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Herbicide management in glyphosate and sulfonylurea-tolerant soybeans

Manejo de herbicidas em soja tolerante a glifosato e sulfonilureias

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ABSTRACT: There is little information on the efficacy and selectivity of sulfonylureas, isolated and in association with glyphosate, in glyphosate and sulfonylurea-tolerant soybeans. Thus, the present study aims to evaluate the efficacy of weed control and selectivity of sulfonylureas, isolated and in association with glyphosate, at post-emergence (V4) of RR2/STS soybean. The experiments were conducted in the in areas located in Piracicaba City, São Paulo State (SP), Brazil (experiment I) and Palotina City, Paraná State (PR), Brazil (experiment II). Treatments were composed of application of the herbicides sulfometuron, chlorimuron, halosulfuron, ethoxysulfuron and glyphosate, isolated and in association, in the BMX Garra RR2/STS cultivar. Experiment I was conducted focusing on the evaluation of the efficacy of weed control; whereas experiment II focused mainly on the evaluation of herbicide selectivity. The experimental design was the randomized complete block, with four replications. Crop injury, weed control, and variables related to agronomic performance were evaluated. Data were submitted to analysis of variance, and the means of the treatments were compared with the Tukey test. Sulfonylureas in association with glyphosate were effective in weed control and selective for the BMX Garra RR2/STS soybean cultivar. The sulfometuron + chlorimuron + glyphosate association presented phytotoxic potential for the BMX Garra RR2/STS cultivar.

KEYWORDS: *Glycine max*; STS; weed control; herbicides selectivity; agronomic performance.

RESUMO: Há poucas informações sobre a eficácia e seletividade de sulfonilureias, isoladas e associadas ao glifosato, na soja tolerante ao glifosato e às sulfonilureias. Assim, o presente estudo teve como objetivo avaliar a eficácia no controle de plantas daninhas e seletividade de sulfonilureias, isoladas e em associação com o glifosato, em pós-emergência (V4) de soja RR2/STS. Os experimentos foram conduzidos em áreas localizadas nos municípios de Piracicaba, São Paulo (SP), Brasil (experimento I) e Palotina, Paraná (PR), Brasil (experimento II). Os tratamentos foram compostos pela aplicação dos herbicidas sulfometurom, clorimurom, halossulfurom, etoxissulfurom e glifosato, isolados e em associação, no cultivar BMX Garra RR2/STS. O experimento I foi realizado com o foco principal na avaliação da eficácia no controle de plantas daninhas; ao passo que o experimento II se concentrou principalmente na avaliação da seletividade dos herbicidas. O delineamento experimental foi o de blocos casualizados, com quatro repetições. Foram avaliados sintomas de injúria, controle de plantas daninhas e variáveis relacionadas ao desempenho agronômico. Os dados foram submetidos à análise de variância, e as médias dos tratamentos foram comparadas pelo teste de Tukey. Sulfonilureias associadas ao glifosato foram eficazes no controle de plantas daninhas e seletivas para o cultivar de soja BMX Garra RR2/STS. A associação sulfometurom + clorimurom + glifosato apresentou potencial fitotóxico para o cultivar BMX Garra RR2/STS.

PALAVRAS-CHAVE: *Glycine max*; STS; controle de plantas daninhas; seletividade de herbicidas; desempenho agronômico.

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INTRODUCTION

Glyphosate tolerant transgenic soybean (Roundup Ready® soybean — RR® soybean) was developed by introducing a gene called *cp4epsps* from the bacteria *Agrobacterium tumefaciens*, strain CP4. This gene encodes an EPSPs enzyme insensitive to glyphosate, thus making soybean plants tolerant to this herbicide (PADGETTE et al., 1995). The "second generation" of glyphosate-tolerant soybean (RR2 soybean) was developed with a different technique of insertion of the *cp4epsps* gene (in addition to the *cry1Ac* gene, from the bacterium *Bacillus thuringiensis* (Bt), which makes insects resistant), under the trademark Intacta® Roundup Ready® 2 Pro (BERNARDI et al., 2012).

