https://doi.org/10.18406/2316-1817v17nunico20251962 e-ISSN 2316-1817

Broad spectrum effectiveness of pyroxasulfone + flumioxazin for weed control in pre-emergence of soybean

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Received in: 25/10/2024
Accepted in: 11/05/2025

Abstract

It is necessary to search for solutions to control weeds, focusing on pre-emergent herbicides. Pyroxasulfone + flumioxazin is believed to be effective in controlling weeds in soybean, as well as other pre-emergent herbicides used in this crop. This study was developed in order to evaluate the effectiveness of the pre-formulated mixture pyroxasulfone + flumioxazin, for application in pre-emergence of soybean. Experiment was conducted in two trials in the 2020-2021 growing season. The treatments consisted of non-treated control, pyroxasulfone + flumioxazin (90 + 60 g ai ha^{-1}), imazethapyr + flumioxazin (100 g ae ha^{-1} + 50 g ai ha^{-1}), diclosulam (29.4 g ai ha^{-1}), sulfentrazone + diuron (175 + 350 g ai ha^{-1}) and s-metolachlor (1,440 g ai ha^{-1}). Trial 1 was infested with *Digitaria insularis* (sourgrass), *Ipomoea* spp. (morning glory), *Urochloa plantaginea* (alexandergrass), and *Amaranthus hybridus* (smooth pigweed). Trial 2 was infested with sourgrass, morning glory, other grasses, and other broadleaves. Weed control, soybean injury and yield were evaluated. Pyroxasulfone + flumioxazin stood out, which was the only herbicide among the best in all evaluations, demonstrating its broad spectrum of action. Also highlighted are the other formulated premixes, imazethapyr + flumioxazin and sulfentrazone + diuron. Diclosulam was almost always among the most effective in controlling broadleaves, but with the worst performance in controlling grasses; the opposite was observed for s-metolachlor. Herbicides are effective in controlling weeds, with emphasis on pyroxasulfone + flumioxazin, imazethapyr + flumioxazin and sulfentrazone + diuron, effective in controlling sourgrass, smooth pigweed, morning glory, alexandergrass, among others.

Key words: Herbicides. Inhibitors of biosynthesis of VLCFA. PPO inhibitors. *Digitaria insularis*. *Amaranthus hybridus*

Introduction

With the advent of glyphosate-tolerant crops, this herbicide became the most used in grain crops, however intensive use was one of the factors that led to the selection of resistant weed biotypes (DUKE, 2018; GREEN, SIEHL, 2021). Therefore, it is necessary to use other herbicides with different mechanisms of action and herbicides with pre-emergent action. Pre-emergent herbicides are effective in controlling weeds that are difficult to control, whether tolerant or resistant to herbicides (GARCIA et al., 2023).

Studies highlight the effectiveness of pre-emergence herbicides in soybean weed control under different growing conditions (BARNES et al., 2017; BRAZ et al., 2017; UNDERWOOD et al., 2018). 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; RIZZARDI et al., 2020), which provides a competitive advantage to the crop due to the extension of the period prior interference (PPI) (KNEZEVIC et al., 2019; DE SANCTIS et al., 2021; RONCATTO et al., 2023).

In this context, it is necessary to search for solutions to control weeds, focusing on herbicides applied in pre-emergence of weeds and cultivation, whether in formulations with one or more molecules. Thus, pyroxasulfone, a group K3 herbicide (HRAC 15) - inhibitors of biosynthesis of very-long-chain fatty acids (VLCFA), with a broad spectrum of action in weed control (TANETANI et al., 2009; NAKATANI et al., 2016). The application of pyroxasulfone was shown to be effective in controlling weeds in soybean pre-emergence, especially in a premix formulated with flumioxazin (MAHONEY et al., 2014; PERKINS et al., 2021).

Pyroxasulfone + flumioxazin is believed to be effective in controlling weeds in soybean, for pre-emergence application, as well as other pre-emergence herbicides commonly used in this crop. Thus, this work was developed in order to evaluate the effectiveness of the pre-formulated mixture pyroxasulfone + flumioxazin in weed control, for application in pre-emergence of soybean.

