Arquivos do Instituto Biológico
ISSN 1808-1657
https://doi.org/10.1590/1808-1657000052022

Sumatran fleabane (*Conyza sumatrensis* [Retz.] E. Walker) control in soybean with combinations of burndown and preemergence herbicides applied in the off-season

Leandro Paiola Albrecht[1] https://orcid.org/0000-0003-3512-6597
Alfredo Junior Paiola Albrecht[1] https://orcid.org/0000-0002-8390-3381
André Felipe Moreira Silva[2,*] https://orcid.org/0000-0002-4846-8089
Lucas Martins da Silva[1] https://orcid.org/0000-0003-0862-7863
Debora Cristine Neuberger[1] https://orcid.org/0000-0002-0923-6699
Gabriel Zanfrilli[1] https://orcid.org/0000-0003-4543-2133
Vagner Maurício da Silva Antunes[1] https://orcid.org/0000-0002-5642-377X

1. Universidade Federal do Paraná – Departamento de Ciências Agronômicas – Palotina (PR), Brazil.
2. Crop Science Pesquisa e Consultoria Agronômica Ltda. – Maripá (PR), Brazil.
*Corresponding author: afmoreirasilva@hotmail.com

ABSTRACT
Sumatran fleabane (*Conyza sumatrensis* [Retz.] E. Walker) can be found in many different agricultural environments and impact different crops, such as soybeans and corn. It is believed that the application of burndown and preemergence herbicides in the off-season are effective in controlling Sumatran fleabane in soybean crops. The objective was to evaluate the effectiveness of burndown and preemergence herbicides in the off-season, with one or two applications, in the control of Sumatran fleabane in soybean cultivation. Five field experiments were conducted in Maripá, state of Paraná (PR), Brazil. The treatments consisted of the application of burndown herbicides in combinations with preemergence ones, with one or two applications. Control of Sumatran fleabane and soybean yield were evaluated. With the set of experiments, it is highlighted that the strategy combining more applications, with different herbicides, burndown and preemergence, is more promising in the control of Sumatran fleabane. When comparing synthetic auxins, dicamba and triclopyr stand out. For sequential application, worse performance was observed for diquat. Combinations between burndown and preemergence herbicides were effective in controlling Sumatran fleabane, for pre sowing application in soybean. With emphasis on managements with sequential applications of saflufenacil with glufosinate or glyphosate. The strategy combining more applications, with different herbicides, burndown and preemergence herbicides, is more promising in the control of Sumatran fleabane.

Keywords: synthetic auxins; protoporphyrinogen oxidase inhibitors; herbicide mixtures; weeds; soybean yield.

INTRODUCTION

Sumatran fleabane (*Conyza sumatrensis* [Retz.] E. Walker) is one of the main species of this genus. It has an annual life cycle, with high seed production, which can be easily dispersed to more than 500,000 m from the mother plant (SHIELDS et al., 2006). Thus, these plants can be found in many different agricultural environments and impact different crops, such as soybeans and maize (BAJWA et al., 2016). TREZZI et al. (2015) indicated that 2.7 *C. bonariensis* plants per square meter are enough to reduce soybean yield by 50%.

Another point to be highlighted are the cases of Sumatran fleabane with resistance to herbicides, with reports all over the world. In South America, cases in Brazil, Paraguay and Argentina stand out. There are reports of single and multiple resistance to several herbicides, especially glyphosate (5-enolpyruvylshikimate-3-phosphate synthase), chlorimuron and other acetolactate synthase inhibitors, paraquat (photosystem I inhibitors), dicamba (synthetic auxins) (SANTOS et al., 2014; PINHO et al., 2019; ZOBIOLE et al., 2019; ALBRECHT et al., 2020a,b; QUEIROZ et al., 2020).

Received: Mar 10, 2022. Accepted: Oct 11, 2022
Section Editor: Silvia Galleti
Peer Review History: Double-blind Peer Review.

Thus, it is necessary to use alternative herbicides, with preemergence activity and different mechanisms of action, for the effective control of Sumatran fleabane. Studies highlight the effectiveness of herbicides with preemergence action in controlling *Conyza* spp. in soybean, for example, flumioxazin (PITTMAN et al., 2019), diclosulam (KRENCHINSKI et al., 2019), diuron (SANTOS et al., 2015), sulfentrazone (ALBRECHT et al., 2021), imazethapyr (ALBRECHT et al., 2020c) among others.

In addition to the use of herbicides with preemergence action, for an effective management of *Conyza* spp. burndown herbicides should also be applied in situations where these weeds are present before sowing soybean. Among these herbicides, glufosinate stands out (ALBRECHT et al., 2020c; CANTU et al., 2021). Glyphosate can also be used, but with cases of resistance and consequent loss of effectiveness, it may be better to use it in post-emergence of soybean.

In this context, it is believed that the application of burndown and preemergence herbicides in the off-season are effective in controlling Sumatran fleabane in soybean crop. The objective of this study was to evaluate the effectiveness of burndown and preemergence herbicides in the off-season, with one or two applications, in the control of Sumatran fleabane in soybean cultivation.

