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Scientific Note

Effectiveness of the S-metolachlor herbicide in the control of *Urochloa decumbens* in Brazilian Savanna soils[1]

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ABSTRACT

The soil characteristics play a pivotal role in shaping the efficacy of pre-emergent herbicides in the context of weed control and their phytotoxic influence on the target crop. This study aimed to assess the effect of soil attributes on the efficacy of the S-metolachlor herbicide, as well as to determine its optimal dose in relation to soil attributes. The experiment was conducted under greenhouse conditions, in a 6 x 8 factorial design, with five replications, using 6 soil types [GMd (Typic Humaquept), NVe (Rhodic Eutrustox), CXbd (Typic Dystrustepts), LVw (Rhodic Acrustox), LVdf (Rhodic Haplustox) and RQo (Typic Quartzpsamment)] and 8 doses of the product [0, 1/8x, 1/4x, 1/3x, 1/2x, 1x, 2x and 4x (with x = 1,920 g ha^{-1})]. Dose-response curves were constructed and the outcomes showed that, for the LVw, RQo and CXbd soils, there was a control of over 90 % with less than half of the recommended dose, while, for the other soil types, lower reductions are possible. The base saturation and soil organic matter content showed a substantial negative correlation (-0.73 and -0.74, respectively) with the efficacy of the product. The S-metolachlor doses required to achieve a control of 90 % are contingent upon specific soil attributes, especially the variables base saturation and organic matter. The clay content did not present any correlation with the S-metolachlor doses for the studied soils.

KEYWORDS: Bioavailability, pre-emergent herbicides, weed control.

RESUMO

Eficácia do herbicida S-metolacloro no controle de *Urochloa decumbens* em solos de Cerrado

As características do solo desempenham papel fundamental na eficácia de herbicidas pré-emergentes, no contexto do controle de plantas daninhas e da sua influência fitotóxica na cultura alvo. Objetivou-se avaliar o efeito dos atributos do solo na eficácia do herbicida S-metolacloro e determinar sua dose ideal em função dos atributos do solo. O experimento foi desenvolvido em casa-de-vegetação, em esquema fatorial 6 x 8, com 5 repetições, utilizando-se 6 tipos de solo [Melânico Distrófico (GMd), Nitossolo Vermelho Eutrófico (NVe), Cambissolo Háplico Tb Distrófico (CXbd), Latossolo Vermelho Ácrico (LVw), Latossolo Vermelho Distróférrico (LVdf) e Neossolo Quartzarênico Órtico (RQo)] e 8 doses do produto [0, 1/8x, 1/4x, 1/3x, 1/2x, 1x, 2x e 4x (com x = 1.920 g ha^{-1})]. Curvas de dose-resposta foram construídas e os resultados mostraram que, para LVw, RQo e CXbd, a dose pode ser reduzida, sendo obtido controle acima de 90 % com menos da metade da dose recomendada, enquanto, para os demais solos, menores reduções são possíveis. A saturação de bases e o teor de matéria orgânica do solo apresentaram correlação forte (-0,73 e -0,74, respectivamente) com a eficácia do produto. As doses de S-metolacloro necessárias para garantir 90 % de controle são afetadas pelos atributos do solo, especialmente a saturação de bases e matéria orgânica. O teor de argila não apresentou correlação com as doses de S-metolacloro nos solos estudados.

PALAVRAS-CHAVE: Biodisponibilidade, herbicidas pré-emergentes, controle de plantas daninhas.

Brazil prominently features as one of the world's largest consumers of pesticides, a market segment that annually yields approximately US$ 12 billion (Sindiveg 2021). Furthermore, it ranks 13th among 20 countries, concerning pesticide use relatively to the quantity of agricultural products produced (Sindiveg 2021).

The upsurge in pesticide application is intrinsically tied to the cultivation of genetically modified glyphosate-resistant soybean and the concurrent proliferation of weed species that exhibit resistance to this particular herbicide. This scenario has needed the introduction of alternative herbicidal products (Vargas & Gazziero 2008). In this context, pre-emergent herbicides have appeared as tools for weed control, offering the ability to manage susceptible plants over more extended periods (Melo et al. 2010, Teixeira Júnior et al. 2020). This serves to mitigate competition with crops during the critical period of interference, which is when the presence

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of weeds can engender substantial yield losses in cultivated crops.

