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ASSOCIATION BETWEEN HERBICIDES AND SUGARCANE STRAW FOR CONTROLLING *Urochloa decumbens* (Stapf) R. D. Webster IN PEANUTS

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Abstract

Signal grass (*Urochloa decumbens*) is a common troublesome weed in peanut areas, and its control is essential. This study evaluated the efficacy of herbicides associated with harvested sugarcane residues in controlling *U. decumbens*. Herbicides were applied with or without sugarcane straw during *U. decumbens* pre-emergence (imazapic, imazethapyr + flumioxazin, diclosulam, s-metolachlor, clomazone, sulfentrazone, sulfentrazone + diuron, pyroxasulfone, and trifluralin) and post-emergence (imazapic, imazethapyr, bentazon + imazamox, quizalofop-p-ethyl, clethodim, haloxyfop-p-methyl, fluazifop-p-butyl, propaquizafop, and glyphosate). Sugarcane residues reduced plant emergence (68%) and emergence speed (77%). Except for imazapic, every pre-emergent herbicide application without sugarcane straw promoted control levels higher than 90%. The highest *U. decumbens* control levels (over 95%) occurred mainly with clomazone, pyroxasulfone, and trifluralin, regardless of the straw factor. Glyphosate and haloxyfop herbicides promoted the highest *U. decumbens* control levels, primarily reducing growth characteristics, followed by propaquizafop, quizalofop-p-ethyl, and fluazifop-p-butyl. The study concluded that sugarcane straw reduced *U. decumbens* emergence. Clomazone, pyroxasulfone, and trifluralin herbicides applied during pre-emergence promoted the highest *U. decumbens* control levels, regardless of the presence or absence of sugarcane straw. All pre-emergence herbicide applications without sugarcane straw controlled *U. decumbens* satisfactorily, except for imazapic. Glyphosate and haloxyfop-p-methyl herbicides applied post-emergence provided the highest *U. decumbens* control levels, followed by propaquizafop, quizalofop-p-ethyl, and fluazifop-p-butyl, regardless of the presence of sugarcane straw.

Keywords: *Arachis hypogaea* L. Chemical control. *Saccharum officinarum* L. Signal grass. Weed.

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1. Introduction

Weed in peanut crops may cause yield losses higher than 70% (Hare et al. 2019; Seale et al. 2020; Arthur et al. 2022). Furthermore, weeds appearing at the end of the crop season may interfere with harvesting, increase production costs, hinder peanut drying, and favor grain contamination with mycotoxin levels, as restricted and enforced by sanitary legislation and consumer markets (Suassuna et al. 2009; Johnson 2019; Alam et al. 2020).

In Brazil, peanuts are often cultivated in sugarcane and pasture reform areas (Costa et al. 2019; Sampaio and Fredo 2021), so managing weeds has become more complex due to the weed flora selected in these crop areas. As for monocot plants, Brazilian pastures widely use signal grass (*Urochloa decumbens*) as forage (Ferreira et al. 2021). That has been frequently mentioned as a serious problem, mainly when this species is poorly controlled and maintained in the crop from the middle to the end of the peanut cycle.

Chemical weed control most commonly prevents weed interference due to its high efficacy, flexibility, and low cost. Using herbicides correctly has proven efficient against several monocot and dicot plants (Jat et al. 2011). Comparatively, the amount of herbicide applied in peanut crops in other countries, such as the USA (Ferrel et al. 2015) and Argentina (Daita et al. 2017), two of the primary peanut producers and exporters, evidences that the herbicide options for managing weeds in Brazilian peanut crops are insufficient. Compared to other annual dicot crops, the number of registered herbicides for peanut cultivation in the Brazilian Ministry of Agriculture and Livestock represents only 7% and 18% of the total recommended application in soybeans and beans, respectively. Among 13 herbicide active ingredients registered for Brazilian crops, five predominantly work on monocot weeds: trifluralin, pendimethalin, and pyroxasulfone for pre-emergence applications, and quizalofop-p-ethyl and clethodim for post-emergence applications. Other herbicides control monocot and dicot weeds: glyphosate for post-emergence before peanut sowing (desiccation); alachlor, s-metolachlor, sulfentrazone, and the flumioxazin + imazethapyr premixture for pre-emergence; imazapic for pre- and post-emergence; and imazethapyr, bentazon, and bentazon + imazamox for post-emergence (Brasil 2023).

However, besides the registered herbicides in Brazil, the literature indicates the possibility of expanding research on grassy products for peanuts, such as clomazone, diclosulam, haloxyfop-p-methyl, fluazifop-p-methyl, and propaquizafop (Dourado Neto et al. 2013; Ferrel et al. 2015; Leon and Tillman 2015; Daita et al. 2017). Another relevant issue for peanut production in sugarcane reform areas is the interference of straw on herbicide applications, mainly during pre-emergence, as it intercepts and retains the applied product, and most may be adsorbed, reducing its action on weeds (Araldi et al. 2015; Matos et al. 2016).