MATERIAL AND METHODS

Location description

Five experiments were carried out with herbicide applications for pre sowing burndown in soybean, located in Maripá, state of Paraná (PR), Brazil (exp. 1: 24°24'28.4"S 53°51'44.4"W; exp. 2: 24°24'28.3"S 53°51'45.5"W; exp. 3: 24°24'28.3"S 53°51'45.5"W; exp. 4: 24°24'29.1"S 53°51'45.3"W; exp. 5: 24°24'29"S 53°51'43.7"W). The climate in the region is Cfa—subtropical with summer rains and dry winters, according to the Köppen–Geiger classification, the meteorological conditions during the experiment are illustrated in Fig. 1. The soil of the experimental area showed a very clayey texture (65.1% clay, 19.55% silt, and 15.35% sand), and with the following chemical characteristics (0–20 cm): pH ($CaCl_2$) of 5.9; organic matter of 1.98% and cation exchange capacity of 19.13 $cmol_c·dm^{-3}$.

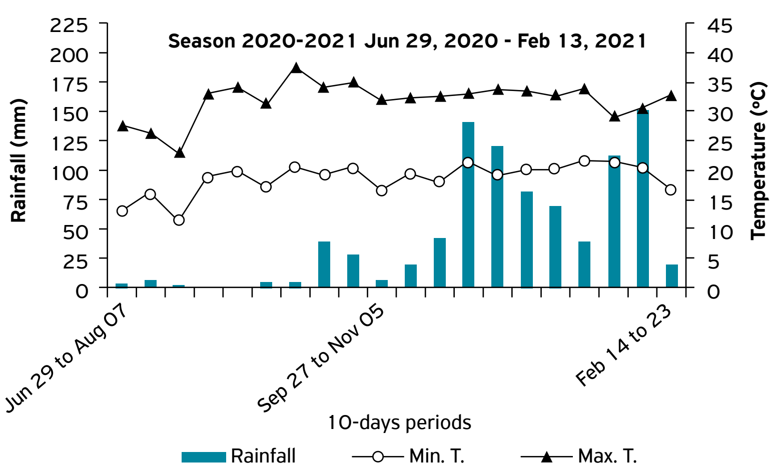

Figure 1. Rainfall, minimum (min) and maximum (max) temperature, during the experiments. Maripá, PR, Brazil, 2020–2021.

Experimental design

Experiments 1 to 4 consisted of two herbicide applications, experiment 5 was composed of a single application. The first application in experiments 1 to 4 and the application in experiment 5 were made on August 24, 2020, under average temperature of 24 °C, relative humidity of 78% and wind speed of 1.7 $km·h^{-1}$. The second application was made ten days after the first application, on September 3, 2020, under average temperature of 27 °C, relative humidity of 62% and wind speed of 2.2 $km·h^{-1}$. For the applications, a CO_2 pressurized backpack sprayer was used, equipped with a 3-m-long application bar, with six XR 110 02 flat fan spray nozzles (Teejet), spaced 50 cm apart, bar height of 50 cm from the target, 2 BAR constant pressure, 0.45 $L·min^{-1}$ flow, and 1 $m·s^{-1}$ speed, thus providing a spray volume of 150 $L·ha^{-1}$.

The area was infested with 19.7 plants·m^{-2} of Sumatran fleabane, with more than 50% plants over 20 cm tall. The soil in the area had a large seed bank of Sumatran fleabane with new emergence flows after the first application. It should be noted that the area had a history and frequency of plants with resistance to 2,4-dichlorophenoxyacetic acid (2,4-D), paraquat and diquat.

Seven treatments were adopted for each experiment (Tables 1 to 5) and a randomized block design with four replications was used. The experimental units consisted of 5 × 3 m plots. For the evaluations, only the central area (5.4 m^2) of each plot was considered.

Table 1. Herbicide treatments in first application at pre sowing soybean burndown to control Sumatran fleabane (exp. 1).

Treatments[1]	Rate[2] (g·ha^{-1})
Nontreated control (without weeding)	-
Nontreated control (with weeding)	-
Glyphosate + metsulfuron	1,500 + 7.2
Glyphosate + 2,4-D	1,500 + 1,005
Glyphosate + chlorimuron + 2,4-D	1,500 + 30 + 1,209
Glyphosate + dicamba	1,500 + 288
Glyphosate + triclopyr	1,500 + 720

[1]Commercial products: Zapp QI 620 (glyphosate), Ally (metsulfuron), Aminol 806 (2,4-D), Classic (chlorimuron), Atectra (dicamba), Triclon (triclopyr). Sequential application of glufosinate (400 g·ha^{-1} of active ingredient [ai]), 10 days after the first application, except for the nontreated control. [2]Rates at acid equivalent (ae), except for metsulfuron and chlorimuron at ai.

Table 2. Herbicide treatments in first application at presowing soybean burndown to control Sumatran fleabane (exp. 2).

Treatments[1]	Rate[2] (g·ha^{-1})
Nontreated control (without weeding)	-
Nontreated control (with weeding)	-
Only sequential application	-
Gly + dicamba + imazethapyr/flumioxazin	1,500 + 288 + 120/60
Gly + dicamba + diclosulam	1,500 + 288 + 20.16
Gly + dicamba + diclosulam	1,500 + 288 + 35.28
Gly + dicamba + sulfentrazone/diuron	1,500 + 288 + 245/490

[1]Commercial products: Zapp QI 620 (gly: glyphosate), Atectra (dicamba), Zethamaxx (imazethapyr/flumioxazin), Spider 840 WG (diclosulam), Stone (sulfentrazone/diuron). Sequential application of glufosinate (400 g·ha^{-1} of active ingredient [ai]), 10 days after the first application, except for the nontreated control. [2]Rates at acid equivalent (ae), except for flumioxazin, diclosulam, and sulfentrazone/diuron at ai.