Among the pre-emergent herbicides, S-metolachlor has garnered approval from the Brazilian Ministry of Agriculture, Livestock and Supply for use in crops such as cotton, sugarcane, bean, corn and soybean (Karam et al. 2003, Soltani et al. 2008, Santos et al. 2012). Characterized by the molecular formula $C_{15}H_{22}ClNO_2$, S-metolachlor can be applied either in pre-emergence or incorporated in pre-planting to control various monocots and dicotyledons. It functions as an inhibitor of long-chain fatty acid synthesis, thereby restraining the growth of seedling shoots and roots (Vidal & Fleck 2001). Classified within the chemical group of acetamides, this herbicide manifests as a non-ionizable molecule, exhibiting a dissipation half-life in soil ($t_{1/2}$) ranging from 6 to 100 days, contingent upon environmental conditions within the study area (O'Connell et al. 1998, Dinelli et al. 2000, Seybold et al. 2001, Mersie et al. 2004, Accinelli et al. 2005, Ma et al. 2006). Its physicochemical properties include a water solubility (S) of 480 mg L^{-1}, vapor pressure of 3.7 (mPa) at 20 ºC, Koc of 200 L kg^{-1} and Log Kow of 3.05 at 25 ºC (University of Hertfordshire 2022). Its degradation in soil is intricately linked to microbiological activity (Ma et al. 2006).

Existing research underscores the substantial influence of soil attributes on the efficacy of pre-emergent herbicides in weed control, their phytotoxic impact on the target crop (Damin et al. 2021, Pacheco et al. 2022), management practices (Alletto et al. 2013), environmental conditions, and their interplay (Mancuso et al. 2011). Organic fractions and clay content are the most influential soil attributes in relation to herbicide behavior (Inoue et al. 2003, Boivin et al. 2005, Rossi et al. 2005, Monquero et al. 2010).

Indeed, the sorption of S-metolachlor into the soil exhibits a positive correlation with organic matter and clay content (Weber et al. 2003, Gannon et al. 2013). Notably, the Brazilian Savanna region owns distinctive edaphoclimatic conditions that distinguish it from other biomes. This distinctive environment is characterized by high levels of iron (Fe) and aluminum (Al) oxides in the clay fraction, coupled with a relatively high anion exchange capacity, low cation exchange capacity, low base saturation and organic matter content. This unique profile may significantly impact the behavior of the herbicide, subsequently influencing its effectiveness and residual activity (Alves et al. 2004). The behavior of pre-emergent herbicides, particularly with respect to their efficacy and residual effects, varies across Brazilian Savanna soils, thus underscoring the potential for dosage reduction in select soil types. Furthermore, within these soils, clay content is an inadequate parameter for predicting the efficacy and residual effects of certain pre-emergent herbicides (Damin et al. 2021, Pacheco et al. 2022).

Consequently, it is imperative to accumulate knowledge pertaining to the efficacy, bioavailability and environmental dynamics of S-metolachlor in various soils. Such insights, acquired through the use of bioindicator plants, are crucial for the formulation of management strategies that minimize environmental contamination risks (Borowik et al. 2017), while concurrently enhancing profitability for agricultural producers. Thus, this study aimed to evaluate the efficacy of S-metolachlor in Brazilian Savanna soils and identify relevant soil attributes that can be employed to customize the ideal herbicide dose for each soil type.

The experiment was conducted in a greenhouse at the Universidade Federal de Goiás, in Goiânia, Goiás state, Brazil (16º35'S, 49º16'W and 749 m of altitude), between April 28 and May 26, 2021.

A completely randomized design was employed, in a 6 x 8 factorial arrangement, with five replications, resulting in a total of 240 experimental units. The factors under consideration were six soil types, classified according to Santos et al. (2018) and USDA (2014), respectively, as it follows: Gleissolo Melânico Distrófico - GMd (Typic Humaquept); Nitossolo Vermelho Eutrófico - NVe (Rhodic Eutrustox); Cambissolo Háplico Tb Distrófico - CXbd (Typic Dystrustepts); Latossolo Vermelho Ácrico - LVw (Rhodic Acrustox); Latossolo Vermelho Distróférrico - LVdf (Rhodic Haplustox); and Neossolo Quartzarênico órtico - RQo (Typic Quartzpsamment).

The S-metolachlor herbicide was administered at eight different doses [0, 1/8x, 1/4x, 1/3x, 1/2x, 1x, 2x and 4x], in relation to the maximum recommended dose, with x representing 1,920 g ha^{-1} of active ingredient.

Each experimental unit comprised pots with a volume equivalent to 0.2 L. The pots were filled with air-dried fine soil collected at the 0.0-0.2 m layer. The soil chemical characterization was performed according to Santos et al. (2018), and the soil chemical profile is presented in Table 1, while the Table 2 shows the particle size composition of the soils.

The soil moisture was adjusted to 60 % of the maximum soil water retention capacity (WRC) and, subsequently, ten *Urochloa decumbens* seeds were sown in each pot, showing an 80 % germination rate. The moisture levels were maintained at 60 % of the WRC throughout the experiment via daily weighing on an electronic scale. Within 24 hours of sowing, the herbicide was applied at doses of 0; 240; 480; 640; 960; 1,920; 3,840; and 7,680 g a.i. ha^{-1}. The commercial product employed was Dual Gold®, containing 960 g L^{-1} of active ingredient. A 200 L ha^{-1} solution volume was administered with a working pressure of 2.0 kgf cm^{-2}. The application was conducted with a knapsack sprayer pressurized with CO_2, coupled to a 2-m-wide spray bar and four flat jet nozzles (XR 110.02), spaced 0.50 m apart.