Thus, considering the possibility of peanut sowing without disturbing the soil in sugarcane reform areas and the need for research on troublesome weed management, this study evaluated the association between herbicides and sugarcane straw on the efficacy of *U. decumbens* control in peanut crops.

2. Material and Methods

Two experiments were conducted in a greenhouse at 22° 43’ 38’’ S and 47° 01’ 01’’ W. The first and second experiments applied post- and pre-emergent herbicides from January to February and March to April 2023.

The substrate in both assays comprised soil extract from an arable layer (0 to 20 cm) of fallow agricultural land in Jaguariúna (São Paulo, Brazil), classified as Red-Yellow Latosol (Embrapa, 2018), containing 80.5% sand, 1.5% silt, and 18.0% clay. The chemical characteristics were water pH = 5.3, Ca^{+2} = 0.9 cmolc dm^{-3}, Mg^{+2} = 0.4 cmolc dm^{-3}, H+Al = 1.6 cmolc dm^{-3}, CEC = 3.3 cmolc dm^{-3}, V = 50.8%, Al^{+3} = 0.0 cmolc dm^{-3}, P = 10.0 mg dm^{-3}, K^{+} = 0.35 cmolc dm^{-3}, and OM = 24.0 g kg^{-1}. Next, the soil was sieved in a 2mm mash, dried under shade, corrected, and fertilized with dolomitic limestone and monoammonium phosphate at 1 and 3 kg m^{-3}. The substrate was used to fill plastic vases with a 2L capacity, constituting the experimental plots for both experiments. The seeds were sown at 1cm deep, with 0.5 g of seeds per pot. Daily irrigation maintained humidity through a system of micro-sprinklers with pre-programmed activation.

The experiments presented a complete randomized design with five replications, and the treatments were arranged in a 10x2 factorial scheme. Factor A in the pre-emergent experiment included imazapic (98 g ha^{-1}), imazethapyr + flumioxazin (120 + 60 g ha^{-1}), diclosulam (35 g ha^{-1}), s-metolachlor (1200 g ha^{-1}), clomazone (1008 g ha^{-1}), sulfentrazone (300 g ha^{-1}), sulfentrazone + diuron (245 + 490 g ha^{-1}), pyroxasulfone (200 g ha^{-1}), trifluralin (2400 g ha^{-1}) herbicides, and an untreated control without application. Factor B corresponded to the absence and presence of sugarcane straw. The straw, composed mainly of leaves, was collected from the plant material deposited on the soil immediately after harvesting the sugarcane and dried in an air circulation oven at 60°C. The straw amount put on the soil immediately after sowing corresponded to 10 t ha^{-1}.

In the post-emergent experiment, factor A consisted of imazapic (98 g ha^{-1}), imazethapyr (40 g ha^{-1}), bentazon + imazamox (900 + 42 g ha^{-1}), quizalofop-p-ethyl (100 g ha^{-1}), clethodim (108 g ha^{-1}), haloxyfop-p-methyl (60 g ha^{-1}), fluazifop-p-butyl (187.5 g ha^{-1}), propaquizafop (125 g ha^{-1}), glyphosate (1500 g ha^{-1}) herbicides, and an untreated control without application. Factor B corresponded to the absence and presence of sugarcane straw, using the same amount of straw collected in the first experiment after sowing.

Herbicide applications

The herbicides were applied one and 20 days after sowing (DAS) in pre- and post-emergent experiments. Regarding post-emergent applications, the plants were at a 1-2 tiller stage and 24cm high on average. The average plant number per vase was 47 and 17 without and with straw, respectively. The herbicides were applied with a CO_2 backpack sprayer equipped with four ST 11002 and XR 11002 flat fan nozzles in a boom for pre- and post-emergent applications, respectively. The nozzles were spaced 0.5 m apart, positioned at a 0.5m height from the target, and had a carrier volume of 200 L ha^{-1}. The spray solutions received adjuvants for post-emergence applications based on usage recommendations for herbicides in Brazil (Brasil 2023): mineral oil (782 g L^{-1}) at 0.5% (v v^{-1}) concentration for clethodim, haloxyfop-p-butyl, and propaquizafop, and methyl esters of vegetable oil [37.5% (v v^{-1})] at 0.5% (v v^{-1}) concentration for imazapic and bentazon + imazamox. Wind speed, temperature, and relative humidity data were recorded at the beginning and end of applications by a digital thermo-hygrometer, whose averages corresponded to 0 m s^{-1}, 28°C, and 70% in the first experiment and 0 m s^{-1}, 29°C, and 65% in the second. After herbicide applications, a 10-hour interval was used for restarting irrigation, with about 4 mm daily for both experiments.

Measured characteristics

The pre-emergent experiment counted the number of plants until emergence stabilization nine DAS to determine the number of emerged plants, emergence speed (ES), and emergence speed index (ESI), according to Maguire (1962).