Table 3. Herbicide treatments in sequential application at presowing soybean burndown to control Sumatran fleabane (exp. 3).

Treatments[1]	Rate[2] (g·ha^{-1})
Nontreated control (without weeding)	-
Nontreated control (with weeding)	-
Without sequential application	-
Glufosinate	400
Glufosinate + imazethapyr/flumioxazin	400 + 120/60
Glufosinate + diclosulam	400 + 20.16
Glufosinate + sulfentrazone/diuron	400 + 245/490

[1]Commercial products: Zapp QI 620 (gly: glyphosate), Atectra (dicamba), Zethamaxx (imazethapyr/flumioxazin), Spider 840 WG (diclosulam), Stone (sulfentrazone/diuron). First application of glyphosate + dicamba, 10 days before of second application, except for the nontreated control. [2]Rates at acid equivalent (ae), except for flumioxazin, diclosulam, and sulfentrazone/diuron at a.i.

Table 4. Herbicide treatments in sequential application at pre sowing soybean burndown to control Sumatran fleabane (exp. 4).

Treatments[1]	Rate[2] ($g \cdot ha^{-1}$)
Nontreated control (without weeding)	-
Nontreated control (with weeding)	-
Diquat	400
Glufosinate	400
Glufosinate	600
Glufosinate + saflufenacil	400 + 35
Glyphosate + saflufenacil	1,240 + 35

[1]Commercial products: Reglone (diquat), Finale (glufosinate), Heat (saflufenacil), Zapp QI 620 (glyphosate). First application of glyphosate (1,500 $g \cdot ha^{-1}$ of acid equivalent [ae]) + dicamba (Atectra: 288 g $ae \cdot ha^{-1}$), 10 days before of second application, except for the nontreated control. [2]Rates at ae for glyphosate, and at active ingredient (ai) for other herbicides.

Table 5. Herbicide treatments in pre sowing soybean burndown to control Sumatran fleabane (exp. 5).

Treatments[1]	Rate[2] ($g \cdot ha^{-1}$)
Nontreated control (without weeding)	-
Nontreated control (with weeding)	-
Glufosinate	400
Glufosinate	600
Glufosinate + saflufenacil	400 + 35
Glyphosate + saflufenacil	1,000 + 35
Glyphosate + saflufenacil + diclosulam	1,000 + 35 + 20.16

[1]Commercial products: Finale (glufosinate), Heat (saflufenacil), Zapp QI 620 (glyphosate), Spider 840 WG (diclosulam). [2]Rates at acid equivalent (ae) for glyphosate, and at active ingredient (ai) for other herbicides.

On September 23, 2020, soybean cultivar 'M 6210 IPRO' was directly sown in rows 0.45 cm spaced apart, with 12 $seeds \cdot m^{-1}$, for all the experiments. In soybean postemergence, weed control was carried out by manual weeding, from 60 days after the first application (DAA) of herbicides, when the soybean was at the V6 stage (FEHR et al., 1971) in a total area, even in the controls.

Evaluations

Control evaluation of Sumatran fleabane was carried out at 21 and 42 DAA, scores were assigned by visual analysis of each experimental unit (0 for absence of injuries, up to 100% for plant death), considering, in this case, symptoms significantly visible in the plants, according to their development (VELINI et al., 1995). For soybean yield, the useful area of each plot was harvested, the weight of harvested grains was corrected to 13% moisture, with results expressed in $kg \cdot ha^{-1}$.

Statistical analysis

Data were tested by analysis of variance (ANOVA) using the F-test ($p < 0.05$). Treatment means were grouped using Tukey's test ($p < 0.05$). For the analysis, the Sisvar 5.6 software (FERREIRA, 2011) was used.

RESULTS

In experiment 1, the application of dicamba or triclopyr, in combination with glyphosate, showed better performance in the control of Sumatran fleabane, at 21 and 42 DAA. There was a final control of up to 78%, inferior only to the weeded control (100%). The effectiveness of herbicide treatments impacted soybean yield, with higher values for the most effective treatments (Fig. 2).

