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Urochloa pasture established by overseeding in soybean crop treated with residual herbicides

Pastagem de Urochloa *formada por sobressemeadura na cultura da soja tratada com herbicidas residuais*

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Establishing pastures through overseeding in soybean crops has become an attractive practice for producers due to its benefits in maintaining ground cover and allowing for earlier grazing. This study aimed to evaluate the impact of herbicides applied to soybean crops on the establishment and nutritional composition of Urochloa pastures overseeded into the legume. Treatments were arranged in a 3x3 factorial scheme, in a randomized block design with three replications. The forage grasses evaluated were *Urochloa brizantha* cv. BRS Xaraés, BRS Ipyporã (a hybrid of *U. ruziziensis* and *U. brizantha*), and *U. brizantha* cv. BRS Piatã. The herbicide treatments applied to soybean were: glyphosate (960 g ha^{-1}); diclosulam (35.3 g ha^{-1}) + glyphosate (960 g ha^{-1}); and sulfentrazone (200 g ha^{-1}) + glyphosate (960 g ha^{-1}). Overseeding was carried out at the R6 stage of soybean development. The following variables were assessed: soybean grain yield, weed and forage plant populations, total, leaf, and stem dry matter, leaf-to-stem ratio, and crude protein, neutral detergent fiber, and acid detergent fiber contents. Diclosulam and sulfentrazone effectively controlled broadleaf weeds and did not negatively affect the forage species. BRS Ipyporã and BRS Xaraés showed higher plant populations compared to BRS Piatã; however, the other productive and nutritional variables of the forage grasses were not influenced by the treatments. The forage grasses demonstrated good adaptability to the overseeding establishment system in soybean crops under Amazonian conditions.
Palavras-chave: diclosulam, sulfentrazone, intercropping.

A formação de pastagens por sobressemeadura na cultura da soja torna-se atrativa para produtores pelas vantagens referentes à manutenção da cobertura vegetal sobre o solo e da antecipação da entrada de animais na área. Neste trabalho, objetivou-se avaliar a contribuição de herbicidas aplicados na cultura da soja no estabelecimento e composição bromatológica de pastagens do gênero Urochloa sobressemeadas na leguminosa. Os tratamentos foram arranjados em esquema fatorial 3x3, dispostos em blocos casualizados com três repetições. Foram avaliadas as forrageiras *Urochloa brizantha* cv. BRS Xaraés, BRS Ipyporã (híbrido de *U. ruziziensis* com *U. brizantha*) e *U. brizantha* cv. BRS Piatã e três herbicidas aplicados na soja: glifosato (960 g ha^{-1}); diclosulam (35,3 g ha^{-1}) e glifosato (960 g ha^{-1}); e sulfentrazona (200 g ha^{-1}) e glifosato (960 g ha-1). As sobressemeaduras foram feitas no estádio R6 da soja. Foram avaliados o rendimento de grãos de soja, as populações de plantas daninhas e dos materiais forrageiros, a matéria seca de folhas, caules e total, a relação folha/colmo e os teores de proteína bruta e de fibras em detergente neutro e ácido. O uso de diclosulam e sulfentrazona contribuíram no controle de plantas daninhas eudicotiledôneas e não afetaram as forrageiras. As forrageiras BRS Ipyporã e BRS Xaraés apresentaram maior população de plantas em relação à BRS Piatã, contudo as demais variáveis produtivas e bromatológicas não foram alteradas pelos tratamentos testados. As forrageiras apresentaram boa adaptabilidade ao sistema de estabelecimento por sobressemeadura na cultura da soja em ambiente amazônico.
Palavras-chave: diclosulam, sulfentrazona, consórcio.

1. INTRODUCTION

The pursuit of increased production on agricultural properties – whether for grain, milk, meat, or fiber – often leads producers to expand cultivated areas. One strategy to avoid this is by increasing productivity rates. Integrated crop-livestock systems (ICLS) are one way to intensify and better utilize already arable land [1]. Among the various integration methods, crop-livestock integration has become an interesting alternative, especially for the renewal of degraded or degrading pastures [2].

An interesting alternative is the ICLS implementation, which allows for multi-crops exploration in the same area through rotation, intercropping, or succession, enabling economic diversification, cost reduction, and even productivity increases. Integrated systems using forages and grain crops have been adopted not only for direct financial benefits but also for improving soil chemical, physical, and biological structure [3, 4]. The use of Urochloa species integrated with soybean has become increasingly attractive due to their plasticity and ability to produce forage during the off-season, as well as providing soil cover [5].

However, there are several challenges in implementing grass-soybean intercropping systems. The low stature and lower competitive ability of soybean compared to forages make simultaneous sowing unfeasible. Additionally, the vigorous vegetative growth of forages, being C_4 photosynthetic plants, can hinder soybean harvest [6, 7]. Associating the two crops is a challenge that can be overcome by early sowing of pastures while soybean is still in the field – overseeding [1].