Both experiments evaluated height and weed control 14 and 28 days after applications (DAA). Height was measured from the soil surface to the highest point of the plant. The control was evaluated with visual notes, where 0% meant no damage, and 100% was plant death, according to Velini et al. (1995). Both experiments evaluated the plants' shoot and root dry biomasses 28 DAA by drying the plant material in a forced air ventilation oven at 65°C for 72 hours until reaching constant mass and then weighing it on a semi-analytical balance.

Statistical analysis

The data underwent the analysis of variance, and the Scott Knott test compared the means at a 0.05 probability.

3. Results

Pre-emergent applications

The analysis of variance for *U. decumbens* emerged seedlings eight DAA, ESI, and ES indicated a significant effect from straw and herbicide factors and their interaction (Table 1). When comparing only the untreated controls, straw reduced weed emergence, ESI, and ES by 68%, 82%, and 77%, respectively.

Considering the absence of straw, applying imazethapyr + flumioxazin, sulfentrazone, and sulfentrazone + diuron caused the highest decreases in emerged plants, with percentages of the untreated control ranging from 88% to 98%. The reductions in emerged plants due to s-metolachlor, clomazone, pyroxasulfone, and trifluralin herbicides were 69%, 62%, 66%, and 65%, respectively. In the presence of straw, only pyroxasulfone, trifluralin, diclosulam, and clomazone significantly reduced emergence, corresponding to 86%, 47%, 44%, and 11%, respectively, related to the untreated control. Both treatments containing sulfentrazone caused the highest ESI and ES reductions, which averaged 84% and 91%, respectively. These two characteristics showed lower reductions with trifluralin (68%), pyroxasulfone (58%), imazethapyr + flumioxazin (25%), and clomazone (18%). However, herbicides did not affect ESI and ES in the presence of sugarcane straw.

Table 1. Effects of pre-emergent herbicides and sugarcane straw on *Urochloa decumbens* emergence.

	Emerged seedlings		Emergence speed index		Emergence speed	
Treatments	AS	PS	AS	PS	AS	PS
Untreated control	39.8^{Aa}	12.8^{Ab}	42.1^{Aa}	7.6^{Ab}	35.3^{Aa}	8.2^{Ab}
Imazapic	37.6^{Aa}	11.6^{Ab}	36.7^{Aa}	8.1^{Ab}	31.4^{Aa}	8.3^{Ab}
Imazethapyr + flumioxazin	4.8^{Da}	10.4^{Aa}	17.0^{Ca}	7.6^{Ab}	10.3^{Ca}	7.8^{Aa}
Diclosulam	32.4^{Ba}	7.2^{Bb}	31.3^{Ba}	4.9^{Ab}	27.0^{Ba}	5.1^{Ab}
S-metolachlor	12.4^{Ca}	11.4^{Aa}	14.7^{Ca}	7.0^{Ab}	12.4^{Ca}	7.6^{Ab}
Clomazone	15.2^{Ca}	3.6^{Bb}	37.6^{Aa}	5.0^{Ab}	26.6^{Ba}	4.3^{Ab}
Sulfentrazone	1.0^{Db}	10.2^{Aa}	5.0^{Da}	6.4^{Aa}	2.5^{Da}	6.6^{Aa}
Sulfentrazone + diuron	2.2^{Db}	9.2^{Aa}	8.4^{Da}	5.7^{Aa}	3.7^{Da}	6.1^{Aa}
Pyroxasulfone	13.6^{Ca}	6.8^{Bb}	17.9^{Ca}	5.4^{Ab}	14.8^{Ca}	5.3^{Ab}
Trifluralin	14.0^{Ca}	1.8^{Bb}	13.1^{Ca}	0.9^{Ab}	11.9^{Ca}	1.1^{Ab}
F_{value} Straw	86.5*		331.4*		237.0*	
F_{value} Herbicide	26.9*		23.2*		26.7*	
F_{value} Straw*Herbicide	21.9*		19.5*		23.3*	
CV (%)	36.7		32.2		31.7	

AS: absence of straw; PS: presence of straw; [1] For each evaluated characteristic, means followed by the same capital letter in the column and lowercase letter in the row do not differ significantly by the Scott Knott test ($p \leq 0.05$). * Significant at 5% probability; ^{NS} not significant.

Imazapic caused the lowest control levels without straw, corresponding to 81% 14 DAA and 63% 28 DAA (Table 2). The other compounds promoted the highest control levels, higher than 85% and 90% 14 and 28 DAA, respectively. However, the best control levels occurred only with clomazone, pyroxasulfone, and trifluralin with straw, showing rates from 88% to 99% in both evaluations and a similar effect with diclosulam (85%) 28 DAA. Therefore, the visual control caused by imazethapyr + flumioxazin, s-metolachlor, sulfentrazone, and sulfentrazone + diuron were reduced or suppressed due to straw presence 14 and 28 DAA.