Material and methods

The experiment was carried out in two trials in the 2020-2021 growing season, trial 1 located in Maripá, state of Paraná (PR), Brazil (24° 24’ 32.6” S 53° 51’ 45.7” W), and trial 2 located in Itaquiraí, state of Mato Grosso do Sul (MS), Brazil (23° 37’ 21.8” S 54° 09’ 66.7” W). In trial 1, on a very clayey soil (62 % clay, 20 % silt, 15 % sand); in trial 2, on sandy soil (12 % clay, 4 % silt, 84 % sand).

This was a randomized block design with four replications. Treatments consisted of non-treated checkplots and application of pre-emergent pyroxasulfone + flumioxazin (90 + 60 g active ingredient [ai] ha^{-1}; Kyojin®), imazethapyr + flumioxazin (100 g acid equivalent [ae] ha^{-1} + 50 g ai ha^{-1}, Zethamaxx®), diclosulam (29.4 g ai ha^{-1}; Spider® 840 WG), sulfentrazone + diuron (175 + 350 g ai ha^{-1}; Stone®) and s-metolachlor (1,440 g ai ha^{-1}; Dual Gold®).

Experimental units were composed of plots of nine soybean rows (4.05 m) x 5 m in length. The treatments were applied via a CO_2 pressurized backpack sprayer with six AIXR 110.015 nozzles (Teejet®), at a pressure of 2 kgf cm^{-2} and a speed of 3.6 km h^{-1}, providing an application volume of 150 L ha^{-1}. Pre-emergence herbicides were applied immediately after sowing soybean. No-till sowing of soybean cultivar M 6210 IPRO (glyphosate-tolerant) was carried out with row spacing of 0.45 m and 15 seeds m^{-1}. At 29 days after application (DAA) of pre-emergence herbicides, quizalofop (30 g ai ha^{-1}; Targa® Max) + glyphosate (1,000 g ae ha^{-1}; Xeque Mate®) was applied in soybean post-emergence, at V_4-V_5 stage (FEHR et al., 1971), to complement weed control, except for non-treated checkplots.

Pre-emergence herbicides were applied on November 17, 2020, in trial 1, under temperature (T) of 33.7 ºC, relative humidity (RH) of 58.8 % and wind speed of 8.3 km h^{-1}. In trial 2, on December 08, 2020, under T of 29.7 ºC, RH of 52 % and wind speed of 0.3 km h^{-1}. The post-emergence application in trial 1 was carried out on December 16, 2020, under T of 24.9 ºC, RH of 64.9 % and wind speed of 6.6 km h^{-1}; in trial 2, on January 06, 2021, under T of 31.2 ºC, RH of 31.2 % and wind speed of 2.1 km h^{-1}.

Regarding the floristic composition of weeds at the time of application, trial 1 was infested with *Digitaria insularis* (L.) Mez ex Ekman (sourgrass) (0.4 plants m^{-2}), *Ipomoea* spp. (morning glory) (0.7 plants m^{-2}), *Urochloa plantaginea* (Link) R.D.Webster (alexandergrass) (1.1 plants m^{-2}) and *Amaranthus hybridus* L. (smooth pigweed) (1.3 plants m^{-2}). Trial 2 was infested with sourgrass (3.2 plants m^{-2}), morning glory (2.1 plants m^{-2}), other grasses (1.7 plants m^{-2}) and other broadleaves (1.9 plants m^{-2}).

Weed control was evaluated at 7, 14, 21, 28 days after of application (DAA) of pre-emergence herbicides and at soybean harvest in trial 1; and at 14, 28 DAA and at harvest in trial 2. Injury to soybean plants was also evaluated at 14 and 28 DAA of pre-emergence herbicides. For all of these, scores were assigned through visual analysis, to each experimental unit (0 for no injury, up to 100 % for plant death), considering, in this case, symptoms significantly visible in plants, according to their development (VELINI et al., 1995). At harvest, soybean yield was evaluated, seven central rows were harvested and the first and last meter of each plot was discarded. Grain moisture was corrected to 13 % and the results were presented in kg ha^{-1}.

Data were tested for normality (Shapiro-Wilk test) and homogeneity (Levene test) (WARRICK, NIELSEN, 1980), then subjected to analysis of variance (ANOVA) using the F-test ($p \leq 0.05$). Treatment means were compared by Tukey's test at the 5 % level. The Sisvar 5.6 software was used for analysis (FERREIRA, 2011).