On the other hand, sulfonylurea tolerant soybean (STS®) is not a transgenic crop, which has been developed with the technique of seed mutagenesis using ethyl methanesulfonate (EMS) alkylating agent, which does not cause mutation by insertion into the DNA, but by the modification of the base already present (ROGOZIN et al., 2001). Mutant seeds from the 'Williams 82' soybean cultivar were selected according to tolerance to chlorsulfuron sulfonylurea. Thus, soybean cultivar W20 STS was developed, which presented high tolerance in post- and pre-emergence for some sulfonylureas (SEBASTIAN et al., 1989). Such tolerance is conferred by semidominant alleles called *Als1* and *Als2* (WALTER et al., 2014; MANTOVANI et al., 2017).

STS cultivars are highly tolerant to the chlorimuron herbicide, which can be applied up to four times above the recommended dose for non-STS cultivars (GREEN, 2007; ROSO; VIDAL, 2011; ALBRECHT et al., 2017). They also show tolerance to other herbicides of the sulfonylureas group.

STS cultivars were commercially launched first in the United States, in 1994 (GREEN, 2012). In Brazil, the first cultivars were only introduced in 2011. Currently, there are commercially available cultivars that mutually present RR or RR2 and STS technologies, allowing the association between sulfonylurea and glyphosate in weed management.

Glyphosate is an herbicide that inhibits the EPSPs enzyme, has a broad action spectrum in weed control and is selective only for transgenic tolerant crops. Sulfonylureas inhibit the ALS enzyme and have action mainly on eudicotyledonous weeds, but some molecules also present action on Cyperaceae (OLIVEIRA JÚNIOR, 2011).

However, there is little information on the efficacy and selectivity of sulfonylureas, such as halosulfuron, ethoxysulfuron, sulfometuron, among others, isolated and in association with glyphosate in soybean. These associations are believed to be effective in weed control and selective for RR2/STS soybean plants. Thus, the present study aimed to evaluate the efficacy of weed control and selectivity of sulfonylureas, isolated and in association with glyphosate, for post-emergence (V4) application of RR2/STS soybean.

MATERIALS AND METHODS

Field experiments

The experiments were conducted in the 2017/18 season, in areas located in Piracicaba City, São Paulo State, Brazil, (experiment I), and Palotina City, Paraná State, Brazil (experiment II). The BMX Garra RR2/STS cultivar was used, which presents indeterminate growth habit and 6.3 relative maturity group.

According to the classification of Köppen, the Piracicaba's climate is characterized as Cwa — humid subtropical, with drought during winter. Palotina's climate is, on the other hand, Cfa — mesothermic, humid subtropical, with predominance of hot summers, low frequency of severe frost and a tendency of concentration of rains during summer. The distribution of precipitation and temperature along the conduction period of each experiment is shown below (Fig. 1).

The fertilization was carried out to correct the soil, considering the extraction of the crop. Sowing of the experiments was performed in the second fortnight of October 2017. The physical and chemical analysis of the soil of experimental areas is presented below (Table 1).

The treatments were composed by the application of herbicides, described in Table 2. The experimental design was the randomized complete block, with four replications. The experimental units were made up of 5 m long plots and five soybean rows, spaced at 0.45 m, the three central lines being considered as useful area, discarding the first and last meter of the plot.

