single-site mutations in the carboxyltransferase domain of plastid acetyl-CoA carboxylase confer resistance to grass-specific herbicides. Proceedings of the National Academy of Sciences 104(9):3627–3632.

López-Ovejero, R.F., H.K. Takano, M. Nicolai, A. Ferreira, M.S.C. Melo, A.L. Cavenaghi et al. 2017. Frequency and dispersal of glyphosate-resistant sourgrass (*Digitaria insularis*) populations across Brazilian agricultural production areas. Weed Science 65(2): 285-94. https://doi.org/10.1017/wsc.2016.31

Lorenzi, H. 2014. Manual de identificação e controle de plantas daninhas: plantio direto e convencional. 7 ed. Plantarum, Nova Odessa, São Paulo, Brasil.

Mapa - Ministério da agricultura Pecuária e Abastecimento - AGROFIT Sistemas deAgrotóxicos Fitossanitários. 2023. Available at http://extranet.agricultura.gov.br /agrofit_cons/!ap_produto_form_detalhe_cons?p_id_produto_formulado_tecnico=7714&p_tipo_janela=NEW (Accessed Jul 2024).

Melo, M.S.C., L.E. Rosa, C.A.C.G. Brunharo, M. NicolaI e P.J. Christoffoleti. 2012. Alternativas para o controle químico de capim-amargoso (*Digitaria insularis*) resistente ao glyphosate. Revista Brasileira de Herbicidas 11(2):195-203. https://dx.doi.org/10.7824/rbh.v11i2.145

Mendes, R.R., D.F. Biffe, J. Constantin, R.S. Oliveira Júnior, E.L. Rosa, A.L.F. Cuba et al. 2016. Controle de amarelinho (*Tecoma stans*) em pastagem com aplicações localizadas de herbicidas. Revista Brasileira de Herbicidas 15(4):303-312. https://dx.doi.org/10.7824/rbh.v15i4.488

Pavan, G. B. 2018. Manejo de capim-amargoso perenizado e tolerante a glyphosate com herbicidas associados ou não a 2,4-D sal de dimetilamina e 2,4-D choline. Dissertação (Mestrado em Agronomia) – Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba. Available at https://www.teses.usp.br/teses/disponiveis/11/11136/tde-18052018-181208/pt-br.php. (Accessed Mar 2025).

Powles, S. B. and Q. Yu. 2010. Evolution in action: plants resistant to herbicides. Annual Review of Plant Biology 61(1): 317-347.

Raimondi, R.T., J. Constantin, R.S. Oliveira Júnior, A.K.S. Sanches e R.R. Mendes. 2019. Altura de roçada afeta o controle de capim-amargoso perenizado. Cultura Agronômica 28(3): 254-267.

Rosa, W., A. Albrecht, L. Albrecht, D. Beck, J. Mochizuki, F. Battisti et al. 2023. Monitoramento de resistência de *Digitaria insularis* a diferentes herbicidas. Revista Agronomia Brasileira 7:1-6.

Scalcon, E. L. 2020. Eficiência de herbicidas no controle de capim-amargoso (*Digitaria insularis*) em diferentes estádios de desenvolvimento. 82 p. Dissertação (Mestrado em Agronomia) – Universidade Federal do Paraná, Curitiba, Paraná. Available at https://acervodigital.ufpr.br/xmlui/handle/1884/6451 (Accessed Mar 2025).

Silva, A.F., A.C. Batista e R.S. Silva. 2023. Dispersão de plantas daninhas resistentes a glifosato no Brasil: recomendações de manejo. Sete Lagoas, MG, Brasil. (Comunicado técnico 259). Available at https://www.infoteca.cnptia.embrapa.br/infoteca/bitstream/doc/1158894/1/Dispersao-de-plantas-daninhas-resistentes-a-glifosato-no-Brasil.pdf (Accessed Abr 2023)

Takano, H.K., M.S.C. Melo, R.F. López-Ovejero, P.H. Westra, T.A. Gaines, and F.E. Dayan. 2020. Trp2027Cys mutation evolves in *Digitaria insularis* with cross-resistance to ACCase inhibitors. Pesticide Biochemistry and Physiology 164(1):1-6. https://doi.org/10.1016/j.pestbp.2019.12.01

Vidal, R. A., M. M. Trezzi and A. A. Balbinot Junior. 2010. Controle químico de *Digitaria insularis* resistente ao glyphosate com diferentes herbicidas. Revista Brasileira de Herbicidas 9(3):124-131.

Zobiole, L.H.S., F.H. Krenchinski, A.J.P. Albrecht, G. Pereira, F.R. Lucio, C. Rossi, et al. 2016. Controle de capim amargoso perenizado em pleno florescimento. Revista Brasileira de Herbicidas 15(2):157-164. https://dx.doi.org/10.7824/rbh.v15i2.474