Imazapic caused the lowest effect on plant height without straw, showing reductions corresponding to 81% (14 DAA) and 42% (28 DAA) compared to the control, with a similar effect from diclosulam (85%) only 14 DAA (Table 2). The other herbicides promoted the highest plant height reductions, with 96% and 92% 14 and 28 DAA, respectively. As in the control evaluations, clomazone, pyroxasulfone, and trifluralin promoted the highest effect on plant height when applied on the straw, with reductions of 86% 14 DAA and 80% 28 DAA. Except for the trifluralin treatment 14 DAA and clomazone at both evaluations, the other herbicide treatments presented lower plant height without than with straw.

All herbicides decreased shoot dry mass when applied directly to the soil (without straw), with the lowest effect caused by imazapic, corresponding to 59% compared to the untreated control (Table 3). The other compounds reduced 97% of shoot dry mass, on average. The applications with straw showed significant reductions in shoot dry mass only for clomazone (100%), pyroxasulfone (93%), trifluralin (85%), diclosulam (80%), and imazapic (69%). For the untreated control and imazapic treatment, sugarcane straw presence reduced shoot dry mass by 63% and 72%, respectively, compared to these herbicide treatments without straw. However, straw presence increased shoot dry mass when applying imazethapyr + flumioxazin (24%), sulfentrazone (33%), and sulfentrazone + diuron (17%). Considering root dry mass and the absence of sugarcane straw, the highest reductions occurred with clomazone, sulfentrazone, sulfentrazone + diuron, pyroxasulfone, and imazethapyr applications, corresponding to 99%, on average, compared to the control.

Except for s-metolachlor, the other herbicides significantly decreased this characteristic in the presence of straw, corresponding to 78%, on average, compared to the untreated control. As in dry shoots, the sugarcane straw reduced root mass by 85% and 59% for the untreated control and imazapic treatments, respectively, compared to the absence of the straw.

Table 2. Effects of pre-emergent herbicides and sugarcane straw on the control and plant height of *Urochloa decumbens*.

Treatments	Control (%)				Plant height (cm)			
	14 DAA		28 DAA		14 DAA		28 DAA	
	AS	PS	AS	PS	AS	PS	AS	PS
Untreated control	0.0Ba	0.0Ca	0.0Ca	0.0Ca	16.6Aa	12.5Aa	27.3Aa	23.8Aa
Imazapic	81.2Ba	72.4Ba	63.4Ba	69.2Ba	3.2Ba	4.0Ca	15.8Ba	10.1Ba
Imazethapyr + flumioxazin	99.0Aa	67.0Bb	98.6Aa	65.0Bb	0.4Cb	6.0Ba	1.2Cb	11.3Ba
Diclosulam	86.4Aa	76.4Ba	91.6Aa	85.4Aa	2.5Bb	5.4Ba	5.3Ca	8.1Ba
S-metolachlor	97.8Aa	59.6Bb	94.0Aa	61.8Bb	1.4Cb	8.3Ba	4.5Cb	14.4Ba
Clomazone	100.0Aa	98.4Aa	100.0Aa	99.2Aa	0.0Ca	0.7Da	0.0Ca	1.2Ca
Sulfentrazone	99.4Aa	56.2Bb	98.4Aa	53.8Bb	0.8Cb	7.8Ba	2.0Cb	13.2Ba
Sulfentrazone + diuron	98.6Aa	64.2Bb	96.4Aa	67.2Bb	0.8Cb	7.7Ba	2.8Cb	11.4Ba
Pyroxasulfone	99.2Aa	87.8Aa	100.0Aa	96.0Aa	0.4Cb	3.0Ca	0.0Cb	4.3Ca
Trifluralin	96.8Aa	94.4Aa	97.6Aa	90.2Aa	0.9Ca	1.4Da	1.8Cb	9.0Ba
F_{value} Straw	46.1*		27.9*		72.5*		38.0*	
F_{value} Herbicide	43.0*		39.9*		28.0*		16.6*	
F_{value} Straw*Herbicide	3.9*		3.8*		6.9*		3.6*	
CV (%)	17.5		18.9		21.7		31.4	

AS: absence of straw; PS: presence of straw; [1] For each evaluated characteristic, means followed by the same capital letter in the column and lowercase letter in the row do not differ significantly by the Scott Knott test (p ≤ 0.05). * Significant at 5% probability; NS not significant.

Table 3. Effect of pre-emergent herbicides and sugarcane straw on shoot and root dry masses of *Urochloa decumbens*.