Overseeding offers several advantages, such as weed suppression, maintenance of soil cover, and earlier grazing. Even after overcoming physical competition for nutrients, light, and space, the technique still requires research to ensure its success in the field, such as herbicide use, determination of optimal seeding rates, and forage production under different management practices [8, 9].

The use and dissipation of herbicides, especially pre-emergents, are associated with several factors, such as soil chemical and physical properties, herbicide characteristics, and environmental factors like temperature and precipitation [10]. Diclosulam has a soil half-life of up to 87 days, depending on edaphoclimatic conditions [11]. Previous studies have shown that the half-life of sulfentrazone can range from 110 to 280 days, depending on soil and environmental conditions [12, 13]. Mendes et al. (2022) [14] describe carryover as a phenomenon in which products from one period interfere with the next; agronomically, it refers to a herbicide's ability to remain available in the soil during subsequent crop cycles, suppressing new weed flushes. These herbicides can persist for several days or even from one season to the next [15, 16].

Due to the potential for long residual effects in the soil, subsequent planting of sensitive crops such as corn, sorghum, and forages may require minimum intervals of up to 280 days after application, depending on edaphoclimatic factors and area management [17] Therefore, the objective was to evaluate the contribution of herbicides applied in soybean to the establishment and bromatological composition of Urochloa forages overseeded in soybean.

2. MATERIAL AND METHODS

The experiment was conducted at the experimental area of the Instituto Federal of Mato Grosso, Guarantã do Norte campus (9°57’40’’S, 54°52’11”W, altitude 345 m), from October 18, 2022, to June 2023. The region's climate is classified as AwA’a’—Super humid with moderate water deficit in winter [18]. Precipitation and temperature data during the experiment are shown in Figure 1, according to data from the automatic weather station (Latitude, -9.952500, Longitude -54.897778, Altitude 283.58, INMET Code A906) located in Guarantã do Norte, State of Mato Grosso, Brazil.

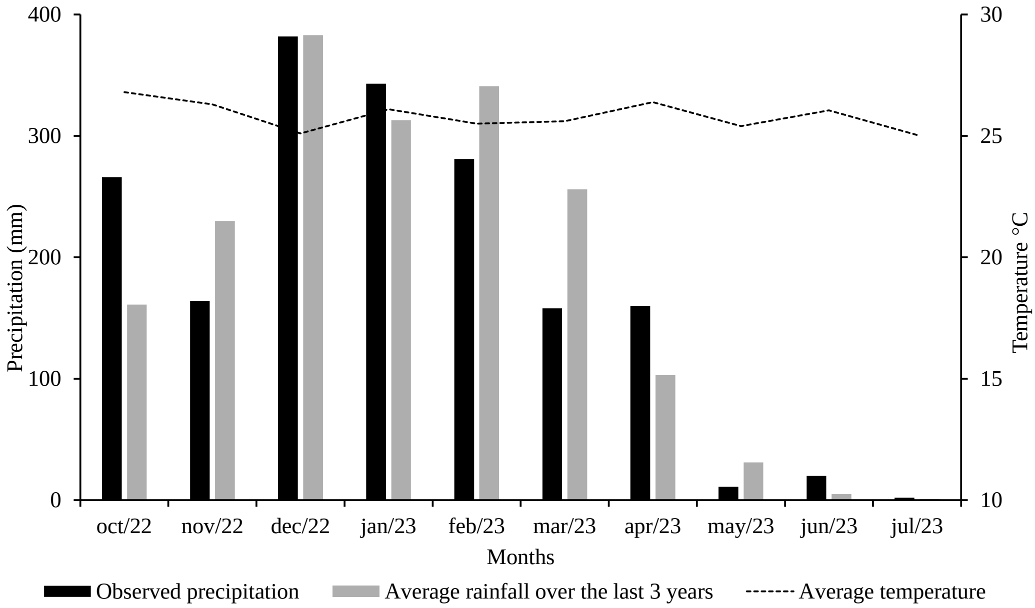

Figure 1: Climatological data of average temperature and precipitation at the Instituto Federal of Mato Grosso, Guarantã do Norte campus, from October 2022 to July 2023.

The soil is classified as Dystrophic Red-Yellow Argisol. Before the experiment, chemical and granulometric analyses yielded: pH in $CaCl_2$ of 5.4, phosphorus 6.6 mg dm^3, potassium 52 mg dm^3, calcium + magnesium 2.4 $mmol_c$ dm^3, cation exchange capacity 4.1 $cmol_c$ dm^3, H+Al 1.6 cmolc dm^3, base saturation 60%, organic matter 20 g kg^{-1}, and sand, silt, and clay contents of 44%, 48.7%, and 7.3%, respectively.

