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SCIENTIFIC ARTICLE

Can sulfentrazone at mixtures be an alternative to control *Conyza sumatrensis*, *Digitaria insularis* and *Commelina benghalensis* in soybean?

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ABSTRACT

The application of herbicides, at pre-emergence of weeds and crops, is an effective and increasingly necessary strategy, due to the control difficulties, including herbicide-resistant weeds. Thus, aimed to evaluate the effectiveness of sulfentrazone, alone or in mixtures, applied in pre-emergence of soybean to control Sumatran fleabane (*Conyza sumatrensis*), sourgrass (*Digitaria insularis*) and Benghal dayflower (*Commelina benghalensis*). The number of weeds m^{-2}, weed control, crop injury, and soybean yield were evaluated. This research shows that mixtures with sulfentrazone are especially interesting, as with diclosulam and, metribuzin + imazethapyr, in the control of Sumatran fleabane, in which diuron tends to aggregate when combined. Sulfentrazone mixed with clomazone or metribuzin, plus diuron, are especially valid for Benghal dayflower. While some triple mixtures attract attention, in the control of sourgrass. The mixtures that tend to have a better control spectrum are: sulfentrazone + clomazone + diuron, and sulfentrazone + metribuzin + diuron. Therefore, the mixtures with sulfentrazone evaluated in the experimental conditions verified in this study, are promising in the integrated management of weeds and do not generate losses in soybean yield.

Keywords: Herbicide-resistance, pre-emergent herbicide, Sumatran fleabane, sourgrass, Benghal dayflower.

INTRODUCTION

In the *Conyza* genus (sin.: *Erigeron*) the species hairy fleabane (*Conyza bonariensis* (L.) Cronquist), horseweed (*Conyza canadensis* (L.) Cronquist), and Sumatran fleabane (*Conyza sumatrensis* E. Walker) stand out. Being among the main weed plants worldwide. These weeds have an annual life cycle, high seed production, and herbaceous size, being found in various agricultural environments. In turn, Sumatran fleabane is believed to have its origin in the subtropical climate region of South America, with dispersion also to North America, Europe, and Asia (BAJWA et al., 2016).

Sourgrass (*Digitaria insularis* [L.] Mez ex Ekman) is a native species of tropical and subtropical regions of America (VELDMAN; PUTZ, 2011), found in various agricultural environments. It has characteristics that make it very aggressive in competing with crops, such as the formation of rhizomes, clumps, and the ability to spread propagules practically throughout the summer (LORENZI, 2014). Another important weed in different environments is Benghal dayflower (*Commelina benghalensis*), that presents tolerance to some herbicides, such as glyphosate (DIAS et al., 2013). This weed is very branched evergreen that reproduces by seeds and vegetative structures (LORENZI, 2014).

In Brazil, cases of resistance in Sumatran fleabane to various herbicides have been reported, such as, glyphosate, chlorimuron, saflufenacil, paraquat, and 2,4-D (PINHO et al. 2019; ZOBIOLE et al. 2019; ALBRECHT et al. 2020a; QUEIROZ et al., 2020; HEAP, 2024; LORENZETTI et al. 2024). Also, sourgrass presents cases of resistance to herbicides, with resistance to acetyl-CoA carboxylase (ACCase) inhibitors (haloxyfop and pinoxaden) and glyphosate (CARVALHO et al., 2011; TAKANO et al., 2020; HEAP, 2024).

Trezzi et al. (2015) indicated that only 2.7 plants of *Conyza* spp. m^{-2} could already reduce soybean yield by 50%. On the other hand, the coexistence of 8 plants m^2 with the soybean crop is enough to reduce yield by 80% (BRAZ et al., 2021). Thus, the adoption of control measures is essential to avoid crop yield losses, with chemical control being widely used.