The evaluations of emergence and phytotoxicity were carried out at intervals of 7, 14, 21 and 28 days after application (DAA), while the emergence was quantified by counting the number of emerged seedlings. The phytotoxicity assessments relied on visual scoring, which ranged from 0 %, signifying no impact on the bioindicator species, to 100 %, representing complete plant mortality (SBCPD 1995).

At 28 DAA, the plant shoots were harvested. Following drying in an oven with forced air circulation at 65 ºC, for 72 hours, the collected material was weighed on a precision scale (0.0001 g) to determine the dry matter, whose data were then converted into percentage of dry matter reduction concerning the control treatment (0 dose), which was designated as having 100 % of dry matter. Other treatments exhibited a percentage of this mass as a result of the reduction induced by the herbicidal product (Pacheco et al. 2022).

Table 2. Particle size composition of soils.

Soil	Clay	Silt	Sand	Texture
	g kg^{-1}			
LVw	480.0	120.0	400.0	Clay
RQo	80.0	40.0	880.0	Sandy
CXbd	610.0	120.0	270.0	Heavy clay
NVe	630.0	130.0	240.0	Heavy clay
GMd	340.0	90.0	570.0	Sandy clay
LVdf	440.0	110.0	450.0	Clay

LVw: Latossolo Vermelho Ácrico (Rhodic Acrustox); RQo: Neossolo Quartzarênico Órtico (Typic Quartzpsamment); CXbd: Cambissolo Háplico Tb Distrófico (Typic Dystrustepts); GMd: Gleissolo Melânico Distrófico (Typic Humaquept); NVe: Nitossolo Vermelho Eutrófico (Rhodic Eutrustox); LVdf: Latossolo Vermelho Distroférrico (Rhodic Haplustox).

The data obtained from the dose-response study were subjected to analysis of variance through the F test, and if the F test was found to be significant, the Tukey test (p = 0.05) was used to compare qualitative treatments, namely soil types or herbicide doses. Non-linear regression models were subsequently fitted according to the equations: y1 = a * [1 - exp(-b * x)] and y2 = a/{1 + exp[-(x - x0)/b]}, where *y1* represents the phytotoxicity (%), while *y2* indicates the dry mass reduction (%), *x* denotes the herbicide dose in g a.i. ha^{-1}, and *a*, *b* and *x0* are coefficients governing the curve. Specifically, *a* corresponds to the lower limit of the curve, while *b* delineates the difference between the maximum and minimum points of the curve.

Using the fitted models, the herbicide doses (g a.i. ha^{-1}) yielding 80 and 90 % reductions in the weed dry matter (C80 and C90) were determined. These values consider the minimum control stipulated by prevailing legislation and the desired control levels

Table 1. Chemical characterization of the experimental soils.

Soil	pH	OM	P	K	Ca	Mg	Al	H + Al	CEC	V
	$CaCl_2$	g dm^{-3}	mg dm^{-3}	cmol$_c$ dm^{-3}						%
LVw	5.3	13	0.8	0.01	0.6	0.3	0.0	1.6	2.5	37.7
RQo	5.7	5	1.4	0.03	0.4	0.2	0.0	0.9	1.5	41.1
CXbd	5.2	20	2.0	0.14	2.7	1.3	0.0	2.4	6.5	63.3
NVe	4.9	31	8.0	0.50	6.2	2.2	0.2	3.3	12.2	72.9
GMd	5.0	51	20.9	0.26	4.4	2.9	0.1	2.2	9.7	77.4
LVdf	5.8	37	7.4	0.24	9.8	4.8	0.0	1.9	16.7	88.6

pH: potential hydrogen; OM: organic matter; P: phosphorus (Melich); Ca: calcium; Mg: magnesium; Al: aluminum; H + Al: hydrogen plus aluminum; K: potassium; CEC: cation exchange capacity; V: base saturation. LVw: Latossolo Vermelho Ácrico (Rhodic Acrustox); RQo: Neossolo Quartzarênico Órtico (Typic Quartzpsamment); CXbd: Cambissolo Háplico Tb Distrófico (Typic Dystrustepts); GMd: Gleissolo Melânico Distrófico (Typic Humaquept); NVe: Nitossolo Vermelho Eutrófico (Rhodic Eutrustox); LVdf: Latossolo Vermelho Distroférrico (Rhodic Haplustox).

under field conditions (FAO 2006). Subsequently, Pearson's correlation analyses were conducted to identify the soil attributes exerting the most significant influence on herbicide effectiveness, which could be employed to adjust the herbicide control percentage. Statistical analyses were performed with the RStudio software, version 4.1.2, and the graphs for regression and correlation analyses were plotted using the Sigma Plot 12.5 software.