Results

Weed control (trial 1)

For the control of sourgrass, the effectiveness of herbicides was ≥ 93 % from 7 to 14 DAA, with no difference between herbicides, with a decrease in control in the following evaluations. At 28 DAA, the most effective herbicides were pyroxasulfone + flumioxazin (87.5 %) and s-metolachlor (98.8 %), superior to the other herbicides. In the last control evaluation, in the soybean harvest, effectiveness ≥ 98.8 % was found for all treatments; and it is noteworthy that at 29 DAA, quizalofop + glyphosate was applied in all herbicide treatments (Table 1).

For the control of morning glory, pyroxasulfone + flumioxazin stood out among the best treatments in all evaluations. At 28 DAA, in addition to the afore mentioned treatment with 85 % control, imazethapyr + flumioxazin (79.3 %) and diclosulam (85 %) were among the most effective. After post-emergence soybean application, no differences were detected between the herbicide treatments at harvest, with an efficacy of at least 96.8 % (Table 2).

Table 1. Sourgrass control at 7, 14, 21, 28 days of application (DAA), and at harvest, with herbicides applied at soybean pre-emergence (trial 1).

Herbicide[1]	Rate[2]	7 DAA	14 DAA	21 DAA	28 DAA	Harvest
	(g ai ha^{-1})			(%)		
Untreated checkplots	-	0.0 b	0.0 b	0.0 c	0.0 c	0.0 b
Pyroxasulfone + flumioxazin	90 + 60	94.3 a	93.8 a	89.3 a	87.5 a	98.8 a
Imazethapyr + flumioxazin	100 + 50	94.0 a	93.0 a	82.5 ab	72.5 b	98.0 a
Diclosulam	29.4	94.8 a	93.0 a	72.5 b	70.0 b	98.3 a
Sulfentrazone + diuron	175 + 350	96.0 a	94.3 a	83.8 a	77.5 b	99.0 a
S-metolachlor	1,440	98.0 a	94.0 a	88.8 a	88.8 a	99.0 a
Mean		79.5	78.0	69.5	66.0	78.9
CV (%)		2.3	1.8	6.5	6.0	0.1
F		*	*	*	*	*

[1]Application at 29 DAA of quizalofop (30 g ai ha^{-1}) + glyphosate (1.000 g ae ha^{-1}) at soybean post-emergence (V_4-V_5 stage) in all treatments, except for the nontreated control. [2]Rate at ae for imazethapyr.

* Significant ($p \leq 0.05$). Means followed by the same letter do not differ from each other by the Tukey's test at the 5 % level.

Source: authors (2021).

Table 2. Morning glory control at 7, 14, 21, 28 days of application (DAA), and at harvest, with herbicides applied at soybean pre-emergence (trial 1).

Herbicide[1]	Rate[2]	7 DAA	14 DAA	21 DAA	28 DAA	Harvest
	(g ai ha^{-1})			(%)		
Untreated checkplots	-	0.0 b	0.0 c	0.0 c	0.0 d	0.0 b
Pyroxasulfone + flumioxazin	90 + 60	96.0 a	89.8 ab	88.0 a	85.0 a	96.5 a
Imazethapyr + flumioxazin	100 + 50	93.8 a	91.8 a	80.5 ab	79.3 a	89.3 a
Diclosulam	29.4	97.3 a	93.0 a	87.5 a	85.0 a	98.0 a
Sulfentrazone + diuron	175 + 350	95.5 a	89.0 ab	76.3 b	67.5 b	88.8 a
S-metolachlor	1,440	95.8 a	85.0 b	73.8 b	52.5 c	95.3 a
Mean		79.7	74.8	67.7	61.5	74.8
CV (%)		3.2	3.3	6.6	4.8	0.1
F		*	*	*	*	*

[1]Application at 29 DAA of quizalofop (30 g ai ha^{-1}) + glyphosate (1.000 g ae ha^{-1}) at soybean post-emergence (V_4-V_5 stage) in all treatments, except for the nontreated control. [2]Rate at ae for imazethapyr.

* Significant ($p \leq 0.05$). Means followed by the same letter do not differ from each other by the Tukey's test at the 5 % level.

Source: authors (2021).

There was a worse performance of diclosulam in the control of alexandergrass, inferior to the others, which did not differ from each other and showed effectiveness ≥90 % at 28 DAA. At harvest, with the effect of post-emergence application, no differences were detected between the herbicide treatments with effectiveness of up to 98.8 % (Table 3). For the control of smooth pigweed, efficiency was observed for the application of all pre-emergence herbicides. With better results at 28 DAA, for pyroxasulfone + flumioxazin (97 %), imazethapyr + flumioxazin (97 %) and diclosulam (96 %) (Table 4).