Given the aggressiveness of these weeds and the growing reports of biotypes resistant to glyphosate and other herbicides, proactive management is required by using. Pre-emergence herbicides are critical in managing weed resistance as they allow for rotation of herbicides and mechanisms of action (KNEZEVIC et al., 2019). The use of pre-emergence herbicides is also fundamental in reducing weed emergence in the field, helping post-emergence control (JOVANOVIĆ et al., 2020). For instance, sulfentrazone and other herbicides applied in pre-emergence of soybean, were found to be effective by Albrecht et al. (2020b), Cantu et al. (2021) and Garcia et al. (2023), for *Conyza* spp. or by Marochi et al. (2018) and Morota et al. (2018) for sourgrass. Sulfentrazone, for example, increased the control of glyphosate-resistant horseweed in soybeans (SOLTANI et al., 2020).

Application of sulfentrazone and other herbicides in soybean pre-emergence may be effective in controlling weeds such as Sumatran fleabane, sourgrass, and Benghal dayflower. Therefore, this study aimed to evaluate the efficacy of sulfentrazone, alone or in tank-mixture, applied in pre-emergence of soybean.

MATERIAL AND METHODS

Five field experiments were conducted at Paraná State (PR) Brazil, in the 2018-2019 growing season. Details on locations, sowing dates, application, and weather conditions during applications of herbicide treatments are shown in Table 1. The regional climate is Cfa, according to the Köppen classification, during the period during which the experiments were conducted, rainfall and temperatures were within the recommended range for soybean development. Table 2 shows the results of soil physical and chemical analysis of these experimental areas.

The sites of experiments 1 and 2 with predominant infestation of Sumatran fleabane plants. Previously, the area was cultivated with maize (exp. 1) or wheat (exp. 2). The site of experiment 3 with predominant infestation of Benghal dayflower plants. Previously, this area was cultivated with maize. For experiment 4 and 5, with predominant infestation of sourgrass plants. Previously, the area was cultivated with maize.

Soybean sowing was performed at all sites under the no-tillage system with an interrow spacing of 0.45 cm. For experiments 1 and 2, it was used the soybean cultivar M 5947 IPRO (Monsanto Co. do Brasil, São Paulo, SP, Brazil), maturation group [MG]: 5.9. For experiment 3, it was used the soybean cultivar M 6210 IPRO (Monsanto Co. do Brasil, São Paulo, SP, Brazil), MG: 6.2 was used. While for experiments 4 and 5 it was used the soybean cultivar BS 2606 IPRO (Basf S.A., São Paulo, SP, Brazil), MG: 6.0. The three cultivars have an indeterminate growth habit and are tolerant to glyphosate.

The experimental design was a randomized block design with four replications and plots with 3 × 6 m. Treatments for weed control are shown in Table 3, applied at soybean pre-emergence. A CO_2-pressurized backpack sprayer equipped with six AIXR 110.015 spray nozzles spaced 0.5 m from each other, calibrated at a pressure of 2.5 kgf cm^{-2} and speed of 3.6 km h^{-1} was used for all applications, which provided an application volume of 150 L ha^{-1}.

Weed control and crop injury on soybean plants were evaluated at 35 days after herbicide application (DAA) for all experiments. These evaluations were performed through visual analysis (0 for no injuries, up to 100% for plant death), considering significantly visible symptoms on plants according to their development (VELINI et al., 1995). The treatments (without herbicide effect), weed control and weed-free control were used as references for evaluations. A score of 0 was given for soybean injury for both, while for weed control a score of 0 was given for weed control and 100% for the weed-free control.

The number of weeds m^{-2} was evaluated at 14, 21, 28, and 35 DAA. A square of 0.25 m^{-2} was used for these evaluations, with two replications per plot. From 35 DAA, weeds in all experiments were controlled with manual weeding, when necessary.

Soybean yield was evaluated at harvest in experiments 1, 2, and 4, the two central rows with four meters in length were harvested and moisture corrected to 13%, with results presented at kg ha^{-1}.

The data were submitted to analysis of variance (ANOVA) by F-test ($P \leq 0.05$). Treatments were grouped by the Scott and Knott test ($P \leq 0.05$). The software Sisvar 5.6 (Ferreira, 2011) was used for analysis.

For crop injury and soybean yield all experiments were combined for analysis. For weed control, the experiments were grouped according to the predominant weed community for analysis. Thus, the joint analysis of experiments 1 and 2 was performed, for control and plants m^{-2} of Sumatran fleabane. Also, joint analysis of experiments 4 and 5, for sourgrass, while experiment 3 (Benghal dayflower) was analyzed separately.