Treatments	Shoot dry mass (g)		Root dry mass (g)	
	AS	PS	AS	PS
Untreated control	2.60Aa	0.97Ab	8.44Aa	1.23Ab
Imazapic	1.07Ba	0.30Bb	1.06Ba	0.43Bb
Imazethapyr + flumioxazin	0.02Cb	0.47Aa	0.05Da	0.39Ba
Diclosulam	0.20Ca	0.19Ba	0.41Ca	0.06Ba
S-metolachlor	0.27Ca	0.56Aa	0.47Ca	0.80Aa
Clomazone	0.00Ca	0.00Ba	0.00Da	0.00Ba
Sulfentrazone	0.02Cb	0.66Aa	0.01Da	0.47Ba
Sulfentrazone + diuron	0.03Cb	0.52Aa	0.04Da	0.55Ba
Pyroxasulfone	0.00Ca	0.07Ba	0.00Da	0.13Ba
Trifluralin	0.05Ca	0.15Ba	0.02Da	0.17Ba
F_{value} Straw	0.11NS		12.3*	
F_{value} Herbicide	20.4*		57.0*	
F_{value} Straw*Herbicide	7.9*		28.6*	
CV (%)	11.3		12.9	

AS: absence of straw; PS: presence of straw; 1 For each evaluated characteristic, means followed by the same capital letter in the column and lowercase letters in the row do not differ significantly by the Scott Knott test (p ≤ 0.05). * Significant at 5% probability; NS not significant.

Post-emergent applications

Glyphosate and haloxyfop herbicides promoted the highest *U. decumbens* control levels, ranging from 92% 14 DAA to 100% 28 DAA, regardless of the absence or presence of straw (Table 4). A similar effect occurred with propaquizafop 28 DAA in the absence of straw (97% and 98%, respectively) and with fluazifop (91%) and quizalofop (99%) only in the absence of straw. Compared to these herbicides, lower control levels occurred for clethodim in both evaluations, ranging from 23% to 56% without straw and 50% to 68% with straw. A few herbicide treatments, such as imazapic, clethodim, and propaquizafop (only 14 DAA), showed that straw presence increased the control level compared to the same compounds without straw.

Regarding plant height evaluations (Table 4), glyphosate caused 100% reductions, regardless of the straw factor 14 DAA. This herbicide effect was followed by decreases caused by haloxyfop, fluazifop, and quizalofop in the absence of straw (64%, on average), similar to clethodim and propaquizafop when applied on the straw. As for the 28 DAA evaluation, haloxyfop and glyphosate caused 100% plant height reductions, followed by a similar effect caused by propaquizafop, quizalofop (both with 91%, on average), and fluazifop (80%).

Table 4. Effects of post-emergent herbicides and sugarcane straw on control and plant height of *Urochloa decumbens*.

Treatments	Control (%)				Plant height (cm)		
	14 DAA		28 DAA		14 DAA		28 DAA
	AS	PS	AS	PS	AS	PS	---
Untreated control	0.0^{Ea}	0.0^{Ea}	0.0^{Da}	0.0^{Fa}	42.6^{Aa}	48.0^{Aa}	47.4^{A}
Imazapic	4.6^{Eb}	23.0^{Da}	17.0^{Cb}	43.6^{Da}	26.9^{Ba}	16.5^{Cb}	27.4^{D}
Imazethapyr	4.4^{Ea}	3.0^{Ea}	4.0^{Da}	7.4^{Fa}	39.7^{Aa}	42.5^{Aa}	43.3^{B}
Bentazon + imazamox	8.2^{Ea}	14.0^{Da}	10.0^{Ca}	15.6^{Ea}	29.6^{Ba}	31.5^{Ba}	33.7^{C}
Quizalofop-p-ethyl	73.6^{Ba}	78.8^{Ba}	98.6^{Aa}	90.4^{Ba}	12.8^{Ca}	9.7^{Ca}	4.9^{G}
Clethodim	23.2^{Db}	50.2^{Ca}	56.0^{Bb}	68.2^{Ca}	23.9^{Ba}	12.7^{Cb}	14.3^{E}
Haloxyfop-p-methyl	92.2^{Aa}	96.4^{Aa}	100.0^{Aa}	100.0^{Aa}	17.0^{Ca}	10.5^{Ca}	0.0^{H}
Fluazifop-p-butyl	62.0^{Ca}	54.4^{Ca}	90.8^{Aa}	71.4^{Cb}	15.6^{Ca}	15.2^{Ca}	9.3^{F}
Propaquizafop	60.4^{Cb}	81.2^{Ba}	97.0^{Aa}	98.2^{Aa}	24.7^{Ba}	12.9^{Cb}	3.2^{G}
Glyphosate	99.4^{Aa}	100.0^{Aa}	100.0^{Aa}	100.0^{Aa}	0.0^{Da}	0.0^{Da}	0.0^{H}
F_{value} Straw	14.4^{*}		2.8^{NS}		6.9^{*}		2.1^{NS}
F_{value} Herbicide	158.2^{*}		426.4^{*}		47.9^{*}		210.0^{*}
F_{value} Straw*Herbicide	3.3^{*}		8.7^{*}		2.5^{*}		2.0^{NS}
CV (%)	20.7		11.0		29.2		21.6

AS: absence of straw; PS: presence of straw; 1 For each evaluated characteristic, means followed by the same capital letter in the column and lowercase letter in the row do not differ significantly by the Scott Knott test (p ≤ 0.05). * Significant at 5% probability; NS not significant.