Table 3. Alexandergrass control at 7, 14, 21, 28 days of application (DAA), and at harvest, with herbicides applied at soybean pre-emergence (trial 1).

Herbicide[1]	Rate[2]	7 DAA	14 DAA	21 DAA	28 DAA	Harvest
	(g ai ha^{-1})			(%)		
Untreated checkplots	-	0.0 b	0.0 b	0.0 c	0.0 c	0.0 b
Pyroxasulfone + flumioxazin	90 + 60	97.8 a	97.3 a	95.0 a	92.5 a	98.5 a
Imazethapyr + flumioxazin	100 + 50	97.5 a	96.8 a	91.5 a	90.5 a	96.8 a
Diclosulam	29.4	98.0 a	97.3 a	81.3 b	76.3 b	98.8 a
Sulfentrazone + diuron	175 + 350	98.0 a	97.3 a	90.0 a	90.0 a	98.0 a
S-metolachlor	1,440	98.0 a	97.3 a	92.0 a	91.3 a	97.3 a
Mean		81.5	81.0	75.0	73.4	78.3
CV (%)		0.6	0.9	4.6	7.2	0.1
F		*	*	*	*	*

[1]Application at 29 DAA of quizalofop (30 g ai ha^{-1}) + glyphosate (1.000 g ae ha^{-1}) at soybean post-emergence (V_4-V_5 stage) in all treatments, except for the nontreated control. [2]Rate at ae for imazethapyr.

* Significant ($p \leq 0.05$). Means followed by the same letter, do not differ from each other by the Tukey's test at the 5 % level.

Source: authors (2021).

Table 4. Smooth pigweed control at 7, 14, 21, 28 days of application (DAA), and at harvest, with herbicides applied at soybean pre-emergence (trial 1).

Herbicide[1]	Rate[2] (g ai ha^{-1})	7 DAA	14 DAA	21 DAA	28 DAA	Harvest
		(%)				
Untreated checkplots	-	0.0 b	0.0 b	0.0 b	0.0 d	0.0 b
Pyroxasulfone + flumioxazin	90 + 60	98.0 a	97.0 a	97.0 a	97.0 a	99.0 a
Imazethapyr + flumioxazin	100 + 50	98.0 a	97.3 a	97.0 a	97.0 a	99.0 a
Diclosulam	29.4	98.0 a	97.3 a	96.3 a	96.0 ab	99.0 a
Sulfentrazone + diuron	175 + 350	98.0 a	97.0 a	96.5 a	91.3 c	99.0 a
S-metolachlor	1,440	98.0 a	97.3 a	95.5 a	94.5 b	99.0 a
Mean		81,7	81.0	80.4	79.3	79.2
CV (%)		0,1	0.6	0.9	1.0	0.1
F		*	*	*	*	*

[1]Application at 29 DAA of quizalofop (30 g ai ha^{-1}) + glyphosate (1.000 g ae ha^{-1}) at soybean post-emergence (V_4-V_5 stage) in all treatments, except for the nontreated control. [2]Rate at ae for imazethapyr.

* Significant ($p \leq 0.05$). Means followed by the same letter do not differ from each other by the Tukey's test at the 5 % level.

Source: authors (2021).

Weed control (trial 2)

Diclosulam had the worst performance in the control of sourgrass, with 53.8 % at 28 DAA, while the other treatments resulted in at least 85.3 %. Even after the application of quizalofop + glyphosate, the treatment with diclosulam reached 81.3 % control at harvest. Meanwhile, the levels of effectiveness for other grasses at harvest were close to those verified for sourgrass, but with no differences between herbicides (Table 5).

Table 5. Sourgrass control at 14 and 28 days of application (DAA), control of sourgrass and other grasses at soybean harvest, under herbicides applied at soybean pre-emergence (trial 2).