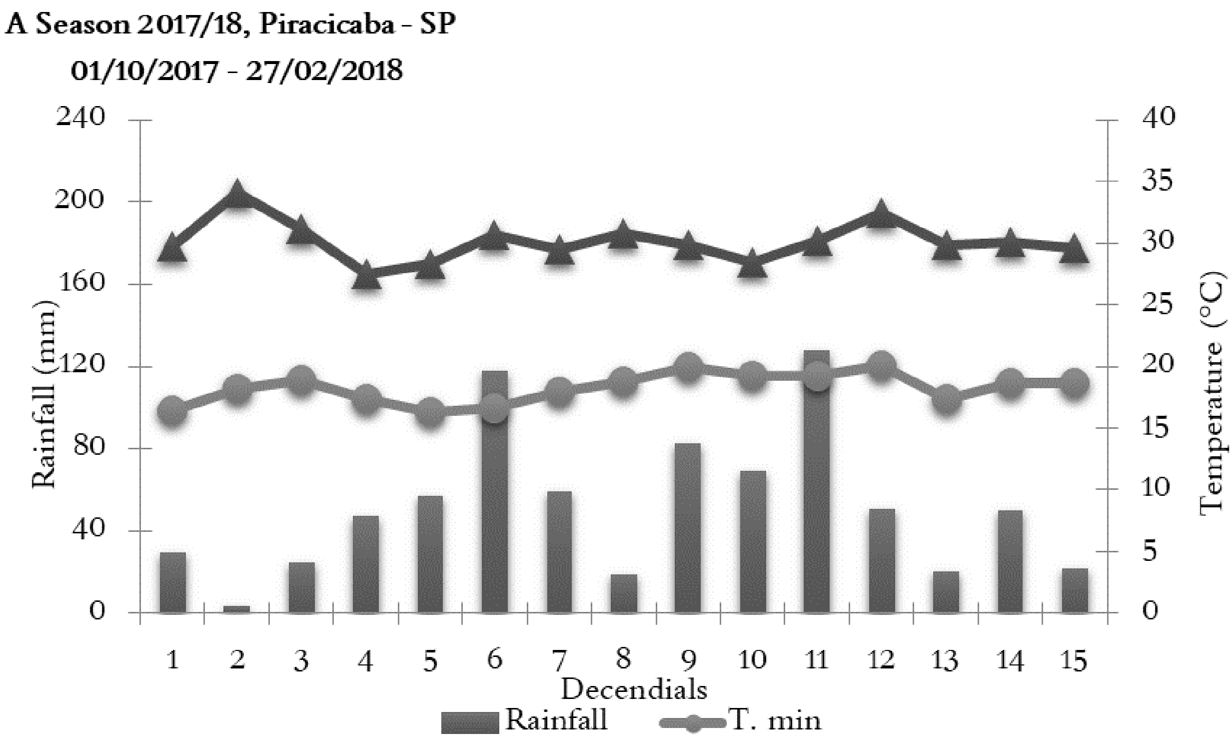
Treatments were applied via CO_2 pressurized coastal sprayer, with bar equipped with four spray nozzle (XR 110.02) at a constant pressure of 2 bar, a flow rate of 0.65 L $min.^{-1}$, working at a height of 50 cm from the target and at a speed of 1 m s^{-1}, reaching an applied band of 50 cm wide with spray nozzle, and providing a spray volume of 200 L ha^{-1}.

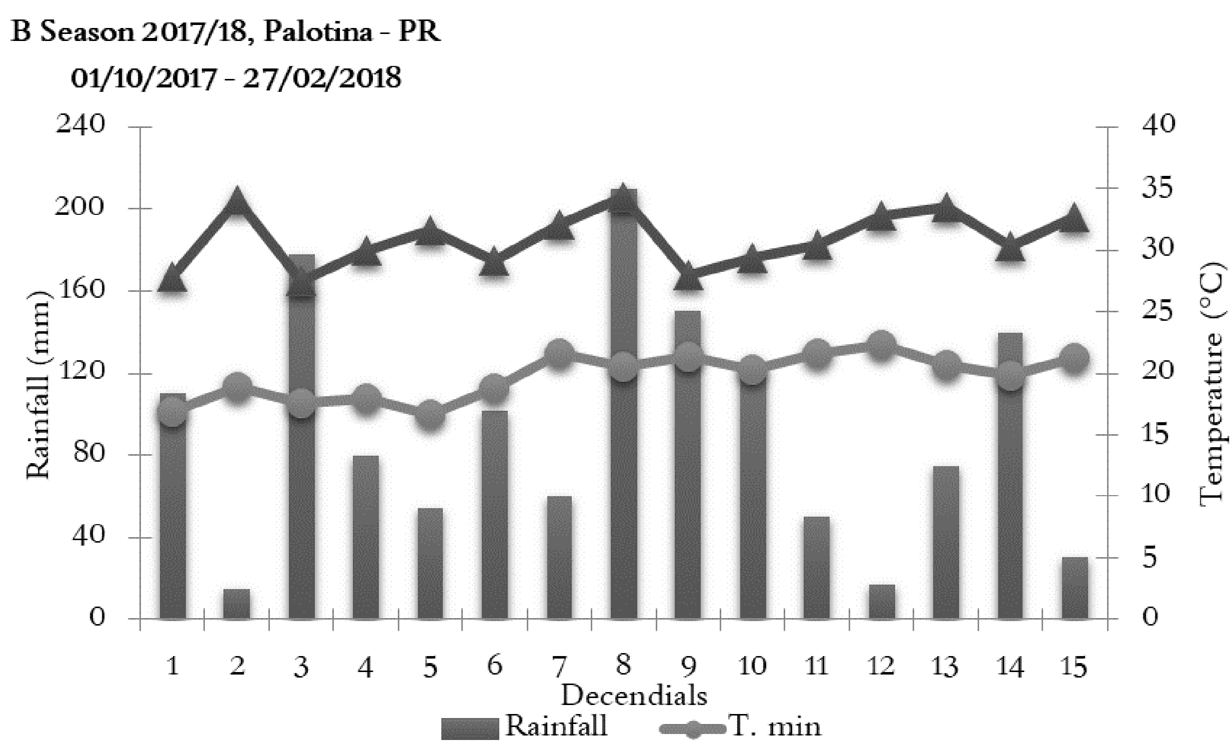
Experiment I was conducted focusing on the evaluation of the efficacy of weed control; whereas experiment II focused mainly on the evaluation of herbicide selectivity. Thus, in experiment II, all the plots were kept free from the presence of weeds, with manual weeding. The area of experiment I was infested, with emphasis on the weeds *Alternanthera tenella*, *Commelina benghalensis*, *Richardia brasilensis*, *Ageratum conyzoides*, *Eleusine indica* and *Digitaria* sp.