The primary symptoms induced by S-metolachlor encompassed leaf curling and wrinkling, diminished growth and plant mortality. Figure 1 shows the progression of poisoning symptoms in *Urochloa decumbens* plants at 7 and 28 days after the herbicide application (DAA) in different soils.

S-metolachlor, as a member of the chloroacetamides chemical group, controls grasses and some broadleaf weeds. Contrary to the Deal & Hess's (1980) assertion that herbicides in this group do not inhibit germination or provoke immediate growth arrest while inhibiting the establishment of susceptible species, there was a discernible reduction in *Brachiaria decumbens* seedling emergence with increasing herbicide doses, irrespectively of soil type (Figure 1). Marchi et al. (2008) pointed out that this phenomenon is due to the phytotoxic action of S-metolachlor, which operates by inhibiting protein synthesis in the apical meristems of shoots and roots. Consequently, this inhibition impedes growth in both the shoot and root systems.

Significant differences in the percentage of phytointoxication (PT%) among the soils were only observed at the doses of 480, 640 and 960 g ha^{-1}. At the 480 g ha^{-1} dose, the Rhodic Acrustox (LVw) and Typic Quartzpsamment (RQo) soils exhibited a higher PT% in *Brachiaria decumbens* plants, when compared to the other soils. Similarly, at the 960 g ha^{-1} dose, in addition to the Rhodic Acrustox (LVw) and Typic Quartzpsamment (RQo), Typic Dystrustepts (CXbd) also displayed a higher PT% in *Brachiaria decumbens* plants than Rhodic Haplustox (LVdf), Rhodic Eutrustox (NVe) and Typic Humaquept (GMd) (Table 3).

The percentage of dry matter reduction (DMR%) disparities among the soils persisted up to the 960 g ha^{-1} dose. Beyond this threshold, the soils

Photos: Mariana Siqueira do Carmo

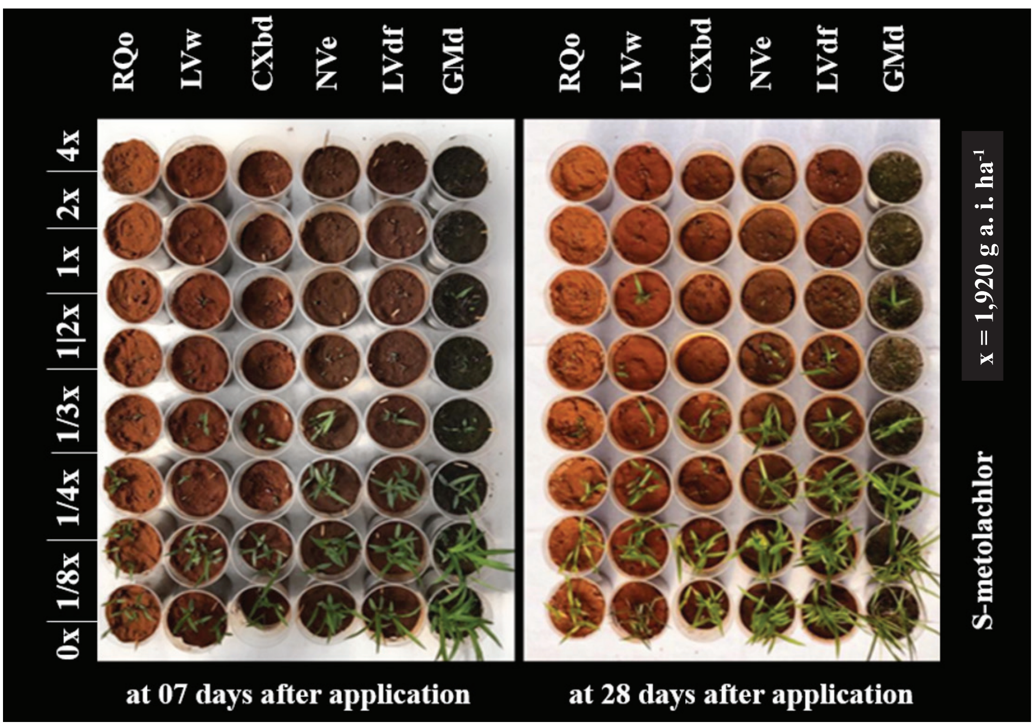

Figure 1. Phytotoxicity symptoms of *Urochloa decumbens* at 7 and 28 days after application of increasing doses (0; 240; 480; 640; 960; 1,920; 3,840; and 7,680 g a.i. ha^{-1}) of S-metolachlor in different soils: RQo: Neossolo Quartzarênico Órtico (Typic Quartzpsamment); LVw: Latossolo Vermelho Ácrico (Rhodic Acrustox); CXbd: Cambissolo Háplico Tb Distrófico (Typic Dystrustepts); NVe: Nitossolo Vermelho Eutrófico (Rhodic Eutrustox); GMd: Gleissolo Melânico Distrófico (Typic Humaquept); LVdf: Latossolo Vermelho Distroférrico (Rhodic Haplustox).

exhibited no significant differences from one another. At the lowest applied dose (240 g ha^{-1}), LVw and CXbd recorded a higher DMR% than the other soils, with LVdf showing the lowest DMR%. When half the recommended dose (960 g ha^{-1}) was administered, LVw, CXbd and RQo had already achieved over 90 % control, distinguishing them from GMd, NVe and LVdf, which recorded control rates exceeding 60 % at this dose (Table 3).