The area had been under soybean-corn rotation for five years. Fifteen days before soybean sowing, glyphosate was applied at 1,500 g ha^{-1} to control weeds. The most frequent weeds were: *Digitaria insularis*, *Cenchrus echinatus*, *Eleusine indica*, *Cyperus rotundus*, and volunteer *Zea mays* (monocots); and *Conyza* spp., *Senna occidentalis*, *Alternanthera tenella*, and *Euphorbia hirta* (eudicots).

On 10/19/2022, the soybean cultivar M8644 (long cycle, determinate growth) was sown at 0.65 m spacing, with a population of 15 plants per meter. Seeds were treated with Vitavax-thiram 200 SC and inoculated with 1 g of *Bradyrhizobium* at $5x10^9$ CFU g^{-1}. Fertilization included 50 and 20 kg ha^{-1} of P_2O_5 and K_2O, respectively, in-furrow, and 20 kg ha^{-1} of K_2O as topdressing.

The experiment used a randomized block design in a 3x3 factorial arrangement with three replications. The forages evaluated were *Urochloa brizantha* cv. Xaraés, BRS Ipyporã (*U. ruziziensis* x *U. brizantha* hybrid), and *Urochloa brizantha* cv. BRS Piatã. Three herbicide regimens were tested: glyphosate (960 g ha^{-1} post-emergence); diclosulam (35.3 g ha^{-1} pre-emergence) and sulfentrazone (200 g ha^{-1} pre-emergence), both followed by glyphosate (200 g ha^{-1}). Glyphosate was applied to all plots at 15 and 30 days after emergence. Each plot measured 16 m^2 (4x4 m), with the four central rows (excluding 1 m at each end) considered as the useful area.

Herbicides were applied using a CO_2-pressurized backpack sprayer at 2 bar and 220 L ha^{-1} spray volume, with AIXR110.015 air-induction nozzles spaced 0.5 m apart and maintained at 0.5 m above the soil. Application conditions were wind speed 2 m s^{-1}, temperature 27°C, and relative humidity 68%.

At the R6 phenological stage of soybean (plants with at least 20% yellow leaves), the three forage materials were broadcast-seeded in their respective plots at 4 kg ha^{-1} of coated seed (with organomineral adhesive and graphite), representing about 2 kg ha^{-1} of viable pure seed. Forty-one days after overseeding (DAO), following soybean harvest (03/04/2023), the population of forage plants (NFP) and the number of monocot weeds (NMW) and eudicot weeds (NEW) per square meter were assessed using random sampling with a 0.3 m² quadrat. Weed identification and classification followed Lorenzi et al. (2014).

At soybean harvest, grain yield (GY) was estimated by harvesting plants from the useful area of each plot, threshing manually, and drying to about 15% moisture. The rest of the soybean was mechanically harvested at approximately 0.20 m height.

At 90 DAO, the first of three pasture cuts was carried out. These were carried out every 28 days at a height of 0.25 m in the three materials; three points were randomly determined within the plot where the pasture cuts were carried out. The cut material was weighed in the field, and a 0.4 kg sample was taken to the lab. In a refrigerated environment, leaves and stems were separated and dried at 65°C for 48 hours to determine total (TDM), leaf (LDM), and stem (SDM) dry matter and the leaf/stem ratio (LSR). Samples were ground in a knife mill with a 1 mm sieve and analyzed for dry matter, crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF), according to Silva and Queiroz (2002) [19].

After sampling, the area was mowed at 25 cm with a tractor-mounted mower, and residual material was raked out. The cutting height was used as the standard for residual height and to simulate animal exit, stimulating regrowth [20].

Results were subjected to analysis of variance and, when significant, to Tukey's test at 5% probability. The statistical program used was Sisvar [21].

3. RESULTS AND DISCUSSION

Table 1 presents results for soybean grain yield, forage plant population, and weed population. No significant interactions were observed for the analyzed variables, only isolated effects for the number of Urochloa forage plants and the number of eudicotyledonous weeds for the herbicide treatments. Since overseeding was performed at R6, well after the critical competition period for soybean, there was no significant difference in grain yield between treatments. The average grain yield was 4,111 kg ha^{-1}, within the expected range for the cultivar under the edaphoclimatic conditions of southern Amazonia [22].

Table 1: Mean squares for soybean grain yield (GY), number of forage plants (NFP), number of monocot weeds (NMW), and number of eudicot weeds (NEW) as a function of treatments.