Data collection

Crop injury was evaluated in both experiments; this evaluation was performed 7, 14, 21, and 28 days after application (DAA). In experiment I, in the same evaluation dates, weed control was evaluated. For the evaluation of crop injury and weed control, percentage visual marks were assigned, varying from 0 to 100% in each experimental unit, in which 0 represents no injuries and 100%, the death of plants (VELINI et al., 1995).

For experiment I, at 28 DAA, weed was collected from an area with 0.25 m² in each plot. The collected material was dried in a forced ventilation oven at 65°C for 72 hours, after which the dry mass of weeds was measured in an analytical balance with accuracy of two decimal places.





Source: LEB – USP/ESALQ (A), C.Vale - Cooperativa Agroindustrial (B).

Figure 1. Representation of rainfall (mm), maximum (°C) and minimum (°C) temperatures during the season of experiments I (A) and II (B).

Evaluation of variables related to agronomic performance (plant height, height of first pod insertion, and yield) was performed. For experiment I, only yield evaluation was performed. Height evaluations were carried out when the plants reached the R7 stage; to determine the two variables, 10 plants were evaluated, randomly chosen in the useful area of the plots, and the measurements were carried out using a wooden millimeter ruler. The results are expressed in centimeters.

To evaluate the yield, plants were taken from the two central lines, discarding the first and last meter of the plot, totaling a harvested area of 2.7 m^2. The plants were at the R8 stage, i.e., 95% of the pods had the typical mature pod color (FEHR et al., 1971). Afterwards, the pods were threshed in a threshing machine for experiments and cleaned with the aid of sieves. The grains produced in each plot had their mass measured and the moisture corrected to 13%. From these data, the yield was calculated.

Statistical analyses

Data were submitted to analysis of variance and the means of the treatments were compared with the TUKEY (1949) test, at $p < 0.05$ (PIMENTEL-GOMES; GARCIA, 2002).

RESULTS

Selectivity of herbicides

Higher crop injury was verified for herbicide associations, especially for sulfometuron association (15 g a.i. ha^{-1}) + chlorimuron (20 g a.i. ha^{-1}) + glyphosate (960 g a.e. ha^{-1}). This association resulted in 8.75% injury at 7 DAA for experiment I (Table 3), and 38.50% at 14 DAA for experiment II (Table 4).

For experiment I, there was a reduction in the percentages of injury throughout the evaluations. As already noted, triple association caused greater injury in soybean plants at 7 DAA. The association halosulfuron (80 g a.i. ha^{-1}) + glyphosate also caused injury in soybean plants (5%), differing from the control (no application); other treatments did not differ from the control one. In the following evaluations, only the triple association caused injuries in the soybean plants, differing from the control one. At 28 DAA, the triple association provided soybean plants with a crop injury of 2.75%, being a low value. Other treatments did not provide any symptoms of injury to RR2/STS soybean plants in this evaluation.