RESULTS

Some differences were observed in experiments 1 e 2 for Sumatran fleabane plants m^{-2} at 14, 21, 28 and 35 DAA, in general all treatments with herbicides reduced the number of weeds compared to the control (without weeding). Herbicides sulfentrazone + diclosulam, sulfentrazone + metribuzin + imazethapyr, sulfentrazone + clomazone + diuron, sulfentrazone + metribuzin + diuron, sulfentrazone/diuron stood out with controls higher than 85% (Table 4).

All herbicide treatments reduced weed infestation, especially at 35 DAA for sulfentrazone application in associations (exp. 3). For weed control, sulfentrazone + clomazone + diuron, sulfentrazone + metribuzin + diuron, and sulfentrazone/diuron stood out, with scores of at least 78.5%. These treatments were higher when compared to the others, but inferior to the treatment with weeding (Table 5).

For experiment 4 and 5, all treatments reduced weed infestation when compared to the control (without weeding). For weed control, the best results as observed for imazethapyr/flumioxazin, sulfentrazone + clomazone + diuron, sulfentrazone + metribuzin + diuron, however with scores at most 77% (Table 6).

All herbicide treatments caused injury to soybean plants; however, symptoms were at most 9.4% (sulfentrazone/diuron). For this treatment, necrotic lesions were observed on the first leaves after emergence and a reduction in plant height. For other treatments, symptoms were mainly observed on the leaves, such as necrosis, yellowing, chlorosis and mainly reduction in height, with the intensity varying with the scores. Yield (kg ha^{-1}) was evaluated in experiments 1, 2, and 4, although differences were observed in all experiments for weed control and soybean injury, it did not reflect soybean yield in the comparison between herbicide treatments (Table 7).

DISCUSSION

Regarding the crop injury, some treatments were more phytotoxic. Other authors have reported these results for flumioxazin (BARBOSA et al., 2023) and sulfentrazone (BELFRY et al., 2016), imazethapyr (BELFRY et al., 2015), or diclosulam (BRAZ et al., 2017). However, symptoms may vary according to rate, cultivar, soil texture, and weather conditions, but in general in these studies, no reductions in yield are observed despite the symptoms.

In the present study, on average across the experiments, no reduction at yield was observed for herbicide treatments compared to the weed-free check (no effect of herbicides and weeds). While the lowest yield was observed for weedy-check (without the effect of herbicides and without weeding), it is believed that the effects on this variable are mainly related to the interference of weeds.

The highest efficacy weed control was observed, in general, for herbicides in associations, especially for sulfentrazone in associations, including control of Sumatran fleabane (exp. 1 and 2), sourgrass and other weeds (exp. 4 and 5). This herbicide has a broad spectrum of action, especially in mixtures, and has a low potential for injury to soybeans (WALSH et al., 2015). Other studies have highlighted that sulfentrazone was effective in controlling *Conyza* spp.

resistant to glyphosate (SOLTANI et al., 2020), *Amaranthus tuberculatus* var. *rudis* (SCHRYVER et al., 2017), and *Euphorbia heterophylla* (RIZZARDI; SILVA, 2014).

In general, associations with the best performance and control spectrum were represented by treatments 11, 12, 13, and 16. Thus, associations with sulfentrazone are valid and important in integrated weed management and may generate new commercial mixtures and effective control of species of complex management. It agrees with Aulakh and Jhala (2015), who verified the effectiveness of sulfentrazone in pre-emergence of soybean in different associations to control *Chenopodium album*, *Amaranthus rudis*, *Solanum ptychanthum*, *Abutilon theophrasti*, *Setaria viridis*, and *Digitaria sanguinalis*. Also, Rawat et al. (2017) observed the effectiveness of sulfentrazone in the control of several weeds, including Benghal dayflower.