Figures 2 and 3 present the PT% and DMR% curves, respectively, and demonstrate that these variables increased with increasing herbicide doses, ultimately plateauing. This behavior is aptly represented by an exponential model. From these fitted models, it was feasible to calculate the doses that yielded 80 and 90 % reductions in the *U. decumbens* dry matter for each soil (Table 4).

The DMR80 and DMR90 doses were estimated from the non-linear regression model and are presented in Table 4. These doses fall below the maximum recommended on the product label (1,920 g a.i. ha^{-1}). Table 5 presents the correlation analyses results between the percentage of dry matter reduction (DMR%) and soil parameters. These analyses revealed a strong negative correlation (-0.74) between the organic matter content and base saturation with DMR%, implying that higher values of these parameters correspond to a reduced

Table 3. Percentage of phytointoxication and percentage of control of *Urochloa decumbens* plants after the application of S-metolachlor in Brazilian Savanna soils.

Soil	Doses (g a.i. ha^{-1})							
	0	240	480	640	960	1,920	3,840	7,680
	Phytotoxicity at 28 DAA (%)							
LVw	0 a*	17 a	55 a	52 bc	100 a	100 a	98 a	100 a
RQo	0 a	24 a	46 a	63 b	95 a	99 a	98 a	100 a
CXbd	0 a	12 a	20 b	80 a	90 a	89 a	98 a	100 a
GMd	0 a	13 a	17 b	64 b	70 b	91 a	98 a	99 a
NVe	0 a	10 a	22 b	40 cd	63 b	94 a	100 a	98 a
LVdf	0 a	17 a	14 b	34 d	66 b	95 a	99 a	100 a
F factors	F_{doses} = 627.43***			F_{soils} = 16.67***		$F_{interaction}$ = 5.88***		CV (%) = 14.78
	Control at 28 DAA (%)							
LVw	0 a	25.97 a	52.44 a	51.80 c	100.00 a	100.00 a	98.30 a	100.00 a
RQo	0 a	13.84 b	29.43 b	64.80 b	97.00 a	99.60 a	98.80 a	99.20 a
CXbd	0 a	26.70 a	44.09 a	87.60 a	96.40 a	92.20 a	99.60 a	99.80 a
GMd	0 a	9.17 b	22.84 b	65.00 b	70.80 b	96.60 a	100.00 a	100.00 a
NVe	0 a	18.40 ab	30.24 b	32.00 d	66.80 b	97.60 a	99.60 a	100.00 a
LVdf	0 a	9.58 b	8.96 c	37.60 d	71.60 b	98.00 a	99.40 a	99.00 a
F factors	F_{doses} = 1,639.87***			F_{soils} = 49.22***		$F_{interaction}$ = 16.18***		CV (%) = 8.97

* Means followed by the same letter do not differ from each other according to the Tukey test (p = 0.05); *** Significant F test at 1 %. DAA: days after herbicide application; LVw: Latossolo Vermelho Ácrico (Rhodic Acrustox); RQo: Neossolo Quartzarênico Órtico (Typic Quartzpsamment); CXbd: Cambissolo Háplico Tb Distrófico (Typic Dystrustepts); GMd: Gleissolo Melânico Distrófico (Typic Humaquept); NVe: Nitossolo Vermelho Eutrófico (Rhodic Eutrustox); LVdf: Latossolo Vermelho Distroférrico (Rhodic Haplustox).

Table 4. Optimal S-metolachlor doses for controlling 80 % (C80) and 90 % (C90) of *Urochloa decumbens*.

Soil	Regression equation	R^2	C80	C90
			g a.i. ha^{-1}	
LVw	y = 100.8269/{1 + exp[-(x -519.5294)/205.6721]}	0.94	796.32	955.10
RQo	y = 100.2213/{1 + exp[-(x -506.2588)/187.0341]}	0.99	913.12	763.48
CXbd	y = 97.3957/{1 + exp[-(x -522.5853)/59.2455]}	0.97	612.98	670.63
NVe	y = 99.6217/{1 + exp[-(x -782.3207)/269.3800]}	0.97	1,160.90	1,384.60
GMd	y = 97.0602/{1 + exp[-(x -625.7320)/193.5374]}	0.97	924.80	1,118.35
LVdf	y = 98.6852/{1 + exp[-(x -766.6645)/177.6424]}	0.99	1,025.01	1,182.03

LVw: Latossolo Vermelho Ácrico (Rhodic Acrustox); RQo: Neossolo Quartzarênico Órtico (Typic Quartzpsamment); CXbd: Cambissolo Háplico Tb Distrófico (Typic Dystrustepts); GMd: Gleissolo Melânico Distrófico (Typic Humaquept); NVe: Nitossolo Vermelho Eutrófico (Rhodic Eutrustox); LVdf: Latossolo Vermelho Distroférrico (Rhodic Haplustox); R^2: coefficient of determination.