For experiment II, besides the triple association, other herbicidal treatments caused injuries to soybean plants. Especially the associations of sulfonylureas with glyphosate. At 7 DAA, only the chlorimuron and glyphosate herbicides, applied in isolation, did not differ from the control. At 14 DAA,

Table 2. Treatments applied in post-emergence RR2/STS soybeans. Season 2017/18.

Treatments[1]		Rates[2]
1	control (without weeding)	-
2	control (with weeding)	-
3	sulfometuron	15
4	chlorimuron	20
5	sulfometuron + chlorimuron	15 + 20
6	ethoxysulfuron	60
7	halosulfuron	80
8	glyphosate	960
9	sulfometuron + glyphosate	15 + 960
10	chlorimuron + glyphosate	20 + 960
11	sulfometuron + chlorimuron + glyphosate	15 + 20 + 960
12	ethoxysulfuron + glyphosate	60 + 960
13	halosulfuron + glyphosate	80 + 960

[1]Comercial products: Curavial® (sulfometuron), Classic® (chlorimuron), Gladium® (ethoxysulfuron), Sempra® (halosulfuron), Roundup® Original (glyphosate).
[2]Rates in grams of active ingredient per hectare (g a.i. ha^{-1}), for glyphosate rates in grams of acid equivalent per hectare (g a.e. ha^{-1}).

Table 1. Result of chemical and physical soil analysis of the experimental area, in depth from 0 to 20 cm.

Piracicaba City – São Paulo									
pH ($CaCl_2$)	Al	H + Al	P (resin)	K	Ca	Mg	SB	CEC	V
5.3	< 1.0	25.0	10.0	2.8	26.0	13.0	41.8	66.8	63.0
Clay				Silt			Sand		
41.0				5.0			54.0		
Palotina – Paraná									
pH ($CaCl_2$)	Al	H + Al	P (Mehlich)	K	Ca	Mg	SB	CEC	V
5.6	< 1.0	46.1	19.4	2.2	55.1	14.7	72.0	118.1	61.0
Clay				Silt			Sand		
66.3				18.7			15.0		

Units: Al, H + Al, K, Ca, Mg, sum of bases (SB), and cation exchange capacity (CTC) ($mmol_c$ dm^{-3}); P (mg dm^{-3}); base saturation (V), clay, silt, and sand (%).

Table 3. Crop injury (%) at 7, 14, 21, and 28 days after application of RR2/STS soybeans under application of post-emergence herbicides. Piracicaba City, São Paulo (experiment I), season 2017/18.

Treatments[1]		Crop injury							
		7		14		21		28	
1	co (without weeding)	0.00	a	0.00	a	0.00	a	0.00	a
2	co (with weeding)	0.00	a	0.00	a	0.00	a	0.00	a
3	sul	1.00	ab	0.50	a	0.00	a	0.00	a
4	chl	0.00	a	0.00	a	0.00	a	0.00	a
5	sul + chl	1.75	ab	0.75	a	0.75	ab	0.00	a
6	eth	0.25	a	0.25	a	0.00	a	0.00	a
7	hal	0.25	a	0.00	a	0.00	a	0.00	a
8	gly	0.00	a	0.00	a	0.00	a	0.00	a
9	sul + gly	0.75	a	0.75	a	0.75	ab	0.00	a
10	chl + gly	0.00	a	0.00	a	0.00	a	0.00	a
11	sul + chl + gly	8.75	c	6.00	b	2.75	b	2.75	b
12	eth + gly	3.50	ab	0.50	a	0.00	a	0.00	a
13	hal + gly	5.00	bc	2.25	a	2.00	ab	0.00	a
	Mean	1.63		0.84		0.48		0.21	
	CV (%)	27.76		24.66		28.56		15.94	
	LSD	4.04		2.63		2.66		1.43	
	F	10.745		10.052		2.858		7.118	
	P > F	0.000*		0.000*		0.007*		0.000*	

[1]co (control), sul (sulfometuron – 15 g a.i. ha^{-1}), chl (chlorimuron – 20 g a.i. ha^{-1}) eth (ethoxysulfuron – 60 g a.i. ha^{-1}), hal (halosulfuron - 80 g a.i. ha^{-1}), gly (glyphosate – 960 g a.e. ha^{-1}).
Means followed by the same letter in the column do not differ from each other with the TUKEY (1949) test (*$p < 0.05$).