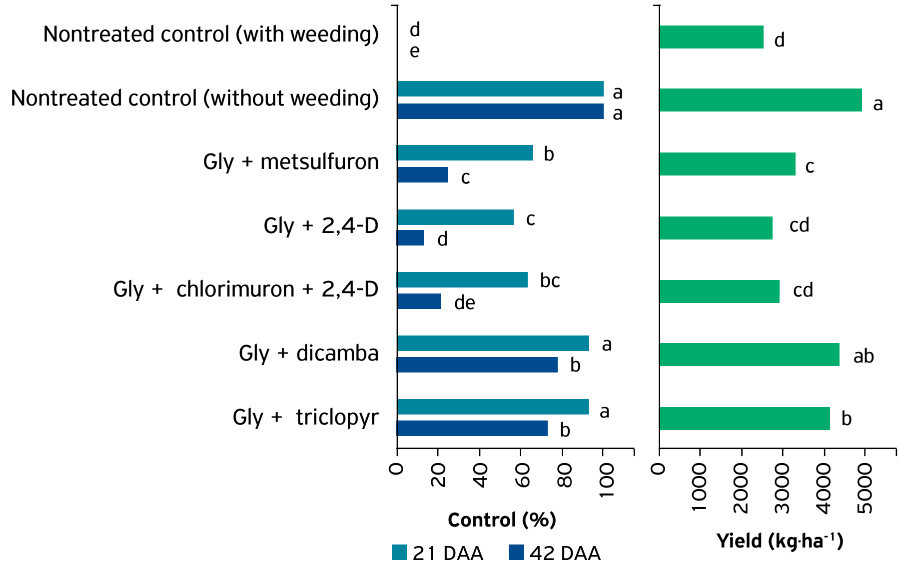

Figure 2. Sumatran fleabane control at 21 and 42 days after first application (DAA), and soybean yield, of treatment herbicides in first application at pre sowing soybean burndown (exp. 1). Sequential application of glufosinate at 10 DAA, except for the except for the nontreated control. Gly: glyphosate. Bars, with same color and letter, do not differ each other by Tukey's test, by 5% level.

The application of glyphosate + dicamba, in combination with preemergence, was also effective in controlling Sumatran fleabane, in experiment 2, with emphasis on the combination with the highest rate of diclosulam. For soybean yield, no differences were detected between the weeded control and glyphosate + dicamba + preemergence, all superior to that observed for the application of glyphosate + dicamba (Fig. 3). Similar results were observed in experiment 3, which evaluated the application of glyphosate + dicamba without sequential application of glufosinate, and had the worst performance among the herbicide treatments. For the others, it is highlighted that preemergence + glufosinate was effective in the control of Sumatran fleabane, with consistent results observed in soybean yield (Fig. 4).

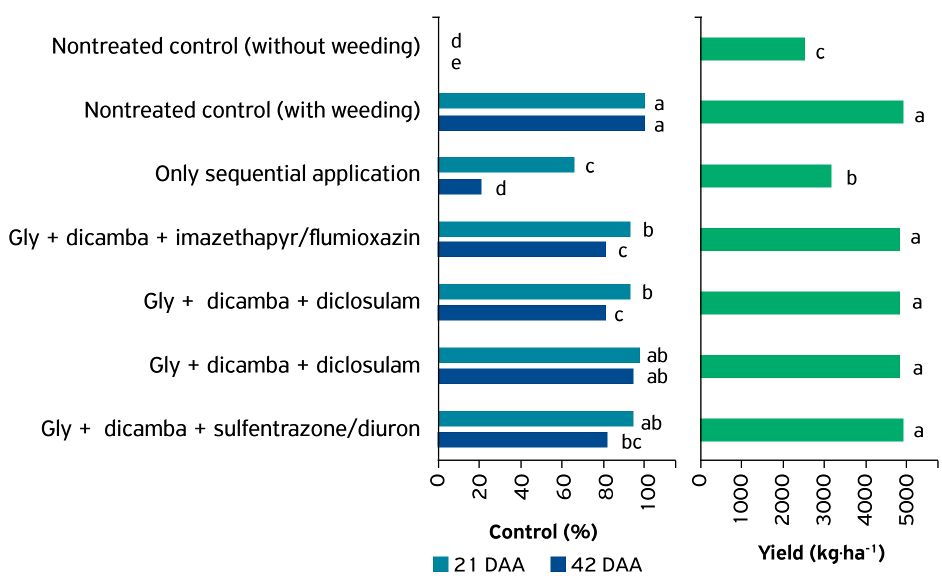

Figure 3. Sumatran fleabane control at 21 and 42 days after first application (DAA), and soybean yield, of treatment herbicides in first application at pre sowing soybean burndown (exp. 2). Sequential application of glufosinate, at 10 DAA, except for the nontreated control. Gly: glyphosate Bars, with same color and letter, do not differ each other by Tukey's test (1949), by 5% level.

For experiment 4, the treatments varied according to the second application, glyphosate + dicamba was used in the first application in all herbicide treatments. In this sequence, when diquat was applied, a worse performance was observed in the control of Sumatran fleabane and in soybean yield. In this sense, the application of glufosinate is highlighted, especially at the highest rate (600 g·ha^{-1}), or in combination with saflufenacil, in this case at the rate of 400 g·ha^{-1} (Fig. 5).

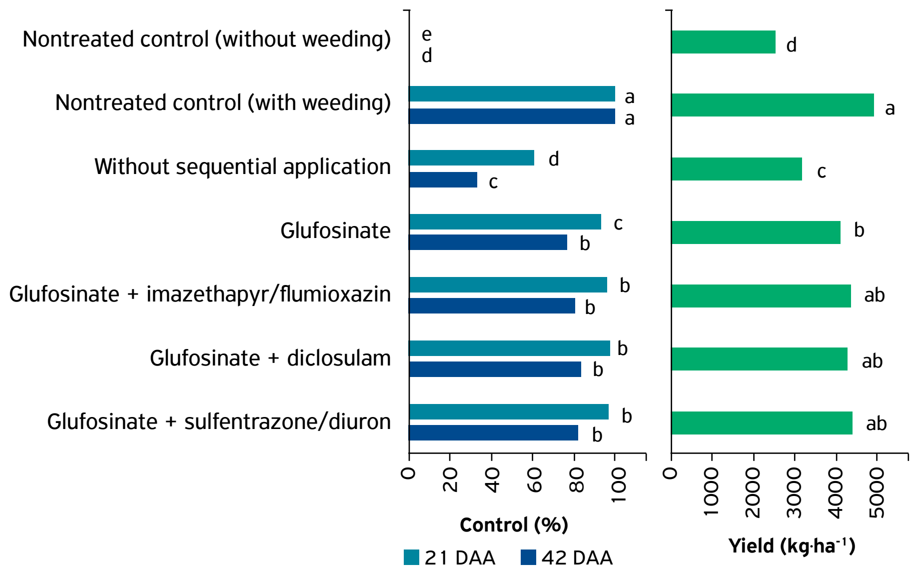

Figure 4. Sumatran fleabane control at 21 and 42 days after application (DAA), and soybean yield, of treatment herbicides in sequential application at pre sowing soybean burndown (exp. 3). First application of glyphosate + dicamba, 10 days before of second application, except for the nontreated control. Bars, with same color and letter, do not differ each other by Tukey's test, by 5% level.