Herbicide[1]	Rate[2] (g ai ha^{-1})	Sourgrass 14 DAA	Sourgrass 28 DAA	Sourgrass Harvest	Grasses Harvest
		(%)			
Untreated checkplots	-	0.0 c	0.0 c	0.0 b	0.0 b
Pyroxasulfone + flumioxazin	90 + 60	96.0 a	94.8 a	94.5 ab	93.3 a
Imazethapyr + flumioxazin	100 + 50	93.3 a	85.3 a	86.8 ab	85.5 a
Diclosulam	29.4	82.5 b	53.8 b	81.3 b	81.3 a
Sulfentrazone + diuron	175 + 350	92.8 a	92.0 a	95.0 a	95.0 a
S-metolachlor	1,440	91.8 a	88.0 a	94.0 ab	94.0 a
Mean		76.0	69.0	75.3	74.8
CV (%)		4.2	6.1	7.7	8.8
F		*	*	*	*

[1]Application at 29 DAA of quizalofop (30 g ai ha^{-1}) + glyphosate (1.000 g ae ha^{-1}) at soybean post-emergence (V_4-V_5 stage) in all treatments, except for the nontreated control. [2]Rate at ae for imazethapyr.

* Significant ($p \leq 0.05$). Means followed by the same letter do not differ from each other by the Tukey's test at the 5 % level.

Source: authors (2021).

S-metolachlor was not effective in the control of morning glory, with 41.3 % at 28 DAA, lower than the others. At harvest, after application in post-emergence, the effectiveness of s-metolachlor was 67 %, with the worst performance among pre-emergence herbicides, once the best treatments reached up to 83.8 % control at harvest. For the control of other broadleaves, no differences were found between pre-emergence herbicides, with effectiveness between 74.5 and 83.1 % (Table 6).

Crop injury and yield

Regarding the injury to soybean, symptoms were observed only for the application of diclosulam, but a maximum of 4.8 % in trial 1, with subsequent recovery of the plants. No symptoms of injury were found on soybean plants in trial 2 (data not shown). For yield, no differences were detected between the herbicide treatments in trial 2, with all of them superior to the checkplots (no application). For trial 1, soybean yield under application of diclosulam or s-metolachlor did not differ from the checkplots, this was not observed for other pre-emergence herbicides. Lower yield is a consequence of the lower level of control of these herbicides for some weeds; diclosulam in general was less effective in controlling grasses and s-metolachlor in controlling broadleaves, other treatments were effective with a broader spectrum of action (Table 7).

Discussion

Among the pre-emergence herbicides, pyroxasulfone + flumioxazin stood out, which was the only treatment among the best in all evaluations, demonstrating its broad spectrum of action. The application of pyroxasulfone + flumioxazin was shown to be effective in controlling grasses and broadleaves in pre-emergence of soybean (MAHONEY et al., 2014; HEDGES et al., 2018; PERKINS et al., 2021). Soybean tolerance to this product is also highlighted, as reported in other studies (MAHONEY et al., 2014; McNAUGHTON et al., 2014).

Table 6. Morning glory control at 14 and 28 days of application (DAA), control of morning glory and other broadleaves at soybean harvest, under herbicides applied at soybean pre-emergence (trial 2)

Herbicide[1]	**Rate**[2] **(g ai ha^{-1})**	**Morning glory**			**Broadleaves**
		14 DAA	**28 DAA**	**Harvest**	**Harvest**
		%			
Untreated checkplots	-	0.0 c	0.0 c	0.0 c	0.0 b
Pyroxasulfone + flumioxazin	90 + 60	98.0 a	97.3 a	83.8 a	76.3 a
Imazethapyr + flumioxazin	100 + 50	96.8 a	95.8 a	77.5 ab	77.5 a
Diclosulam	29.4	95.0 a	91.0 a	83.8 a	81.3 a
Sulfentrazone + diuron	175 + 350	97.5 a	96.3 a	83.8 a	80.0 a
S-metolachlor	1,440	42.5 b	41.3 b	67.0 b	74.5 a
Mean		71.6	70.3	66.0	64.9
CV (%)		4.2	8.2	7.6	9.0
F		*	*	*	*

[1]Application at 29 DAA of quizalofop (30 g ai ha^{-1}) + glyphosate (1.000 g ae ha^{-1}) at soybean post-emergence (V_4-V_5 stage) in all treatments, except for the nontreated control. [2]Rate at ae for imazethapyr.

* Significant ($p \leq 0.05$). Means followed by the same letter do not differ from each other by the Tukey's test at the 5 % level.

Source: authors (2021).