The efficacy of sulfentrazone was observed in this study, especially in mixtures with metribuzin, imazethapyr, clomazone, and diuron (tank mixture or formulated premix). Metribuzin application in different mixtures was also effective in controlling *Conyza* spp. and *D. sanguinalis* (VOLLMER et al., 2019), while Hedges et al. (2019) observed the effectiveness of imazethapyr in controlling horseweed in different chemical management programs. Moreover, clomazone in mixtures was effective in controlling *Conyza* spp. (SANTIAGO et al., 2018), and weeds of the Poaceae family (GLATKOVA; PACANOSKI, 2019), such as sourgrass (SANTIAGO et al., 2018). Also, clomazone + sulfentrazone was effective in controlling *Commelina* spp. (BILLORE, 2017).

In turn, diuron was effective in controlling sourgrass when in association with paraquat (GILO et al., 2016) and effective in controlling in different chemical management programs (LAMEGO et al., 2013). However, with the resistance of Sumatran fleabane to paraquat (ZOBIOLE et al., 2019; ALBRECHT et al., 2020c), in addition to the banning of this herbicide in Brazil, it is necessary to use other herbicides in the pre-sowing soybean burndown (ALBRECHT et al., 2022).

Pre-emergent herbicides are essential in controlling weed emergence flows, increasing the period prior interference (PPI). Knezevic et al. (2019) found that pre-emergent herbicides (sulfentrazone + imazethapyr or saflufenacil + imazethapyr + pyroxasulfone) applied in pre-emergence of soybean increased PPI, which may make post-emergence glyphosate application more flexible, reducing selection pressure of biotypes resistant to this herbicide.

The use of pre-emergent herbicides and different mode of action is essential. They are effective in controlling difficult-to-control weeds, whether herbicide-tolerant or resistant. In this context, the use of acetolactate synthase and protoporphyrinogen oxidase inhibitor herbicides and those with other mechanisms of actions, associations of them, and non-chemical control methods are paramount, (WESTWOOD et al., 2018; SCURSONI et al., 2019), especially in the problem of glyphosate-resistant weeds. Therefore, all herbicides used in this study can be used as alternatives to control Sumatran fleabane, sourgrass, and other weeds in pre-emergence, the example of Benghal dayflower.

CONCLUSION

This research shows that mixtures with sulfentrazone are especially interesting, as with diclosulam and, metribuzin + imazethapyr, in the control of Sumatran fleabane, in which diuron tends to aggregate when combined. Sulfentrazone mixed with clomazone or metribuzin, plus diuron, are especially valid for Benghal dayflower. While some triple mixtures attract attention, in the control of sourgrass. The mixtures that tend to have a better control spectrum are: sulfentrazone + clomazone + diuron, and sulfentrazone + metribuzin + diuron. Therefore, the mixtures with sulfentrazone evaluated in the experimental conditions verified in this study, are promising in the integrated management of weeds and do not generate losses in soybean yield.

AUTHORSHIP CONTRIBUTION (CONTRIBUIÇÃO DE AUTORIA)

Conceptualization: LPA, AJPA, DGA, REBT, EDM. Data curation: LPA, AJPA, AFMS. Formal analysis: AFMS, FEB, PJF. Funding acquisition: LPA, AJPA. Investigation: LPA, AJPA, FEB, PJF. Methodology: LPA, AJPA. Project administration: LPA. Resources: LPA, AJPA, DGA, REBT, EDM. Software: LPA, AJPA, AFMS. Supervision: LPA, AJPA. Validation: LPA, AJPA, DGA, REBT, EDM. Visualization: LPA, AJPA, DGA, REBT, EDM. Writing – original draft: LPA, AFMS. Writing – review & editing: all the authors.

AVAILABILITY OF DATA AND MATERIAL (declaração de disponibilidade de dados de pesquisa)

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

FUNDING

Not applicable.

CONFLICTS OF INTEREST

All authors declare that they have no conflict of interest.

ETHICAL APPROVAL

Not applicable.

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Table 1. Local, sowing dates, and weather conditions during applications of herbicide treatments of the experiments.