Brachiaria control. The cation exchange capacity demonstrated a moderate (-0.68) correlation with the DMR%. Notably, there was no significant correlation between the clay content and DMR% (-0.05[ns]).

S-metolachlor, being a non-ionic herbicide, does not donate or accept protons, remaining in the molecular form, and is classified as a lipophilic and non-polar molecule (University of Hertfordshire

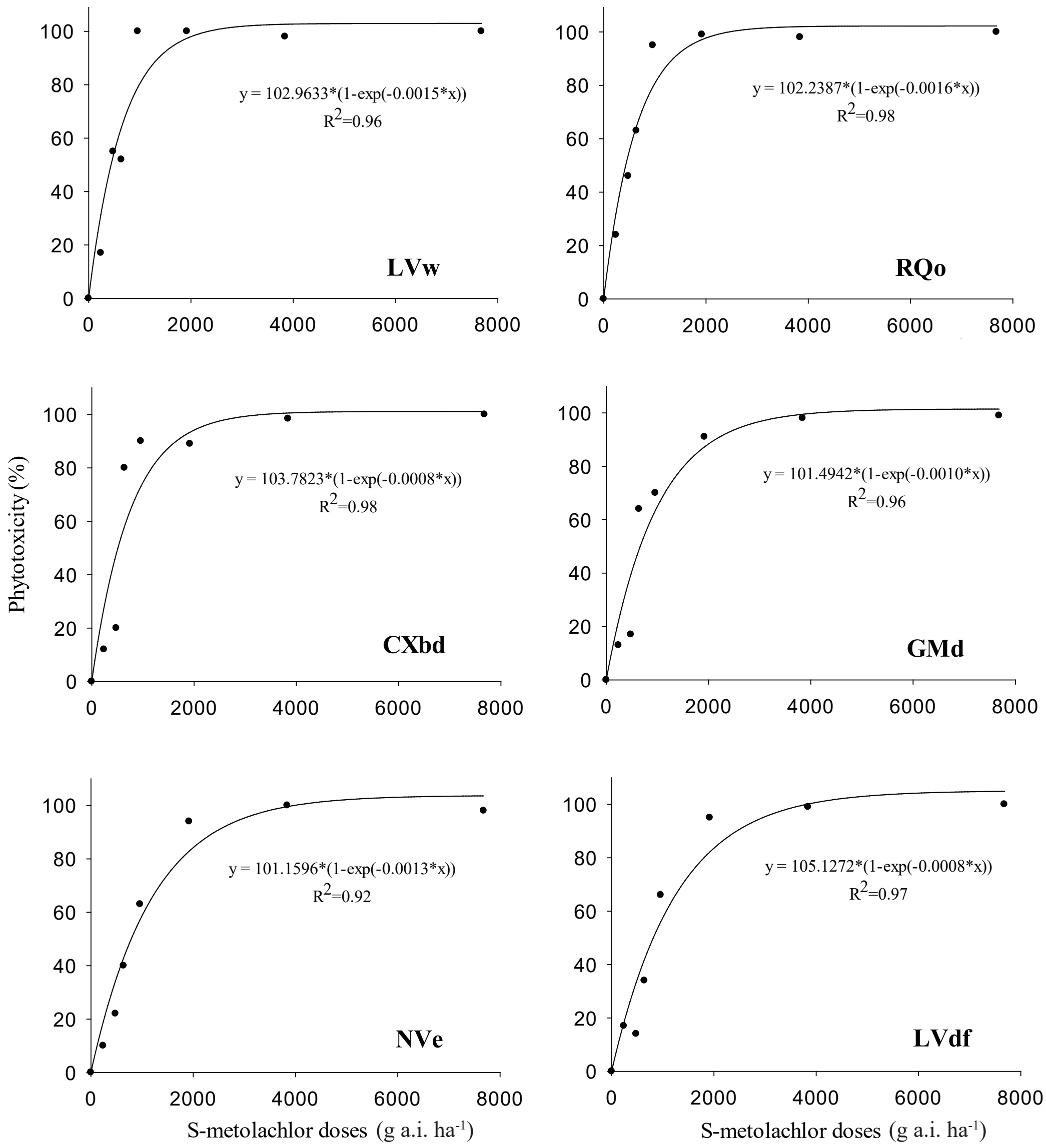

Figure 2. Percentage of phytointoxication of *Urochloa decumbens* plants at 28 days after the application of increasing S-metolachlor doses. LVw: Latossolo Vermelho Ácrico (Rhodic Acrustox); RQo: Neossolo Quartzarênico Órtico (Typic Quartzpsamment); CXbd: Cambissolo Háplico Tb Distrófico (Typic Dystrustepts); GMd: Gleissolo Melânico Distrófico (Typic Humaquept); NVe: Nitossolo Vermelho Eutrófico (Rhodic Eutrustox); LVdf: Latossolo Vermelho Distroférrico (Rhodic Haplustox).