Table 7. Soybean yield under herbicide application at soybean pre-emergence

Herbicide[1]	**Rate**[2]	**Trial 1**	**Trial 2**
	(g ai ha^{-1})	**(kg ha^{-1})**	
Untreated checkplots	-	2,328 c	426 b
Pyroxasulfone + flumioxazin	90 + 60	3,820 a	2,560 a
Imazethapyr + flumioxazin	100 + 50	3,741 a	2,432 a
Diclosulam	29.4	3,303 abc	2,213 a
Sulfentrazone + diuron	175 + 350	3,607 ab	2,492 a
S-metolachlor	1,440	3,007 abc	2,040 a
Mean		3,270	2,027
CV (%)		12.5	14.1
F		*	*

[1]Application at 29 DAA of quizalofop (30 g ai ha^{-1}) + glyphosate (1.000 g ae ha^{-1}) at soybean post-emergence (V_4-V_5 stage) in all treatments, except for the nontreated control. [2]Rate at ae for imazethapyr.

* Significant ($p \leq 0.05$). Means followed by the same letter do not differ from each other by the Tukey's test at the 5 % level.

Source: authors (2021).

Other pre-emergence herbicides composed of formulated premixes, imazethapyr + flumioxazin and sulfentrazone + diuron, with a broad spectrum of action, are also highlighted. These formulated premixes have shown promise in the management of soybean weeds, being selective for crops (ALBRECHT et al., 2020, 2021; CANTU et al., 2021; BARBOSA et al., 2023). The effectiveness of protoporphyrinogen oxidase (PPO) inhibitors, such as flumioxazin and sulfentrazone, in combination with other herbicides with different mechanisms of action, is reiterated with a broad spectrum of action (CORREIA, 2020; HOUSTON et al., 2021).

The other pre-emergence herbicides evaluated in this study had a variable effectiveness depending on weed species. Diclosulam was almost always among the most effective in controlling eudicot species, but with the worst performance in controlling grasses, and the opposite was observed for s-metolachlor. In other studies, a similar spectrum of action was found for diclosulam (GOLUBEV, 2021) or s-metolachlor (SOLTANI et al., 2019). Even so, almost always when in combination to post-emergence herbicides in soybean, high efficacy results were achieved. This indicates that pre-emergence applications can suppress the need for a post-emergence application, but commonly it does not replace post-emergence control, the combination of the two applications is usually the most effective (SARANGI, JHALA, 2019; SONG et al., 2020). This characterizes the importance of pre-emergence herbicides in increasing PPI (DE SANCTIS et al., 2021), which facilitates weed management at soybean post-emergence.

The use of herbicides in pre-emergence is essential in reducing weed emergence in the field, helping post-emergence control (JOVANOVIĆ et al., 2020; RIZZARDI et al., 2020; BAUER et al., 2021). With emphasis on the pre-formulated mixtures pyroxasulfone + flumioxazin, imazethapyr + flumioxazin and sulfentrazone + diuron, which were almost always equal to or superior to pre-emergence herbicides composed of a single molecule. Mainly pyroxasulfone + flumioxazin, which was the only treatment among the most effective in all evaluations for all weeds in both trials. This formulated premix is presented as an alternative for pre-emergence application on soybean, with effectiveness similar or superior to herbicides commonly used in this application modality.

Finally, it is noteworthy that pre-emergence herbicides assume a prominent role within the resistance management in the integrated management of weeds. Since effective and selective options for post-emergence soybeans in controlling resistant weeds are becoming scarce. Sometimes, with the infestation of weeds in post-emergence of soybean, in addition to interference, there are problems of injury, as many of the herbicides combined to glyphosate, such as acetolactate synthase (ALS) inhibitors (ALONSO et al., 2011) or PPO inhibitors (BEAM et al., 2018) may cause this problem. This reinforces the pre-emergence herbicides use in this study, as only diclosulam caused visual damage, but of a maximum of 4.8 % in trial 1, with subsequent recovery of the plants.

Conclusion

The herbicides applied in soybean pre-emergence are effective in controlling weeds, with emphasis on pyroxasulfone + flumioxazin, imazethapyr + flumioxazin and sulfentrazone + diuron, effective in controlling sourgrass, morning glory, smooth pigweed, alexandergrass, among other grasses and broadleaves. There is a need to combine pre- and post-emergence herbicides for effective weed management in soybean, in which pyroxasulfone + flumioxazin is a promising option for pre-emergence application.

Acknowledgements

The authors are grateful for the support of the Federal University of Paraná (UFPR) and the *Supra Pesquisa* team at UFPR.

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