	Local	Coordinates	Sowing date	Application date	T (ºC)	RH (%)	Wind (km h^{-1})
Exp. 1	Palotina	24°20'48.89"S 53°51'37.58"W	Oct 15, 2018	Oct 16, 2018	27.5	65.8	6.8
Exp. 2	Palotina	24°20'48.89"S	Oct 15, 2018	Oct 16, 2018	23.1	62.5	4.5

		53°51'37.58"W					
Exp. 3	Assis Chateaubriand	24°18'07.13"S 53°36'53.60"W	Sep 14, 2018	Sep 13, 2018	20.5	75.1	6.0
Exp. 4	Palotina	24°14'06.32"S 53°50'44.40"W	Sep 11, 2018	Sep 12, 2018	27.0	65.0	4.0
Exp. 5	Francisco Alves	24°09'16.30"S 53°50'29.11"W	Sep 11, 2018	Sep 12, 2018	27.0	55.5	4.0

RH: Relative humidity.

Table 2. Results of soil physical and chemical analysis.

	Sand (%)	Silt (%)	Clay (%)	Texture	pH at CaCl	OM (%)
Exp. 1	15.00	18.75	66.25	Very clayey	4.8	1.55
Exp. 2	15.00	18.75	66.25	Very clayey	4.8	1.55
Exp. 3	21.55	21.30	57.15	Clayey	5.6	1.90
Exp. 4	20.00	18.75	61.25	Very clayey	4.8	2.23
Exp. 5	78.75	10.00	11.25	Sandy	5.3	1.14

OM: organic matter.

Table 3. Herbicide treatments, alone or in mixtures, applied in pre-emergence of soybean, 2018-2019 growing season.

Treatments[1]	Rates[2]
1. Weedy check[3] (without weeding)	-
2. Imazethapyr/flumioxazin	100/50
3. Sulfentrazone	300
4. Sulfentrazone + clomazone	200 + 500
5. Sulfentrazone + imazethapyr	200 + 100
6. Sulfentrazone + metribuzin	200 + 360
7. Sulfentrazone + diclosulam	200 + 25.2
8. Sulfentrazone + diuron	200 + 200

9. Sulfentrazone + clomazone + metribuzin	200 + 500 + 360
10. Sulfentrazone + clomazone + imazethapyr	200 + 500 + 70
11. Sulfentrazone + metribuzin + imazethapyr	200 + 360 + 70
12. Sulfentrazone + clomazone + diuron	200 + 500 + 200
13. Sulfentrazone + metribuzin + diuron	200 + 360 + 200
14. Sulfentrazone + diclosulam + diuron	200 + 25.2 + 200
15. Diclosulam	25.2
16. Sulfentrazone/diuron	245/490
17. Weed-free check[3] (with weeding)	-

[1]Commercial products: Zethamaxx® (imazethapyr/flumioxazin); Ponteiro® BR (sulfentrazone); Grande® BR (clomazone); Pivot® 100 SL (imazethapyr); Coronel® BR (metribuzin); Spider® 840 WG (diclosulam); Diox® (diuron); Stone® (sulfentrazone/diuron).

[2]Rates at g of active ingredient (ai) ha^{-1}, and at g of acid equivalent (ae) ha^{-1} for imazethapyr.

[3]Without herbicides.

Table 4. Number of weeds m^{-2} at 14, 21, 28, and 35 days after application (DAA) of herbicides and Sumatran fleabane control at 35 DAA, 2018-2019 growing season (exp. 1 and 2).

Treatments	Weeds m^{-2}				Control
	14 DAA	21 DAA	28 DAA	35 DAA	(%)
1. Weedy check[1] (without weeding)	2.2 b	3.5 c	4.8 c	6.4 d	0.0 f
2. Imazethapyr/flumioxazin	0.9 a	1.3 b	2.0 b	2.2 c	83.6 c
3. Sulfentrazone	1.2 a	2.0 b	2.6 b	2.5 c	76.9 d
4. Sulfentrazone + clomazone	0.9 a	1.6 b	2.7 b	3.1 c	68.5 e
5. Sulfentrazone + imazethapyr	0.7 a	1.3 b	2.5 b	2.6 c	75.3 d
6. Sulfentrazone + metribuzin	0.6 a	1.1 b	2.6 b	2.8 c	79.1 d
7. Sulfentrazone + diclosulam	0.8 a	1.2 b	2.0 b	2.1 b	86.1 b
8. Sulfentrazone + diuron	0.9 a	2.1 b	2.2 b	2.6 b	76.1 d