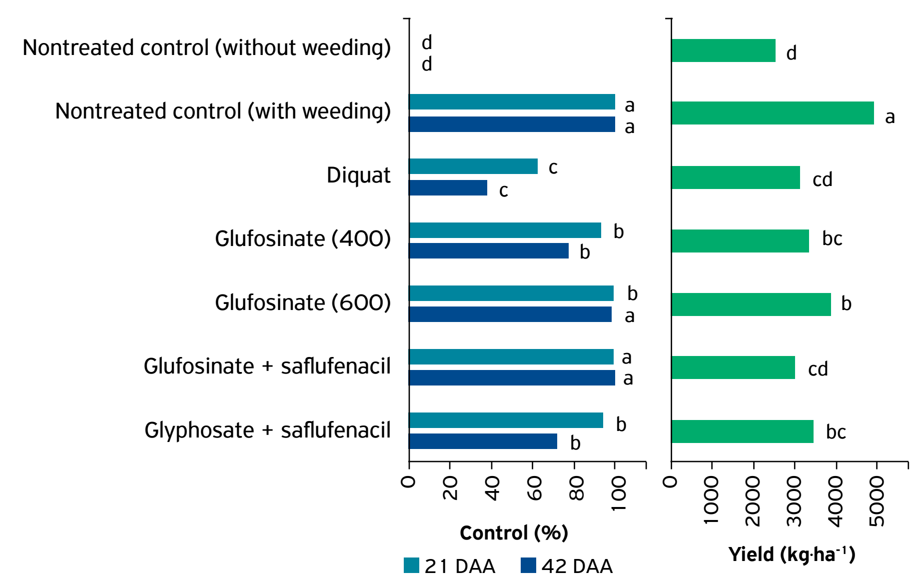

Figure 5. Sumatran fleabane control at 21 and 42 days after first application (DAA), and soybean yield, of treatment herbicides in sequential application at pre sowing soybean burndown (exp. 4). First application of glyphosate + dicamba, 10 days before of second application, except for the except for the nontreated control. Bars, with same color and letter, do not differ each other by Tukey's test, by 5% level.

In experiment 5, in a single application of herbicides, the efficacy of glufosinate + saflufenacil stands out, with 85% control at 21 DAA, however at 42 DAA, 52.5% control was observed, even though it was among the most effective treatments. Therefore, the productivity of all herbicide treatments was lower than that observed in the weeded control (Fig. 6). These results reinforce the need for more interventions to control Sumatran fleabane in soybean, with the combination of burndown herbicides with preemergence ones.

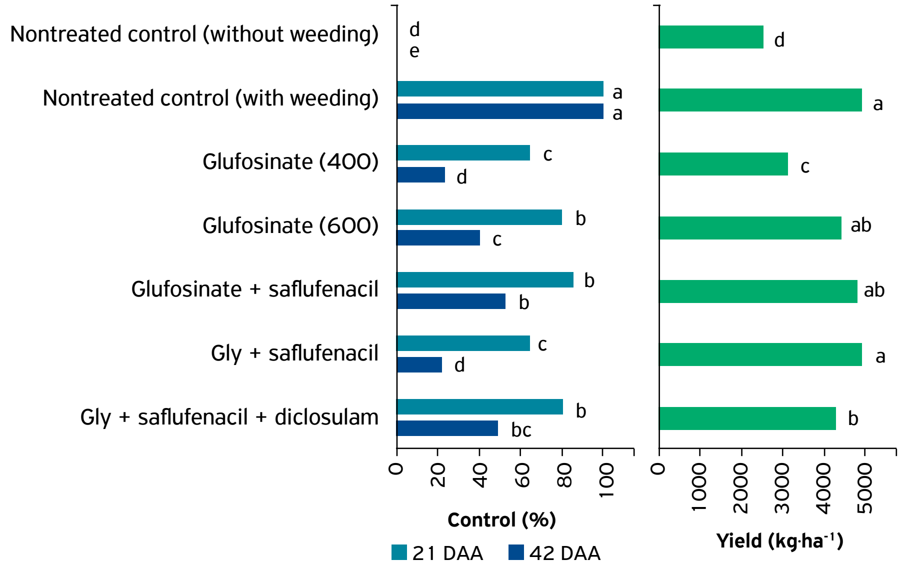

Figure 6. Sumatran fleabane control at 21 and 42 days after application (DAA), and soybean yield, of treatment herbicides at pre sowing soybean burndown (exp. 5). Bars, with same color and letter, do not differ each other by Tukey's test, by 5% level.