Regarding shoot dry mass (Table 5), glyphosate, haloxyfop, propaquizafop, quizalofop, and fluazifop caused the highest reductions (98%, on average) compared to the untreated control without straw, followed by similar decreases from clethodim (47%) and imazapic (26%). When straw was present, glyphosate, haloxyfop, quizalofop and propaquizafop caused the highest reductions (97%, on average), followed by intermediate decreases from fluazifop and clethodim (71%, on average). Regarding herbicide treatments with significant effects compared to the untreated control with or without straw, the straw increased shoot mass for fluazifop. However, it reduced shoot mass when applying imazapic and clethodim compared to the same herbicide treatments without straw. Concerning root dry mass compared to the untreated control, glyphosate, haloxyfop, and quizalofop caused the highest reductions (80%, on average), followed by effects from propaquizafop and fluazifop (65%, on average).

4. Discussion

Considering the untreated control in the first experiment (Table 1), significant reductions in emerged plants (68%) and emergence speed (80%, on average) occurred due to the presence of sugarcane straw (10 t ha^{-1}). Additionally, sugarcane straw reduced shoot (63%) and root (85%) dry masses in the untreated control compared to the same treatment without straw (Table 3). Silva Junior et al. (2016) verified that 12 t ha^{-1} of sugarcane straw reduced *U. decumbens* emergence by over 90%, reaching 100% at 18 t ha^{-1}, and germination time increased (36%) with 15 t ha^{-1} of straw. The authors mentioned that decreases in *U. decumbens* emergence and emergence speed are probably due to lower thermal variations provided by sugarcane straw. This species usually has higher emergence rates in periods with higher temperatures. Thus, straw on the soil may reduce the temperature range, affecting this species' germination.

Therefore, based on *U. decumbens* control exclusively due to straw presence in the pre-emergent experiment, it is worth considering sowing peanuts on sugarcane residues to improve control, aiding integrated weed management. Regarding the effects on the crop, Bolonhezi et al. (2007) showed no statistical differences in pod yield, kernel yield, the number of pods, and pegs between no-tillage (direct peanut sowing on sugarcane residues - from 6.0 to 14.8 t ha^{-1} of dry mass) and conventional tillage systems despite the decrease in plant stand. Similarly, Crusciol and Soratto (2009) inferred that cover crops (*Urochloa brizantha*, *Pennisetum glaucum*, and *Panicum maximum*), even with high straw mulch production (from 6.0 to 17.0 t ha^{-1} of dry mass), did not influence peanut pod yield in the no-till system. Also, production management systems with cultures implemented in the straw provide many other benefits, including protection against soil erosion, higher organic carbon content, increased microbial population, and soil moisture conservation (Matos et al. 2016).

Table 5. Effects of post-emergent herbicides and sugarcane straw on shoot and root dry masses of *Urochloa decumbens*.

Treatments	Shoot dry mass (g)		Root dry mass (g)
	AS	PS	---
Untreated control	12.9^{Aa}	9.2^{Aa}	14.2^{A}
Imazapic	9.6^{Ba}	4.7^{Bb}	11.5^{B}
Imazethapyr	15.3^{Aa}	11.0^{Ab}	16.9^{A}
Bentazon + imazamox	11.5^{Aa}	5.9^{Bb}	12.8^{A}
Quizalofop-p-ethyl	0.4^{Ca}	0.6^{Da}	3.4^{D}
Clethodim	6.9^{Ba}	2.7^{Cb}	8.8^{B}
Haloxyfop-p-methyl	0.0^{Ca}	0.0^{Da}	2.7^{D}
Fluazifop-p-butyl	0.8^{Cb}	2.7^{Ca}	4.6^{C}
Propaquizafop	0.3^{Ca}	0.4^{Da}	5.3^{C}
Glyphosate	0.0^{Ca}	0.0^{Da}	2.5^{D}
F_{value} Straw	13.9*		98.8*
F_{value} Herbicide	63.9*		24.7*
F_{value} Straw*Herbicide	3.8*		1.4^{NS}
CV (%)	19.7		19.5

AS: absence of straw; PS: presence of straw; 1 For each evaluated characteristic, means followed by the same capital letter in the column and lowercase letters in the row do not differ significantly by the Scott Knott test (p ≤ 0.05). * Significant at 5% probability; NS not significant.