Table 4. Crop injury (%) at 7, 14, 21, and 28 days after application of RR2/STS soybeans under application of post-emergence herbicides. Palotina City, Paraná (experiment II), season 2017/18.

Treatments[1]		Crop injury							
		7		14		21		28	
1	co (without weeding)	-		-		-		-	
2	co (with weeding)	0.00	a	0.00	a	0.00	a	0.00	a
3	sul	7.00	bc	2.00	ab	0.25	a	0.00	a
4	chl	1.00	a	1.75	ab	0.25	a	0.00	a
5	sul + chl	9.50	c	7.00	c	3.75	bc	3.00	bc
6	eth	7.50	bc	4.75	bc	2.25	ab	1.25	ab
7	hal	5.25	b	2.00	ab	0.50	a	0.00	a
8	gly	0.00	a	0.00	a	0.00	a	0.00	a
9	sul + gly	14.25	d	13.00	d	9.50	d	7.00	d
10	chl + gly	8.50	c	8.25	c	6.00	c	3.75	c
11	sul + chl + gly	36.25	g	38.50	f	33.50	f	28.50	f
12	eth + gly	29.00	f	22.25	e	15.50	e	12.00	e
13	hal + gly	19.75	e	15.75	d	10.50	d	6.25	d
	Mean	11.50		9.60		6.83		5.15	
	CV (%)	10.47		16.56		18.78		16.64	
	LSD	2.99		3.95		3.19		2.13	
	F	365.645		206.633		233.706		372.680	
	P > F	0.000*		0.000*		0.000*		0.000*	

[1]co (control), sul (sulfometuron – 15 g a.i. ha^{-1}), chl (chlorimuron – 20 g a.i. ha^{-1}) eth (ethoxysulfuron – 60 g a.i. ha^{-1}), hal (halosulfuron – 80 g a.i. ha^{-1}), gly (glyphosate – 960 g a.e. ha^{-1}).
Means followed by the same letter in the column do not differ from each other with the TUKEY (1949) test (*$p < 0.05$).

once again, all associations caused injury to soybean plants, whereas ethoxysulfuron (60 g i.a. ha^{-1}) differed from the control only for the application of isolated herbicides. At 21 and 28 DAA, the associations caused injuries and all isolated herbicides did not differ from the control. Finally, at 28 DAA, the triple association caused 28.50% of crop injury, superior to all other treatments.

The tolerance of the BMX Garra RR2/STS cultivar for the application of the chlorimuron and glyphosate herbicides is also highlighted, which did not differ from the control for both experiments, in all evaluations of crop injury.

For the variables related to agronomic performance (experiment II), no differences were verified between treatments for height of insertion of the first pod. However, differences are verified for total plant height and yield (Table 5).

The chlorimuron, sulfometuron, halosulfuron, and glyphosate herbicides, applied in isolation, did not reduce the height of the soybean plants in relation to the control one, and all other treatments provided a reduction in height.

For the yield, some differences were verified. However, it is not possible to verify a standard for the treatments that reduce the values. The application of sulfometuron + chlorimuron + glyphosate presented lower values of soybean yield in relation to ethoxysulfuron, glyphosate and sulfometuron + glyphosate. However, it did not show reduction in relation to the control.

Efficacy of herbicides in weed control

Higher control scores were observed for the isolated application of glyphosate or in association with all sulfonylureas. For these treatments, control scores were higher than 87% in all evaluations, reaching scores above 93% at 28 DAA (Table 6). For the dry mass of weeds, the same treatments were also observed, which presented lower values and did not differ from the weeding control, which was kept free from weed infestation.

Regarding yield, the application of glyphosate — isolated or in associations — is highlighted. However, the chlorimuron and halosulfuron herbicides that presented lower values of weed control did not present reductions in yield when compared to the weeding control. Thus, only the sulfometuron and ethoxysulfuron herbicides reduced yield compared to the weeding control and were still the only ones that did not differ from the control without weeding.

DISCUSSION

As verified in the present study, RR2/STS soybeans were tolerant for post-emergence application of chlorimuron (20 g a.i. ha^{-1}) and glyphosate (960 g a.e. ha^{-1}), without crop injury and reductions in variables related to agronomic performance (SILVA et al., 2016).