Table 5. Pearson's correlations between the percentage of *Urochloa decumbens* control and the main physical and chemical soil characteristics.

Parameter	pH ($CaCl_2$)	OM g dm^{-3}	CEC $cmol_c$ dm^{-3}	V	Clay
				%	
% control	0.16[ns]	-0.74***	-0.68***	-0.73***	-0.05[ns]

pH: potential hydrogen; OM: organic matter; CEC: cation exchange capacity; V: base saturation. *** Significant (p < 0.01); [ns] not significant.

2023). This herbicide displays moderate solubility and moderate sorption to soil particles (Dollinger et al. 2019, Peña et al. 2019, Sigmund et al. 2019). It exhibits a greater affinity to the organic fraction of the soil. Indeed, prior studies have indicated that the sorption of S-metolachlor into the soil positively correlates with soil organic matter and clay content (Weber et al. 2003, Inoue et al. 2011, Gannon et al. 2013).

A variation in organic matter content from 0.9 to 5.7 % increases the sorption coefficient (Kd) of S-metolachlor approximately sixfold. This parameter quantifies the retention of the herbicide by the solid phase (Weber et al. 2003). In another investigation,

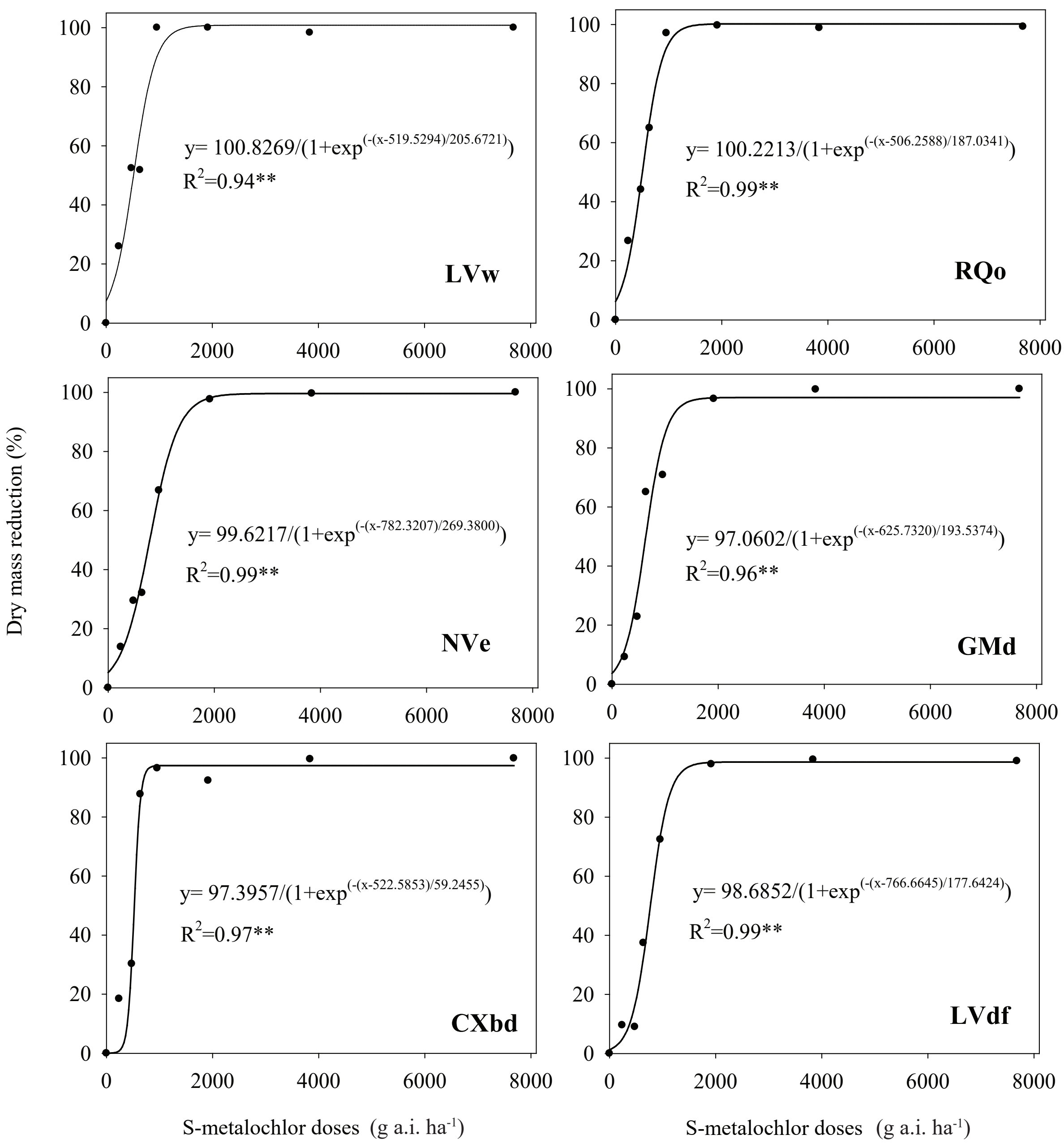

Figure 3. Reduction percentage in the dry matter of *Urochloa decumbens* plants at 28 days after the application of increasing S-metolachlor doses. LVw: Latossolo Vermelho Ácrico (Rhodic Acrustox); RQo: Neossolo Quartzarênico Órtico (Typic Quartzpsamment); CXbd: Cambissolo Háplico Tb Distrófico (Typic Dystrustepts); GMd: Gleissolo Melânico Distrófico (Typic Humaquept); NVe: Nitossolo Vermelho Eutrófico (Rhodic Eutrustox); LVdf: Latossolo Vermelho Distroférrico (Rhodic Haplustox).

Gannon et al. (2013) demonstrated that the Kd values of S-metolachlor ranged from 1.08 to 9.32 L kg^{-1} in soils with organic matter content levels of 1.2 and 4.5 %. Moreover, studies have indicated that the residual activity of S-metolachlor in soils with varying attributes, irrespectively of dose, prolonged with increasing clay and organic matter contents in the soil (Inoue et al. 2011). Typically, the organic carbon content is higher in topsoil due to mulch presence and decomposition, gradually diminishing with depth (Lal et al. 1994, Six et al. 2000, Pinheiro et al. 2004). This variation in organic matter distribution exerts a pronounced impact on soil properties, thereby substantially modifying pesticide action (Alletto et al. 2010). Bedmar et al. (2011) observed a sorption of S-metolachlor 1.78 times higher in the surface soil (0-5 cm), with 4.4 % of organic carbon, than in the subsoil (> 81 cm), with 0.2 % of organic carbon. Similar outcomes were reported by Marín-Benito et al. (2018).