SV	D.F.	GY	NFP	NMW	NEW
		kg ha^{-1}	----plants m^{-2}----		
Block	2	7,851,311^{ns}	24.40*	690.77^{ns}	18.28^{ns}
FC	2	22,641^{ns}	21.23*	23.10^{ns}	1.45^{ns}
HD	2	1,494,902^{ns}	12.38^{ns}	279.07^{ns}	29.97*
FC x HD	4	1,711,241^{ns}	4.73^{ns}	381.13^{ns}	2.53^{ns}
Error	16	1,065,732	5.65	277.71	7.28
CV (%)		25.06	53.20	58.00	58.19
Average		4,119.11	4.47	28.56	4.63

SV (Source of Variation), df (degrees of freedom), FC (Forage Cultivars), HD (Herbicides), FC x HD (interaction Forage Cultivars x Herbicides), CV (coefficient of variation), * Significant at 5% probability by F test, ns – not significant.

The average number of Urochloa plants in this study was below the recommended number in the literature, which is around 10 to 20 plants per m² for conventionally established Urochloa pastures [23, 24]. This lower plant number is unlikely to be associated with residual herbicide management, as no significant difference was observed in forage population between herbicide treatments, and glyphosate has no residual activity. However, there are few studies indicating the ideal seeding rate for forage materials in overseeding systems [8, 25], especially in Amazonian environments.

Figure 2 shows that BRS Ipyporã and *Urochloa brizantha* cv. BRS Xaraés exhibited the highest plant populations, with mean values of 5.67 and 4.69, respectively. At the R6 growth stage, light incidence below the soybean canopy is low due to the high leaf area index [26]. However, as soybean plants progress into senescence and leaves fall onto the soil surface, seed–soil contact is reduced and seeds become more exposed to the environment. These conditions favor moisture loss, increase light exposure and air circulation, and promote seedling mortality and reduced seed germination, resulting in lower forage plant density [27]. Thus, BRS Piatã, compared to Ipyporã, would be less suitable for overseeding at this soybean stage, regarding initial plant establishment.

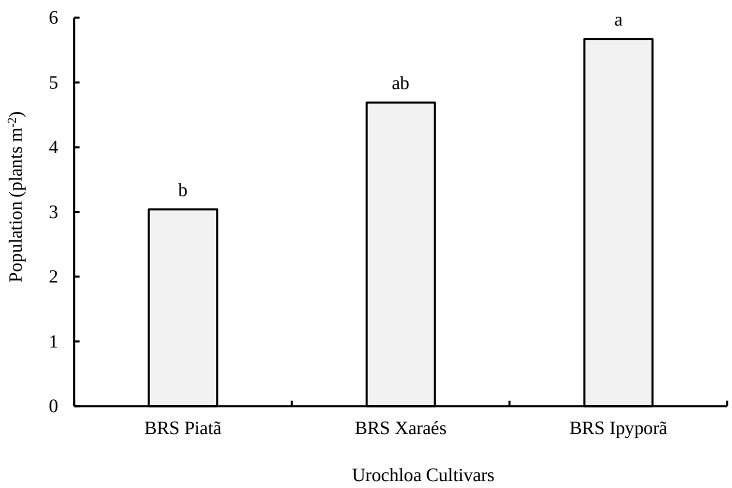

Figure 2: Population of Urochloa *forage plants overseeded in soybean. Means followed by the same letter do not differ at 5% probability by Tukey's test.*

Regarding weeds, monocotyledonous weeds predominated, with an average of 28.56 plants m⁻² across treatments (Table 1). The most common monocots were *Digitaria insularis*, *Cenchrus echinatus*, and *Eleusine indica*. For eudicotyledonous weed control, the treatment without pre-emergent herbicides had the highest number of eudicot weeds per unit area (Figure 3).

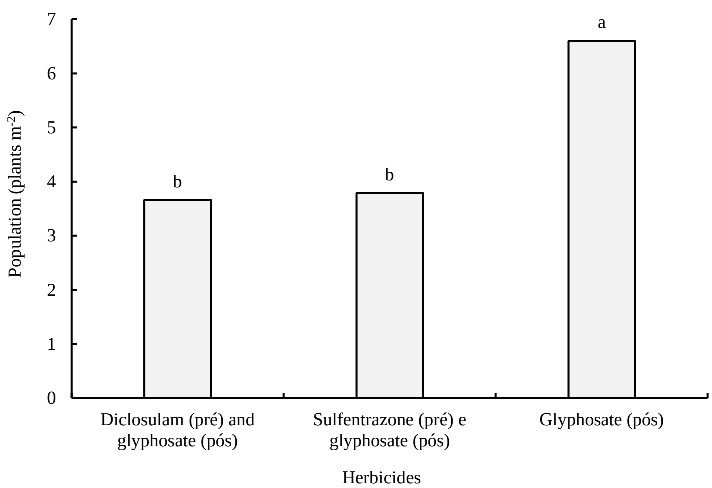

Figure 3: Number of eudicotyledonous weeds in areas with forages overseeded in soybean treated with diclosulam (35.3 g ha^{-1}) and glyphosate (960 g ha^{-1}), sulfentrazone (200 g ha^{-1}) and glyphosate (960 g ha^{-1}), and glyphosate (960 g ha^{-1}).