DISCUSSION

With the set of experiments, the strategy combining more applications, with different herbicides, burndown and preemergences, is more promising in the control of Sumatran fleabane. In the first application, when in combination with glyphosate + synthetic auxin, dicamba and triclopyr can be highlighted as partners of glyphosate. Other studies highlight dicamba (FLESSNER; PITTMAN, 2019; ASKEW et al., 2021) or triclopyr (CANTU et al., 2021), in different combinations, especially with burndown and preemergences herbicides. Also, dicamba and triclopyr can be used as an alternative to 2,4-D, which were superior in this study. Resistance to 2,4-D has been reported in southern Brazil, due to the rapid necrosis mechanism (PINHO et al., 2019; QUEIROZ et al., 2020), which helps to explain the results of this study.

Another important tool in the control of Sumatran fleabane is the use of preemergence herbicides, even in advance, with application 30 days before soybean sowing. preemergence herbicides increase the effectiveness of treatments, and should be applied for pre sowing soybean desiccation. The application of imazethapyr/flumioxazin, sulfentrazone/diuron or diclosulam was effective in different combinations. As already pointed out by other studies in different managements, especially those with more interventions, and with different mechanisms of action (SOLTANI et al., 2017; RIZZARDI et al., 2020; SCHRAMSKI et al., 2021).

Also, the importance of sequential application, with burndown herbicides, was demonstrated with these results. In particular, glufosinate proved to be effective when compared to diquat. The application of glufosinate is supported by other studies in different management situations of Sumatran fleabane (ALBRECHT et al., 2020c; CORREIA, 2020). The combination of glufosinate with saflufenacil was also effective in controlling the sequential application. This combination is important in the control of Sumatran fleabane and other weeds, widely used in pre sowing soybean, with studies even indicating a synergistic effect (JHALA et al., 2013; TAKANO et al., 2020).

Although with lower efficacy compared to glufosinate + saflufenacil, the combination glyphosate + saflufenacil was also promising in the control of Sumatran fleabane, superior to that observed for diquat. As well as, when in combination with glufosinate, also with glyphosate, saflufenacil is recommended in this modality of application, and a synergistic effect is observed in some situations in the control of *Conyza* spp. (DALAZEN et al., 2015; PIASECKI et al., 2020).

The importance of diversifying chemical control tactics, with better results for treatments combining more herbicides with different mechanisms of action, is reiterated. Rotation, herbicide combination and use of preemergence herbicides are very important in preventing the selection of resistant weed biotypes, as well as in their control (KNEZEVIC et al., 2019; BUSI et al., 2020).

Combinations between burndown and preemergence herbicides were effective in the control of Sumatran fleabane, for pre sowing application in soybean. With emphasis on managements with sequential applications of saflufenacil with glufosinate or glyphosate. It is highlighted that the strategy combining more applications, with different herbicides, burndown and preemergence, is more promising in the control of Sumatran fleabane.

AUTHORS' CONTRIBUTIONS

Conceptualization: Albrecht, L.P.; Albrecht, A.J.P. **Data curation:** Albrecht, L.P.; Albrecht, A.J.P.; Silva, L.M.; Neuberger, D.C.; Zanfrilli, G.; Antunes, V.M.S. **Formal analysis:** Albrecht, L.P.; Silva, A.F.M. **Funding acquisition:** Albrecht, L.P.; Albrecht, A.J.P. **Investigation:** Albrecht, L.P.; Albrecht, A.J.P.; Silva, L.M.; Neuberger, D.C.; Zanfrilli, G.; Antunes, V.M.S. **Methodology:** Albrecht, L.P.; Albrecht, A.J.P. **Project administration:** Albrecht, L.P.; Albrecht, A.J.P. **Resources:** Albrecht, L.P.; Albrecht, A.J.P. **Supervision:** Albrecht, L.P.; Albrecht, A.J.P. **Validation:** Albrecht, L.P.; Albrecht, A.J.P.; Silva, A.F.M. **Visualization:** Albrecht, L.P.; Albrecht, A.J.P.; Silva, L.M.; Neuberger, D.C.; Zanfrilli, G.; Antunes, V.M.S. **Writing – original draft:** Silva, A.F.M.; Albrecht, L.P. **Writing – review & editing:** Albrecht, L.P.; Albrecht, A.J.P.; Silva, L.M.; Neuberger, D.C.; Zanfrilli, G.; Antunes, V.M.S.

AVAILABILITY OF DATA AND MATERIAL

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

FUNDING

Conselho Nacional de Desenvolvimento Científico e Tecnológico
https://doi.org/10.13039/501100003593
Grant No. 308202/2020-1

CONFLICTS OF INTEREST

All authors declare that they have no conflict of interest.

ETHICAL APPROVAL

Not applicable.

ACKNOWLEDGEMENTS

The authors acknowledge the support of the Supra Pesquisa team from the Federal University of Paraná (UFPR), and the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq-Brazil) for granting scientific initiation scholarships to undergraduate students and productivity scholarship to the first author.