Table 5. Variables related to the agronomic performance of RR2/STS soybeans under application of post-emergence herbicides. Palotina City, Paraná (experiment II), season 2017/18.

Treatments[1]		HP	Height		Yield	
1	co (without weeding)	-	-		-	
2	co (with weeding)	26.88	108.97	a	4,296	ab
3	sul	25.72	99.22	abcd	4,081	ab
4	chl	26.63	105.94	abc	4,079	ab
5	sul + chl	25.82	95.38	cde	3,949	ab
6	eth	25.35	95.91	bcd	4,420	a
7	hal	25.53	98.72	abcd	4,231	ab
8	gly	26.16	106.13	ab	4,406	a
9	sul + gly	25.47	98.07	bcd	4,401	a
10	chl + gly	24.91	91.66	def	3,926	ab
11	sul + chl + gly	23.60	84.94	ef	3,809	b
12	eth + gly	24.13	82.57	f	4,060	ab
13	hal + gly	25.13	91.75	def	4,274	ab
	Mean	25.44	96.60		4161.41	
	CV (%)	6.67	4.46		5.56	
	LSD	4.22	10.70		574.22	
	F	1.228	14.245		3.182	
	P > F	0.308^{ns}	0.000**		0.005**	

[1]co (control), sul (sulfometuron – 15 g a.i. ha^{-1}), chl (chlorimuron – 20 g a.i. ha^{-1}) eth (ethoxysulfuron – 60 g a.i. ha^{-1}), hal (halosulfuron – 80 g a.i. ha^{-1}), gly (glyphosate – 960 g a.e. ha^{-1}). HP: height of first pod insertion, and height (cm), yield (kg ha^{-1}).
Means followed by the same letter in the column do not differ from each other with the TUKEY (1949) test (*p < 0.05). ^{ns}non-significant.

In a comparable way, the tolerance for chlorimuron (up to 60 g a.i. ha^{-1}) was verified, and for nicosulfuron (200 g a.i. ha^{-1}) and metsulfuron (7.2 g a.i. ha^{-1}), which are also herbicides from the sulfonylurea group (ALBRECHT et al., 2017).

Other studies also report the efficacy at weed control (POSTON et al., 2008) and selectivity (ALBRECHT et al., 2018; SILVA et al., 2018) of chlorimuron in STS soybeans. However, there is little information on its association with sulfometuron and glyphosate in RR2/STS soybeans, especially in the soil and climatic conditions of Brazil.

The halosulfuron herbicide was shown to be effective in weed control and selective for STS soybeans (NANDULA et al., 2009). The application of this herbicide, isolated or in combination, is also reported as effective in controlling weeds, such as *Armoracia rusticana* (JOHANNING et al., 2016), *Chenopodium album*, *Amaranthus retroflexus*, and *Ambrosia artemissifolia* (LI et al., 2016).

In the present study, sulfonylureas, sulfometuron, chlorimuron, halosulfuron, and ethoxysulfuron were selective for soybean plants, with greater efficacy for associations with glyphosate. However, some associations showed phytotoxic potential, mainly the sulfometuron + chlorimuron + glyphosate association.

JEFFRIES et al. (2014) observed reduction in height and biomass of SS5911N R2 (STS) cultivar for post-emergence application of sulfometuron (4 g a.i. ha^{-1}). PIASECKI; RIZZARDI (2016) observed the efficacy, at control of RR maize voluntary, and selectivity of chlorimuron + sulfometuron for pre-emergence application in the BMX Turbo RR/STS cultivar.

NONEMACHER et al. (2017) verified control of 88% of *Urochloa plantaginea* and *Digitaria ciliaris* at 21 DAA for the application of sulfometuron (15 g ha^{-1} i.a.) + chlorimuron (20 a.i. ha^{-1}), in pre-emergence, followed by the post-emergence application of glyphosate (1,080 a.e. ha^{-1}).

Thus, despite the effectiveness of weed control, caution is recommended in the use of this association in STS soybeans, since the selectivity may vary with the cultivar and mode of application.