The main eudicot weeds were *Conyza* spp. and *Senna occidentalis*. Both diclosulam and sulfentrazone are used in soybean weed management and are recommended for several eudicot species and some grasses. Post-emergence application of selective herbicides such as glyphosate or glufosinate ammonium after sulfentrazone or diclosulam has shown significant results for hard-to-control species. Shyam et al. (2021) [28], evaluating the management of glyphosate-resistant *Amaranthus palmeri* in Enlist E3TM soybean, found that sulfentrazone + chloransulam-methyl (195 + 25 g ai ha^{-1}) pre-emergence and 2,4-D + glufosinate (2,080 g ha^{-1} + 656 g ha^{-1}) post-emergence achieved over 90% control of *A. palmeri*.

Albrecht et al. (2020) [29], evaluating herbicide efficacy for Conyza spp. control with sequential glufosinate ammonium applications before soybean sowing, found that diclosulam provided 80% control one week after application. Conversely, studies report cross-resistance of Conyza spp. to diclosulam and multiple resistance to glyphosate, diclosulam, and chlorimuron in Uruguay [30]. Thus, using herbicides from different chemical groups is important to avoid loss of technologies due to weed resistance.

No significant differences were observed in the bromatological and dry mass components of the forages for crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), leaf dry matter (LDM), stem dry matter (SDM), total dry matter (TDM), or leaf/stem ratio (LSR) among the treatments (Table 2). CP content was not influenced by treatments, averaging 12.18%, which is close to values reported in the literature [31-33].

Table 2: Mean squares for crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), leaf dry matter (LDM), stem dry matter (SDM), total dry matter (TDM), and leaf/stem ratio (LSR) in the performance analysis of forage materials overseeded in soybean managed with herbicides.

SV	D.F.	CP	NDF	ADF	LDM	SDM	TDM	LSR
		---------% MS-----------			----------------- kg ha^{-1} -------------			
Block	2	0.70^{ns}	0.77^{ns}	1.59^{ns}	10,891^{ns}	17,731^{ns}	531,942*	0.77^{ns}
FC	2	0.48^{ns}	0.11^{ns}	0.25^{ns}	16,230^{ns}	732,4^{ns}	79,075^{ns}	0.44^{ns}
HD	2	0.14^{ns}	1.00^{ns}	0.26^{ns}	21,774^{ns}	1,273^{ns}	44,968^{ns}	0.11^{ns}
FC x HD	4	0.04^{ns}	0.11^{ns}	0.31^{ns}	20,596^{ns}	6,250^{ns}	170,750^{ns}	0.22^{ns}
Error	16	0.20	0.40	0.55	17,752	11,727	101,920	0.40
CV%		3.7	1.07	2.03	9.86	12.88	11.74	0.40

SV (Source of Variation), df (degrees of freedom), FM (Forage Cultivars), HD (Herbicides), FC x HD (interaction Forage Cultivars x Herbicides), CV (coefficient of variation), * Significant at 5% probability by F test, ns – not significant.

Herbicides must be available in the soil solution to be absorbed by roots and cause plant injury. Thus, more clayey soils tend to have lower amounts of herbicide molecules available in solution, as is the case for sulfentrazone and diclosulam, due to their binding to negative charges on soil colloids [34, 35]. Along with local climatic conditions, higher organic matter and clay content in the soil interfere with herbicide availability to forages over time, due to intense microbiological activity that accelerates degradation. Thus, at the time of forage overseeding, there was no herbicide available to cause phytotoxic effects that would compromise yield and bromatological composition [16].

NDF and ADF contents are important for ruminant nutritional management. NDF quantifies components with higher digestibility by ruminal microbiota, such as cellulose and hemicellulose, while ADF quantifies less digestible elements that are still essential for other processes [36]. Table 3 shows the means of productive and bromatological variables as a function of forage materials and herbicide management. There were no statistical effects for response variables or for the interaction or isolated factors: herbicides and forage materials.

Table 3: Crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), leaf dry matter (LDM), stem dry matter (SDM), total dry matter (TDM), and leaf/stem ratio (LSR) in the performance analysis of forage materials overseeded in soybean managed with herbicides.

Urochloa Cultivars	CP	NDF	ADF	LDM	SDM	TDM	LSR
	-------------% MS------------			------------------kg ha^{-1}--------			
BRS Ipyporã	12.00^{ns}	59.40^{ns}	36.40^{ns}	1,305^{ns}	830^{ns}	2,617^{ns}	1.11^{ns}
BRS Xaraés	12.10	59.50	36.70	1,356	846	2,735	1.55
BRS Piatã	12.40	59.30	36.60	1,390	845	2,802	1.33
Herbicides							
Diclosulam e glyphosate	12.10^{ns}	59.10^{ns}	36.60^{ns}	1,337^{ns}	853^{ns}	2,652^{ns}	1.44^{ns}
Sulfentrazone e glyphosate	12.10	59.40	36.40	1,405	832	2,709	1.33
Glyphosate	12.30	59.70	36.70	1,309	836	2,793	1.22

ns – not significant by F test.