REFERENCES

ALBRECHT, A.J.P.; ALBRECHT, L.P.; ALVES, S.N.R.; SILVA, A.F.M.; SILVA, W. de O.; LORENZETTI, J.B.; DANILUSSI, M.T.Y.; BARROSO, A.A.M. Pre-sowing application of combinations of burndown and pre-emergent herbicides for *Conyza* spp. control in soybean. *Agronomía Colombiana*, Bogotá, v.39, n.1, p.121-128, 2021. https://doi.org/10.15446/agron.colomb.v39n1.89545

ALBRECHT, A.J.P.; ALBRECHT, L.P.; SILVA, A.F.M.; RAMOS, R.A.; CORRÊA, N.B.; CARVALHO, M.G.; LORENZETTI, J.B.; DANILUSSI, M.T.Y. Control of *Conyza* spp. with sequential application of glufosinate in soybean pre-sowing. *Ciência Rural*, Santa Maria, v.50, n.9, e20190868, 2020c. https://doi.org/10.1590/0103-8478cr20190868

ALBRECHT, A.J.P.; PEREIRA, V.G.C.; SOUZA, C.N.Z. de; ZOBIOLE, L.H.S.; ALBRECHT L.P.; ADEGAS, F.S. Multiple resistance of *Conyza sumatrensis* to three mechanisms of action of herbicides. *Acta Scientiarum*. *Agronomy*, Maringá, v.42, e42485, 2020a. https://doi.org/10.4025/actasciagron.v42i1.42485

ALBRECHT, A.J.P.; THOMAZINI, G.; ALBRECHT, L.P.; PIRES, A.; LORENZETTI, J.B.; DANILUSSI, M.T.Y.; SILVA, A.F.M.; ADEGAS, F.S. *Conyza sumatrensis* resistant to paraquat, glyphosate and chlorimuron: confirmation and monitoring the first case of multiple resistance in Paraguay. *Agriculture*, Basel, v.10, n.12, 582, 2020b. https://doi.org/10.3390/agriculture10120582

ASKEW, M.C.; CAHOON JR., C.W.; YORK, A.C.; FLESSNER, M.L.; LANGSTON JR., D.B., FEREBEE IV, J.H. Comparison of 2,4-D, dicamba and halauxifen-methyl alone or in combination with glyphosate for preplant weed control. *Weed Technology*, Cambridge, v.35, n.1, p.93-98, 2021. https://doi.org/10.1017/wet.2020.83

BAJWA, A.A.; SADIA, S.; ALI, H.H.; JABRAN, K.; PEERZADA, A.M.; CHAUHAN, B.S.; Biology and management of two important *Conyza* weeds: A global review. *Environmental Science and Pollution Research*, Berlin, v.23, n.24, p.24694-24710, 2016. https://doi.org/10.1007/s11356-016-7794-7

BUSI, R.; POWLES, S.B.; BECKIE, H.J.; RENTON, M. Rotations and mixtures of soil-applied herbicides delay resistance. *Pest Management Science*, London, v.76, n.2, p.487-496, 2020. https://doi.org/10.1002/ps.5534

CANTU, R.M.; ALBRECHT, L.P.; ALBRECHT, A.J.P.; SILVA, A.F.M.; DANILUSSI, M.T.Y.; LORENZETTI, J.B. Herbicide alternative for *Conyza sumatrensis* control in pre-planting in no-till soybeans. *Advances in Weed Science*, Londrina, v.39, e2021000025, 2021. https://doi.org/10.51694/AdvWeedSci/2021;39:000012

CORREIA, N.M. Management and development of fleabane plants in central Brazil. *Planta Daninha*, Viçosa, v.38, e020238215. 2020. https://doi.org/10.1590/S0100-83582020380100084

DALAZEN, G.; KRUSE, N.D.; MACHADO, S.L.O.; BALBINOT, A. Synergism of the glyphosate and saflufenacil combination for controlling hairy fleabane. *Pesquisa Agropecuária Tropical*, Goiânia, v.45, p.249-256, 2015. https://doi.org/10.1590/1983-40632015v4533708

FEHR, W.R.; CAVINESS, C.E.; BURMOOD, D.T.; PENNINGTON, J.S. Stage of development descriptions for soybeans, *Glycine max* (L.) Merrill. *Crop Science*, v.11, n.6, p.929-931, 1971. https://doi.org/10.2135/cropsci1971.0011183X001100060051x

FERREIRA, D.F. Sisvar: A computer statistical analysis system. *Ciência e Agrotecnologia*, Lavras, v.35, n.6, p.1039-1042, 2011. https://doi.org/10.1590/S1413-70542011000600001

FLESSNER, M.L.; PITTMAN, K.B. Horseweed control with preplant herbicides after mechanical injury from small grain harvest. *Agronomy Journal*, Madison, v.111, n.6, p.3274-3280, 2019. https://doi.org/10.2134/agronj2019.03.0174

JHALA, A.J.; RAMIREZ, A.H.M.; SINGH, M. Tank mixing saflufenacil, glufosinate, and indaziflam improved burndown and residual weed control. *Weed Technology,* Cambridge, v.27, n.2, p.422-429, 2013. https://doi.org/10.1614/WT-D-12-00141.1

KNEZEVIC, S.Z.; PAVLOVIC, P.; OSIPITAN, O.A.; BARNES, E.R.; BEIERMANN, C.; OLIVEIRA, M.C.; LAWRENCE, N.; SCOTT, J.E.; JHALA, A. Critical time for weed removal in glyphosate-resistant soybean as influenced by preemergence herbicides. *Weed Technology*, Cambridge, v.33, n.3, p.393-399, 2019. https://doi.org/10.1017/wet.2019.18

KRENCHINSKI, F.H.; PEREIRA, V.G.C.; ZOBIOLE, L.H.S.; ALBRECHT, A.J.P.; ALBRECHT, L.P.; PETERSON, M. Halauxifen-methyl + diclosulam: new option to control *Conyza* spp. prior soybean sowing. *Planta Daninha*, Viçosa, v.37, e019189000, 2019. https://doi.org/10.1590/S0100-83582019370100059