Although some studies have established a link between S-metolachlor sorption and clay content (Weber et al. 2003, Inoue et al. 2011, Gannon et al. 2013), the current research revealed no correlation between DMR% and soil clay content. Alleto et al. (2013) examined the sorption of S-metolachlor in over 50 soils and likewise failed to identify a correlation between sorption and clay content. This pattern has also been reported for other herbicides in Brazilian Savanna soils, as confirmed by Arruda (2020), Damin et al. (2021) and Pacheco et al. (2022). These authors did not discern a correlation between the efficacy or residual effect of pre-emergent herbicides and the clay content of Brazilian Savanna soils.

In addition to organic fraction retention, nonpolar herbicides may exhibit increased sorption to cation exchange capacity (CEC) or cations present in the CEC, owing to the formation of an induced dipole. The magnitude of this effect tends to be more pronounced for molecules with higher molecular weights (Oepen et al. 1991). This process is likely responsible for the significant correlation observed between CEC and base saturation with DMR% in *Brachiaria decumbens* induced by S-metolachlor.

The results of this study underscore the potential for reducing S-metolachlor doses in Brazilian Savanna soils, mainly in Rhodic Acrustox (LVw), Typic Quartzpsamment (RQo) and Typic Dystrustepts (CXbd), since these soils required less than half of the recommended rate to achieve 90 % of dry mass reduction. Furthermore, the clay content showed no correlation with DMR%, whereas the organic matter content and base saturation exhibited a strong association with the DMR induced by S-metolachlor. These findings suggest that these attributes can be employed to adjust herbicide doses. Manzano (2013) has also advocated for a review of the herbicide doses recommended by manufacturers, as they currently rely solely on soil texture. Tailoring herbicide applications according to soil attributes leads to variable application rates, considering the unique characteristics of each area. This approach holds the potential for economic and environmental benefits (Lima & Mendes 2020), as it allows herbicides to be applied to the soil only at the necessary product doses to ensure adequate control.

Soil attributes significantly influence the efficacy of the S-metolachlor herbicide in managing *Urochloa decumbens* plants. The dose required for achieving a 90 % reduction in the *U. decumbens* dry mass in the examined soils spans from 670.6 to 1,182.0 g ha^{-1} of active ingredient. The soil organic matter, base saturation and cation exchange capacity emerge as soil attributes displaying a strong correlation with the product's effectiveness. Conversely, the clay content exhibits no discernible correlation with S-metolachlor doses in the soils under investigation.

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