The lack of significant difference between forage materials in productive aspects may be associated with their genetic similarity. The BRS Ipyporã hybrid is a pasture cultivar resulting from a cross between *U. ruziziensis* and *U. brizantha*, released by Embrapa in 2017 as an alternative to diversify areas managed solely with BRS Xaraés and BRS Piatã, with similar production, quality, and versatility [37-39]. BRS Xaraés and BRS Piatã are *Urochloa brizantha* genotypes from different African regions, developed prior to BRS Ipyporã's release, demonstrating genetic proximity and possibly similar behavior [40-42].

Dry matter values and other aboveground components are consistent with literature, with values exceeding 4 t ha^{-1} in medium fertility areas among *Urochloa* hybrids [43, 44]. Paraíso et al. (2019) [45], evaluating *Urochloa* hybrids in the Amazon, including Ipyporã, found this to be an attractive alternative for diversifying forage livestock systems in the Amazon biome, due to high forage yield and better adaptability to pasture spittlebug (*Deois flavopicta*), a key pest in Brazilian pastures, in addition to high forage production.

4. CONCLUSIONS

The use of pre-emergent herbicides diclosulam and sulfentrazone, complemented with post-emergence glyphosate, is a viable alternative for establishing overseeded pastures in soybean crops. It does not harm forages after soybean cultivation and improves weed control, especially for eudicots.

The forage materials BRS Ipyporã and BRS Xaraés outperform BRS Piatã when established by overseeding in soybean.

5. ACKNOWLEDGMENTS

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6. BIBLIOGRAPHICAL REFERENCES

1. Borghi E, Bortolon L, Bortolon ESO, Camargo FP, da Silva RR, Avanzi JC, et al. Sobressemeadura de capins na soja para sistemas de integração lavoura-pecuária. Palmas (TO): Embrapa Pesca e Aquicultura; 2017.
2. Feltran-Barbieri R, Féres JG. Degraded pastures in Brazil: improving livestock production and forest restoration. R Soc Open Sci. 2021 May;8:201854. doi: 10.1098/rsos.201854