PIASECKI, C.; CARVALHO, I.R.; AVILA, L.A.; AGOSTINETTO, D.; VARGAS, L. Glyphosate and saflufenacil: Elucidating their combined action on the control of glyphosate-resistant *Conyza bonariensis*. *Agriculture*, Basel, v.10, n.6, 236, 2020. https://doi.org/10.3390/agriculture10060236

PINHO, C.F.; LEAL, J.F.L.; SOUZA, A. S.; OLIVEIRA, G.F.P.B.; OLIVEIRA, C.; LANGARO, A.C.; MACHADO, A.F.L.; CHRISTOFFOLETI, P.J.; ZOBIOLE, L.H.S. First evidence of multiple resistance of Sumatran fleabane (*Conyza sumatrensis* (Retz.) E. Walker) to five-mode-of-action herbicides. *Australian Journal of Crop Science*, v.13, n.10, p.1688-1697, 2019. https://doi.org/10.21475/ajcs.19.13.10.p1981

PITTMAN, K.B.; BARNEY, J.N.; FLESSNER, M.L. Horseweed (*Conyza canadensis*) suppression from cover crop mixtures and fall-applied residual herbicides. *Weed Technology*, Cambridge, v.33, n.2, p.303-311, 2019. https://doi.org/10.1017/wet.2018.111

QUEIROZ, A.R. de; DELATORRE, C.A.; LUCIO, F.R.; ROSSI, C.V.S.; ZOBIOLE, L.H.S.; MEROTTO JR, A. Rapid necrosis: A novel plant resistance mechanism to 2,4-D. *Weed Science*, Cambridge, v.68, n.1, p.6-18, 2020. https://doi.org/10.1017/wsc.2019.65

RIZZARDI, M.A.; ROCKENBACH, A.P.; SCHNEIDER, T. Residual herbicides increase the period prior to interference in soybean cultivars. *Planta Daninha*, Viçosa, v.38, e020222194, 2020. https://doi.org/10.1590/S0100-83582020380100091

SANTOS, F.M.; VARGAS, L.; CHRISTOFFOLETI, P.J.; MARTIN, T.N.; MARIANI, F., SILVA, D.R.O. Alternative herbicides to control *Conyza sumatrensis* (Retz.) E. H. Walker resistant to and EPSPs inhibitors. *Revista Ceres*, Viçosa, v.62, n.6, p.531-538, 2015. https://doi.org/10.1590/0034-737X201562060004

SANTOS, G.; OLIVEIRA JR., R.S.; CONSTANTIN, J.; FRANCISCHINI, A.C.; MACHADO, M.F.P.S.; MANGOLIN, C.A.; NAKAJIMA, J.N. *Conyza sumatrensis*: A new weed species resistant to glyphosate in the Americas. *Weed Biology and Management*, 14, v.2, p.106-114, 2014. https://doi.org/10.1111/wbm.12037

SCHRAMSKI, J.A.; SPRAGUE, C.L.; RENNER, K.A. Integrating fall-planted cereal cover crops and preplant herbicides for glyphosate-resistant horseweed (*Conyza canadensis*) management in soybean. *Weed Technology*, Cambridge, v.35, n.2, p.234-241. 2021. https://doi.org/10.1017/wet.2020.117

SHIELDS, E.J.; DAUER, J.T.; VANGESSEL, M.J.; NEUMANN, G. Horseweed (*Conyza canadensis*) seed collected in the planetary boundary layer. *Weed Science*, Cambridge, v.54, n.6, p.1063-1067, 2006. https://doi.org/10.1614/WS-06-097R1.1

SOLTANI, N.; BROWN, L.R.; SIKKEMA, P.H. Control of glyphosate-resistant Canada fleabane in soybean with preplant herbicides. *Canadian Journal of Plant Science*, Ottawa, v.97, n.3, p.408-410, 2017. https://doi.org/10.1139/cjps-2016-0299

TAKANO, H.K.; BEFFA, R.; PRESTON, C.; WESTRA, P.; DAYAN, F.E. Glufosinate enhances the activity of protoporphyrinogen oxidase inhibitors. *Weed Science*, Cambridge, v.68, n.4, p.324-332, 2020. https://doi.org/10.1017/wsc.2020.39

TREZZI, M.M.; VIDAL, R.A.; PATEL, F.; MIOTTO JR., E.; DEBASTIANI, F.; BALBINOT JR., A.A.; MOSQUEN, R. Impact of *Conyza bonariensis* density and establishment period on soyabean grain yield, yield components and economic threshold. *Weed Research*, v.55, n.1, p.34-41, 2015. https://doi.org/10.1111/wre.12125

VELINI, E.D.; OSIPE, R.; GAZZIERO, D.L.P. *Procedimentos para instalação, avaliação e análise de experimentos com herbicidas*. Londrina: Sociedade Brasileira da Ciência das Plantas Daninhas, 1995.

ZOBIOLE, L.H.S.; PEREIRA, V.G.C.; ALBRECHT, A.J.P.; RUBIN, R.S.; ADEGAS, F.S.; ALBRECHT, L.P. Paraquat resistance of Sumatran fleabane (*Conyza sumatrensis*). *Planta Daninha*, Viçosa, v.37, e019183264, 2019. https://doi.org/10.1590/S0100-83582019370100018