9. Sulfentrazone + clomazone + metribuzin	0.9 a	1.6 b	1.9 b	1.9 c	84.3 c
10. Sulfentrazone + clomazone + imazethapyr	0.9 a	1.4 b	2.1 b	1.8 c	85.1 c
11. Sulfentrazone + metribuzin + imazethapyr	1.2 a	1.3 b	1.9 b	1.4 c	89.3 b
12. Sulfentrazone + clomazone + diuron	0.9 a	1.9 b	1.3 b	1.6 c	87.4 b
13. Sulfentrazone + metribuzin + diuron	0.9 a	1.6 b	1.8 b	1.6 c	87.1 b
14. Sulfentrazone + diclosulam + diuron	0.8 a	1.3 b	1.9 b	1.8 c	83.9 c
15. Diclosulam	1.1 a	1.7 b	1.3 b	1.8 c	82.1 c
16. Sulfentrazone/diuron	1.1 a	1.2 b	2.1 b	1.6 c	86.5 b
17. Weed-free check[1] (with weeding)	0.0 a	0.0 a	0.0 a	0.0 a	100.0 a
Mean	0.9	1.5	2.1	2.2	78.3
CV (%)	15.2	19.3	20.0	19.0	4.6
F	*	*	*	*	*

[1]Without herbicides. * Means followed by the same letter in the column do not differ by Scott & Knott test ($P \leq 0.05$).

Table 5. Number of weeds m^{-2} at 14, 21, 28, and 35 days after application (DAA) of herbicides and Benghal dayflower control at 35 DAA, 2018-2019 growing season (exp. 3).

Treatments	Weeds m^{-2}				Control
	14 DAA	21 DAA	28 DAA	35 DAA	(%)
1. Weedy check[1] (without weeding)	5.8 d	16.8 d	26.8 e	47.5 d	0.0 h
2. Imazethapyr/flumioxazin	0.8 a	10.8 c	17.0 c	29.5 c	52.5 f
3. Sulfentrazone	1.8 b	10.8 c	18.0 c	27.8 c	63.3 e
4. Sulfentrazone + clomazone	1.8 b	8.0 b	11.5 b	20.5 b	68.0 d
5. Sulfentrazone + imazethapyr	2.3 b	9.0 a	11.8 b	17.3 b	71.0 d
6. Sulfentrazone + metribuzin	2.0 b	10.8 c	14.5 c	20.0 b	68.8 d
7. Sulfentrazone + diclosulam	2.0 b	13.0 c	16.8 c	21.3 b	67.5 d
8. Sulfentrazone + diuron	4.0 c	9.0 b	11.8 b	50.5 b	64.5 e
9. Sulfentrazone + clomazone + metribuzin	2.3 b	7.8 b	11.3 b	18.8 b	76.3 c

10. Sulfentrazone + clomazone + imazethapyr	2.5 b	7.3 b	9.5 b	18.3 b	75.0 c
11. Sulfentrazone + metribuzin + imazethapyr	2.5 b	13.0 c	15.0 c	20.5 b	77.0 c
12. Sulfentrazone + clomazone + diuron	1.0 a	11.0 c	12.8 b	17.0 b	78.5 b
13. Sulfentrazone + metribuzin + diuron	0.8 a	6.5 b	10.8 b	16.8 b	79.3 b
14. Sulfentrazone + diclosulam + diuron	5.3 d	15.3 d	17.8 c	20.5 b	68.5 d
15. Diclosulam	6.3 d	17.3 d	21.0 d	32.3 c	53.3 g
16. Sulfentrazone/diuron	1.3 a	8.8 b	11.3 b	15.3 b	79.0 b
17. Weed-free check[1] (with weeding)	0.0 a	0.0 a	0.0 a	0.0 a	100.0 a
Mean	2.47	10.21	13.88	16.98	67.43
CV (%)	14.28	3.26	11.26	8.08	2.91
F	*	*	*	*	*

[1]Without herbicides. * Means followed by the same letter in the column do not differ by Scott & Knott test ($P \leq 0.05$).

Table 6. Number of weeds m^{-2} at 14, 21, 28, and 35 days after application (DAA) of herbicides and sourgrass control at 35 DAA, 2018-2019 growing season (exp. 4 and 5).