3. Crusciol CA, Nascente AS, Borghi E, Soratto RP, Martins PO. Improving soil fertility and crop yield in a tropical region with palisadegrass cover crops. Agron J. 2015 Sep;107(6):2271-80. doi: 10.2134/agronj14.0603
4. Bilotto F, Vibart R, Mackay A, Costall D, Harrison MT. Towards an integrated phosphorus, carbon and nitrogen cycling model for topographically diverse grasslands. Nutr. Cycl. Agroecosystems. 2022 Sep;124(2):153-72. doi: 10.1007/s10705-022-10231-3
5. Volf MR, Crusciol CA, Kovar JL, Rosolem CA. Unraveling the role of ruzigrass in soil K cycling in tropical cropping systems. Nutr. Cycl. Agroecosystems. 2023 Apr;126(20):181-94. doi: 10.1007/s10705-023-10283-z
6. Vilela L, Martha Junior GB, Macedo MCM, Marchão RL, Guimarães Júnior R, Pulrolnik K, et al. Sistemas de integração lavoura-pecuária na região do cerrado. Pesqui Agropecu Bras. 2011 Oct;46(10):1127-38. doi: 10.1590/s0100-204x2011001000003
7. Taiz L, Zeiger E, Møller IM, Murphy A. Fisiologia e desenvolvimento vegetal. Porto Alegre (RS): Artmed Editora; 2017.
8. Volf MR, Crusciol CA, Custódio CC, Bossolani JW, Machado FG, Wruck FJ, et al. Interseeding of ruzigrass into soybean: strategies to improve forage cultivation in no-till systems. Ann Agric Sci. 2021 Jun;66(1):16-24. doi: 10.17138/tgft(9)1-12
9. Manfron ACA, Bondan C, Fontaneli RS, Zeni M. Sobressemeadura de forrageiras na entressafra de grãos no Brasil. Res Soc Dev. 2022 Mar;11(5):e10111527914. doi: 10.33448/rsd-v11i5.27914
10. Monqueiro PA, Silva PD. Comportamento de herbicidas no ambiente. In: Barroso AAM, Murata AT, editores. Matologia: estudos sobre plantas daninhas. Jaboticabal (SP): Fábrica da Palavra; 2021. p. 253-94.
11. Lavorenti A, Rocha AA, Prata F, Regitano JB, Tornisielo VL, Pinto OB. Comportamento do diclosulam em amostras de um latossolo vermelho distroférrico sob plantio direto e convencional. Rev Bras Ciênc Solo. 2003 Oct;27:183-90.
12. Brum CS, Franco AA, Scorza Júnior RP. Degradação do herbicida sulfentrazone em dois solos de Mato Grosso do Sul. Rev Bras Eng Agríc Ambient. 2013 May;17(5):558-64. doi: 10.1590/s1415-43662013000500014
13. Gehrke VR, Camargo ER, Avila LA. Sulfentrazone: environmental dynamics and selectivity. Planta Daninha. 2020 Apr;38:e020215663. doi: 10.1590/s0100-83582020380100032
14. Mendes KF, Ionoue MH, Tornisileo VL. Herbicidas no ambiente: impacto e detecção. Viçosa (MG): Editora UFV; 2022.
15. Melo CAD, Dias RDC, Mendes KF, Assis ACLP, Reis MRD. Herbicides carryover in systems cultivated with vegetable crops. Rev Bras Herbic. 2016 Jan/Mar;15(1):67-78. doi: 10.7824/rbh.v15i1.434
16. Araujo GR, Paiva Ferreira GA, Vaz V, da Costa Lima A, Spolidorio ES, Mendes KF. *Canavalia ensiformis* enhances the phytoremediation of remineralized and sulfentrazone-contaminated tropical soils. Chemosphere. 2023 Jan;348:140725. doi: 10.1016/j.chemosphere.2023.140725
17. Damin V, Carrijo BS, Costa NA. Residual activity of sulfentrazone and its impacts on microbial activity and biomass of brazilian savanna soils. Pesq Agropec Trop. 2021 Nov;51:e68340. doi: 10.1590/1983-40632021v5168340
18. Thornthwaite CW. An approach toward a rational classification of climate. Geogr Rev. 1948 Jan;38(1):55-94.
19. Silva JS, Queiroz AC. Análise de alimentos: métodos químicos e biológicos. 3. ed. Viçosa (MG): Editora UFV; 2002.
20. Santos ÉMD, Fonseca CELD, Karia CT, Ramos A, Carmona R, Pessoa-Filho M. Genetic parameters and correlations of forage yield and nutritional quality in ruzigrass (*Urochloa ruziziensis*) half-sib families. CBAB 2024 Oct;24(4):e486124411. doi: 10.1590/198470332024v24n4a48
21. Ferreira DF. Sisvar: um sistema computacional de análise estatística. Ciênc Agrotec. 2011 nov/dez;35(6):1039-42. doi: 10.1590/s1413-70542011000600001
22. Araújo LLM, Ramos D, Brachtvogel E, Kovalski A. Ação de bioestimulantes em cultivares comerciais de soja na região norte do Vale do Araguaia-MT. PesquisAgro. 2021 jan/jul;4(1):3-21. doi: 10.33912/agro.2596-0644.2021.v4.n1.p3-21.id1146
23. Zimmer AH, Macedo MCM, Kichel NA, de Almeida RG. Degradação, recuperação e renovação de pastagens. Campo Grande (MS): Embrapa Gado de Corte; 2012.
24. Prado Paim T, de Carvalho VP, Silva MD, Souza BR, Leite LBS, Júnior GC, Claudio FL, et al. Densidade de semeadura de diferentes espécies forrageiras. Informe Goiano. 2021 Apr/jun;9(2):1-8.
25. Dias-Filho MB. Formação e manejo de pastagens. Belém (PA): Embrapa Amazônia Oriental; 2012.