Except for imazapic, every pre-emergent herbicide applied directly on the soil in this study without sugarcane straw promoted *U. decumbens* control levels higher than 85% 14 DAA and 90% 28 DAA (Table 2). Consequently, these compounds reduced plant height (Table 2) and shoot and root dry masses by more than 90% 28 DAA (Table 3). The high control levels of this study confirm *U. decumbens* susceptibility to pre-emergent applications of clomazone, sulfentrazone, diuron + sulfentrazone, and trifluralin, corroborating weed target recommendations for these herbicides (Rodrigues and Almeida, 2018; Brasil, 2023). Using pre-emergent doses of imazapic (87.5, 175, and 350 g ha^{-1}), Vasconcelos et al. (2020) found, respectively, 10%, 62.5%, and 60% of control, 22%, 79%, and 81% of shoot mass reduction, and 61%, 88%, and 87% of root mass reduction for *U. decumbens*. Damin et al. (2021) verified that pre-emergent applications of sulfentrazone (600 g ha^{-1}) provided more than 80% of control levels and shoot mass reductions for *U. decumbens* in four soil types. However, they found control and shoot mass lower than 45% only in a Gley soil, probably due to its pH lower than 5.0 and a large amount of organic matter.

Applying pre-emergent herbicides on the straw promoted the highest *U. decumbens* control levels (over 95%), mainly with clomazone, pyroxasulfone, and trifluralin, reflecting the most substantial reductions in plant height and shoot and root dry masses. Despite the lower control effect on *U. decumbens* from the other herbicides, diclosulam stood out with 85% control 28 DAA, intermediate plant height reduction 28 DAA, and similar shoot and root dry mass decreases compared to the three described pre-emergent treatments.

Correia et al. (2012) observed *U decumbens* control levels of more than 80% from pre-emergent applications of s-metolachlor (from 1440 to 2400 kg ha^{-1}) or clomazone (1200 g ha^{-1}), regardless of 14 or 20 t ha^{-1} of sugarcane straw. Santos et al. (2022) verified that, despite low herbicide retention by sugarcane residues, clomazone (900 g ha^{-1}), imazapic (245 g ha^{-1}), and sulfentrazone (800 g) satisfactorily controlled and reduced *U. decumbens* shoot mass from 2 up to 10 t ha^{-1}, regardless of the presence of sugarcane straw. Comparing this information to the present study, the straw interference in s-metolachlor, sulfentrazone, and imazapic effects might be due to the lower doses (1200, 300, and 98 g ha^{-1}) than those in the mentioned studies, as they were based on label recommendations for peanuts (Brasil 2023), usually lower than doses used in sugarcane crops.

Regarding the interference of straw on the action of the pre-emergent herbicides, research has found that herbicide interception and retention at the plant material deposited on the soil promotes lower leaching of certain active ingredients through the straw, reducing herbicide availability and causing a lower contact and uptake by weeds (Ferreira et al. 2016; Ferreira et al. 2020). Studies using diuron (Araldi et al. 2016) and sulfentrazone (Carbonari et al. 2016) demonstrated that their retention by sugarcane straw depends on factors such as the amount of plant residues on the soil, the period without precipitation, and the rain volume after application.

Herbicides with high solubility in water, low octanol-water coefficient (K_{ow}), and low steam pressure tend to be more adequate for pre-emergent applications in areas with crop residues on the soil, as they may leach more easily from mulch and become more available to weeds (Silva and Monquero 2013; Matos et al. 2016). Therefore, the lowest control effects of some treatments in this study due to straw presence may be explained by the low solubility in water for some compounds, such as flumioxazin (1.8 mg L^{-1}), diuron (42 mg L^{-1}), and sulfentrazone (110 mg L^{-1}). However, the low solubility for other tested herbicides, such as trifluralin and pyroxasulfone (0.3 and 3.5 mg L^{-1}, respectively) (Rodrigues and Almeida 2018; Nakatani et al. 2016), did not affect their efficacy in controlling *U. decumbens*. Nonetheless, pyroxasulfone has a low K_{ow} (2.4) (Silva and Monquero, 2013; Nakatani et al. 2016), which might have contributed to its low retention in the straw. In this context, Matte et al. (2021) verified that pyroxasulfone (100 g ha^{-1}) herbicide had a higher ability to transpose 5 t ha^{-1} of soybean or corn straw (5 t ha^{-1}) and control *Digitaria insularis* after 30 mm of precipitation than s-metolachlor (1920 g ha^{-1}) and trifluralin (1125 g ha^{-1}). Thus, considering the potential for using the no-tillage peanut system on sugarcane straw, the factors that may affect the dynamics and the biological action of pre-emergent herbicides to control *U. decumbens* and other common species in this crop should receive more attention.