The ethoxysulfuron and halosulfuron herbicides are presented as alternatives in weed management, in association with glyphosate in RR2/STS soybeans. Despite crop injury, no reductions in soybean yield were observed for experiment II, whereas for experiment I, in addition to presenting no crop

Table 6. Weed control (%) at 7, 14, 21, and 28 at days after application, dry mass of weeds (g) and yield (kg ha^{-1}) of RR2/STS soybeans under post-emergence herbicide application. Piracicaba City, São Paulo (Experiment I) season 2017/2018.

Treatments[1]		Control 7		Control 14		Control 21		Control 28		Dry mass		Yield	
1	co (without weeding)	0.00	d	0.00	d	0.00	d	0.00	e	16.78	d	1,945	cd
2	co (with weeding)	100.00	a	100.00	a	100.00	a	100.00	a	0.00	a	3,395	ab
3	sul	53.75	c	61.25	bc	56.25	bc	55.00	cd	7.47	c	1,778	d
4	chl	50.00	c	61.25	bc	53.75	bc	46.25	cd	12.66	d	2,256	bcd
5	sul + chl	62.50	b	67.50	b	67.50	b	65.00	b	6.16	bc	3,597	a
6	eth	56.25	b	56.25	bc	45.00	c	37.50	d	14.59	d	1,388	d
7	hal	47.50	c	47.50	c	45.00	c	40.00	d	14.93	d	2,195	bcd
8	gly	88.75	a	93.75	a	96.00	a	96.50	a	1.45	ab	3,156	abc
9	sul + gly	88.75	a	94.50	a	96.75	a	96.75	a	0.93	a	3,725	a
10	chl + gly	87.50	a	93.00	a	94.25	a	94.75	a	1.90	ab	3,807	a
11	sul + chl + gly	89.25	a	93.50	a	94.25	a	95.25	a	1.13	a	3,646	a
12	eth + gly	91.25	a	94.75	a	93.75	a	93.75	a	2.09	ab	3,726	a
13	hal + gly	87.50	a	88.75	a	92.50	a	96.50	a	0.94	a	3,347	ab
Mean		69.46		73.23		71.92		70.55		6.24		2,920	
CV (%)		16.66		17.13		16.02		12.54		32.16		17.88	
LSD		9.57		9.34		8.89		7.10		5.02		1,308	
F		70.466		69.292		90.434		166.148		39.734		11.124	
P > F		0.000*		0.000*		0.000*		0.000*		0.000*		0.000*	

[1]co (control), sul (sulfometuron – 15 g a.i. ha^{-1}), chl (chlorimuron – 20 g a.i. ha^{-1}) eth (ethoxysulfuron – 60 g a.i. ha^{-1}), hal (halosulfuron – 80 g a.i. ha^{-1}), gly (glyphosate – 960 g a.e. ha^{-1}).
Means followed by the same letter in the column do not differ from each other with the TUKEY (1949) test (*$p < 0.05$).

injury, when associated with glyphosate, they were effective in weed control.

Sulfonylureas, ethoxysulfuron, and halosulfuron do not present recommendations for use in soybean. Even for STS soybeans, recommendations are not clear. Halosulfuron is registered in Brazil only for the crop of sugarcane and beans, with recommendation for control of Cyperaceae and voluntary soybean. Ethoxysulfuron is registered in Brazil for the crop of sugarcane, rice, and beans (RODRIGUES; ALMEIDA, 2018; MAPA, 2020).

Thus, the results of the present study place the two herbicides as alternatives for the control of weeds in RR2/STS soybeans. Given the possibility of using other herbicides, in addition to glyphosate, STS soybean may be an alternative for control and prevention of the selection of glyphosate resistant weeds, since the association and rotation of herbicides with different mechanisms of action are important in this sense (COUSENS; FOURNIER-LEVEL, 2018; GREEN, 2018).

CONCLUSION

Sulfometuron, chlorimuron, halosulfuron, and ethoxysulfuron herbicides, in association with glyphosate, applied in post-emergence, were effective in weed control and selective for the BMX Garra RR2/STS soybean cultivar.

The association of sulfometuron + chlorimuron + glyphosate presented phytotoxic potential for the BMX Garra RR2/STS cultivar, although without reductions in yield compared to the control without application. Therefore, caution in the recommendations of use for RR2/STS cultivars is of utmost importance.

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