Treatments	Weeds m^{-2}				Control
	14 DAA	21 DAA	28 DAA	35 DAA	(%)
1. Weedy check[1] (without weeding)	21.1 b	25.5 d	35.8 d	55.6 d	0.0 e
2. Imazethapyr/flumioxazin	5.4 a	7.8 b	12.9 b	20.8 b	73.0 b
3. Sulfentrazone	4.9 a	14.1 c	20.0 c	28.0 c	60.5 e
4. Sulfentrazone + clomazone	3.3 a	12.0 c	18.3 c	26.8 c	63.9 d
5. Sulfentrazone + imazethapyr	5.0 a	12.5 c	23.1 c	30.3 c	65.0 d
6. Sulfentrazone + metribuzin	6.1 a	10.9 c	19.8 c	29.1 c	57.1 e
7. Sulfentrazone + diclosulam	6.5 a	12.6 c	21.8 c	28.3 c	63.0 d
8. Sulfentrazone + diuron	6.3 a	14.1 c	24.8 c	33.6 c	60.9 e
9. Sulfentrazone + clomazone + metribuzin	4.5 a	14.6 c	20.5 c	27.3 c	65.0 d
10. Sulfentrazone + clomazone + imazethapyr	3.5 a	8.5 b	16.6 b	22.4 b	68.4 c

11. Sulfentrazone + metribuzin + imazethapyr	4.3 a	14.1 c	20.3 c	24.4 b	70.1 c
12. Sulfentrazone + clomazone + diuron	4.4 a	7.9 b	12.4 b	16.1 b	77.0 b
13. Sulfentrazone + metribuzin + diuron	3.5 a	6.6 b	14.4 b	20.3 b	75.1 b
14. Sulfentrazone + diclosulam + diuron	3.1 a	13.1 c	19.6 c	26.6 c	60.4 e
15. Diclosulam	4.3 a	9.8 b	21.0 c	32.3 c	58.4 e
16. Sulfentrazone/diuron	6.3 a	12.6 c	16.6 c	22.3 b	68.8 c
17. Weed-free check[1] (with weeding)	0.0 a	0.0 a	0.0 a	0.0 a	100.0 a
Mean	5.4	11.6	18.7	26.1	63.9
CV (%)	39.1	35.4	36.7	20.1	8.4
F	*	*	*	*	*

[1]Without herbicides. * Means followed by the same letter in the column do not differ by Scott & Knott test ($P \leq 0.05$).

Table 7. Crop injury and yield of soybean plants under herbicides, 2018-2019 growing season.

Treatments	Crop injury[2]	Yield[3]
	%	kg ha^{-1}
1. Weedy check[1] (without weeding)	0.0 a	1,766 b
2. Imazethapyr/flumioxazin	2.8 b	2,249 a
3. Sulfentrazone	5.4 c	2,232 a
4. Sulfentrazone + clomazone	3.3 b	2,175 a
5. Sulfentrazone + imazethapyr	5.9 c	2,166 a
6. Sulfentrazone + metribuzin	3.9 b	2,200 a
7. Sulfentrazone + diclosulam	5.7 c	2,098 a
8. Sulfentrazone + diuron	4.0 b	2,154 a
9. Sulfentrazone + clomazone + metribuzin	5.1 c	2,230 a
10. Sulfentrazone + clomazone + imazethapyr	3.5 b	2,248 a
11. Sulfentrazone + metribuzin + imazethapyr	6.3 c	2,162 a

12. Sulfentrazone + clomazone + diuron	5.8 c	2,209 a
13. Sulfentrazone + metribuzin + diuron	6.3 c	2,195 a
14. Sulfentrazone + diclosulam + diuron	6.9 c	2,077 a
15. Diclosulam	4.6 c	2,187 a
16. Sulfentrazone/diuron	9.4 d	2,192 a
17. Weedy-free check[1] (with weeding)	0.0 a	2,229 a
Mean	4.6	2,163
CV (%)	16.8	10.6
F	*	*

[1]Without herbicides. [2]Mean of all experiments. [3]Mean of experiments 1, 2 and 4. * Means followed by the same letter in the column do not differ by Scott & Knott test ($P \leq 0.05$).