Considering the characteristics evaluated in the second experiment (Tables 4 and 5), the post-emergent applications of glyphosate and haloxyfop promoted the highest *U. decumbens* control, regardless of the straw factor. Their effects continued due to propaquizafop, quizalofop-p-ethyl, and fluazifop-p-butyl applications. Corroborating these findings, Barroso et al. (2010) applied herbicides at a 2-tiller stage, detecting the best *U. decumbens* control with haloxyfop-p-methyl (60 g ha^{-1}) compared to fluazifop-p-butyl (125 g ha^{-1}) and clethodim (84 g ha^{-1}), which corresponded to 96%, 72%, and 33% 44 DAA. Although the clethodim herbicide belongs to the ACCAse inhibitor action mode, such as haloxyfop, propaquizafop, quizalofop-p-ethyl, and fluazifop-p-butyl, the *U. decumbens* control results in this study were unsatisfactory (from 56% to 68%). Clethodim also caused lower reductions in growth characteristics (plant height and dry mass) compared to grass herbicides tested with the same action mode. Imazapic, imazethapyr, and bentazon + imazamox promoted the lowest *U. decumbens* control levels, ranging from 7% to 44% 28 DAA. Minor reduction effects occurred in growth characteristics, indicating that these compounds are not fit for controlling *U. decumbens*.

Other studies have reported high glyphosate and fluazifop-p-butyl efficacy for controlling *U. decumbens*. Brighenti and Muller (2014) verified that glyphosate (1080 g ha^{-1}) applied on 30-cm-high *U. decumbens* promoted 99% control 21 DAA, with similar results for the same herbicide dose mixed with imazethapyr at 100 g ha^{-1}. Anesio et al. (2017) found that *U. decumbens* was highly susceptible to glyphosate (720 g ha^{-1}) and fluazifop-p-butyl (200 g ha^{-1}) for 3-tiller stage applications and 30 cm of plant height. Silveira et al. (2019) inferred that glyphosate (90 g ha^{-1}) or fluazifop-p-butyl (200 g ha^{-1}) effectively controlled *U. decumbens* 50 DAS. Rodrigues et al. (2020) found that this weed species was susceptible to glyphosate (90 g ha^{-1}) or fluazifop-p-butyl (300 g ha^{-1}) for applications on 20-cm-high plants.

Some post-emergence applications showed few significant differences between the results without and with straw. Most cases demonstrated intermediate or low herbicide effects compared to the highest values. That was not expected, as these herbicides are usually most uptake by leaves. For instance, the highest shoot mass reduction for clethodim in the presence of straw might be due to more spraying herbicide distribution on the leaves, considering the lower plant density in this situation, which would contribute to its higher deposition, uptake, and effects on the plants compared to no straw. However, herbicides also uptake by roots, such as imazapic and imazamox, may present the highest shoot dry mass reduction for straw related to some herbicide amount retained by sugarcane residues, reducing its action compared to no straw (Table 5). Santos et al. (2022) found that sugarcane straw (10 t ha^{-1}) did not affect imazapic (245 g ha^{-1}) efficacy for controlling *U. decumbens* through pre-emergent applications. In this case, the higher herbicide dose than that of our study might explain the interference not identified by the authors.

Based on *U. decumbens* susceptibility to the chemical treatments in this study and the herbicides registered to peanuts in the Brazilian Ministry of Agriculture (Brasil 2023), glyphosate may be used in pre-sowing peanut desiccation applications. As for pre-emergent applications, pyroxasulfone and trifluralin are available for this crop with high control levels, regardless of the straw factor. For pre-emergent applications directly on the soil, sulfentrazone, s-metolachlor, imazethapyr + flumioxazin, and imazapic may be options for managing *U. decumbens*. Considering post-emergent applications after peanut emergence, the best results occurred with quizalofop-p-ethyl. Thus, it is possible to infer the existence of more options for pre-emergent applications. Consequently, this application mode cannot be neglected when managing *U. decumbens* in peanut crop areas in Brazil. However, new control strategies require improved development for controlling this species post-emergence, mainly for escaping plants or new emergence fluxes along the peanut cycle.

In this context, new studies are needed on the application timing for post-emergent herbicides. Thus, evaluations involving risks of herbicide residues in peanut grains should also be included, especially for later applications focusing on controlling *U. decumbens* and other troublesome weed species. In this context, new studies are required on these and other herbicides with application potential on peanut crops, considering mixtures, doses, application timing, and selectivity aspects. Different control methods should be associated with improving *U. decumbens* management, considering sowing peanuts directly on crop residues, mainly where peanuts are cultivated for reforming sugarcane crop areas.

5. Conclusions

The 10 t ha^{-1} of sugarcane straw reduced *U. decumbens* emergence.

Clomazone (1008 g ha^{-1}), pyroxasulfone (200 g ha^{-1}), and trifluralin (2400 g ha^{-1}) herbicides applied during pre-emergence promoted the highest *U. decumbens* control levels, regardless of the presence of sugarcane straw. All herbicide pre-emergent applications without sugarcane straw satisfactorily controlled *U. decumbens*, except for imazapic (98 g ha^{-1}).

Glyphosate (1500 g ha^{-1}) and haloxyfop-p-methyl (60 g ha^{-1}) herbicides in post-emergent applications, regardless of the presence of sugarcane straw, provided the best *U. decumbens* control levels, followed by propaquizafop (125 g ha^{-1}), quizalofop-p-ethyl (100 g ha^{-1}), and fluazifop-p-butyl (187.5 g ha^{-1}).

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