26. Raza MA, Gul H, Hasnain A, Khalid MHB, Hussain S, Abbas G, et al. Leaf area regulates the growth rates and seed yield of soybean (*Glycine max* L. Merr.) in intercropping system. Int J Plant Prod. 2022. Jun;16(4):639-52. doi: 10.1007/s42106-022-00201-8
27. Missio RL, Severo IK, Candiotto L, Candiotto F, Soares LF, Elejalde DAG, et al. Overseeding annual summer pastures on soybean crops to overcome the autumnal forage shortage. Cienc Rural 2024. Jan;54(1):e20220588. doi: 10.1590/0103-8478cr20220588
28. Shyam C, Chahal PS, Jhala AJ, Jugulam M. Management of glyphosate-resistant palmer amaranth (*Amaranthus palmeri*) in 2,4-D, glufosinate-, and glyphosate-resistant soybean. Weed Technol. 2021 Aug;35(1):136-43. doi: 10.1017/wet.2020.91
29. Albrecht AJP, Albrecht LP, Silva AFM, Ramos RA, Corrêa NB, Carvalho MGD, et al. Control of *Conyza* spp. with sequential application of glufosinate in soybean pre-sowing. Ciênc Rural 2020 Sep;50(9):e20190868. doi: 10.1590/0103-8478cr20190868
30. Kaspary TE, Waller Barcena ME, García MA, Cabrera M, Hill SM. *Conyza bonariensis'* resistance to glyphosate, diclosulam, and chlorimuron: confirmation and alternative control for the first case of multiple and cross-resistance in Uruguay. Agron. 2023 Dec;14(1):79. doi: 10.3390/agronomy14010079
31. Codognoto LDC, Conde TT, Maltoni KL, Faria GA. Glyphosate in the production and forage quality of marandu grass. Semin., Ciênc Agrár. 2021 Apr;42(3):1695-706. doi: 10.5433/1679-0359.2021v42n3supl1p1695
32. Delevatti LM, Cardoso AS, Barbero RP, Leite RG, Romanzini EP, Ruggieri AC, et al. Effect of nitrogen application rate on yield, forage quality, and animal performance in a tropical pasture. Sci Rep. 2019 May;9(1):7596. doi: 10.1038/s41598-019-44138-x
33. Pasquini Neto RP, Furtado AJ, da Silva GV, Lobo AAG, Abdalla Filho AL, Brunetti HB, et al. Forage accumulation and nutritive value in extensive, intensive, and integrated pasture-based beef cattle production systems. Crop Pasture Sci. 2024 May;75(5):1-15. doi: 10.1071/cp24043
34. Faustino LA, Freitas MAM, Passos ABRJ, Saraiva DT, Faria AT, Silva AA, et al. Mobilidade do sulfentrazone em solos com diferentes características físicas e químicas. Planta Daninha. 2015 Dec;33(4):795-802. doi: 10.1590/s0100-83582015000400018
35. Braga DF, Freitas FCL, Rocha PRR, Araújo AGD, Melo VC. Leaching of sulfentrazone in soils from the sugarcane region in the northeast region of Brazil. Planta Daninha. 2016 Jul;34(1):161-9.
36. Silva JBD, Pascoal LAF, Andretta I, Silva MKD, Hauschild L, Gomes BK, et al. Meta-analytical study of the effect of fibers in neutral detergent and acidic detergent in the diet of finishing pigs. Ciênc Rural 2021 Apr;52(1):e20201024. doi: 10.1590/0103-8478cr2020104
37. Gouveia BT, Mateus RG, Barrios SCL, do Valle CB, de Sousa Bueno Filho JS, Fernando Rios E, et al. Combining ability and selection for agronomic and nutritional traits in Urochloa spp. hybrids. Grass Forage Sci. 2022 Nov;77(1):33-44. doi: 10.1111/gfs.12555
38. Matias FI, Candido AR, Machado WKR, Cesar do Amaral PN, Dias AM, Borges do Valle C, et al. *Urochloa* spp. multivariate performance: similarities and divergences among intra-and interspecific populations. Crop Sci. 2021 Nov;61(2):1104-16. doi: 10.1002/csc2.20401
39. Barros WL, Vendruscolo MC, Francisco A. Características produtivas do capim Ipyporã sob doses de nitrogênio no quarto ano de produção. Encicl Biosf. 2022 Sep;19(41):16-25. doi: 10.18677/encibio_2022c3 2022
40. Barros JS, Castro LCS, Silva FDL, Alves FV, Almeida RGD, Santos DMD, et al. Productive and nutritional characteristics of piatã-grass in integrated systems. Rev Bras Saúde Prod Anim. 2018 Apr-Jun;19:144-56. doi: 10.1590/s1519-99402018000200001
41. Martins DC, Villela SDJ, Almeida RG, Araújo SAC, Silva LD, Paschoaloto JR, et al. Animal performance and nutritional characteristics of piatã-grass in integrated systems. Arq Bras Med Vet Zootec. 2020 May/Jun;72(3):1027-33. doi: 10.1590/1678-4162-11065
42. Pereira M, da Graça Morais M, Fernandes PB, dos Santos VAC, Glatzle S, de Almeida RG. Beef cattle production on piatã grass pastures in silvopastoral systems. Trop Grassl.-Forrajes Trop. 2021 Jan;9(1):1-12. doi: 10.17138/tgft(9)1-12
43. Aleme M, Mengistu G, Tulu D, Dejene M, Temteme S. Analysis of genotype by environment interaction for dry matter yield of *Urochloa* spp. (*Brachiaria* spp.) genotypes in humid lowlands of southwest Ethiopia. Eco-Gen. 2023 Sep;28:100185. doi: 10.1016/j.egg.2023.100185
44. dos Santos ML, Santos PM, Barioni LG, Pereira BH, Cuadra SV, Pequeno DNL, et al. Yield gap analysis framework applied to pasture-based livestock systems in central Brazil. Field Crops Res. 2024 Jun;314:109416. doi: 10.1016/j.fcr.2024.109416
44. Paraiso IG, Silva DS, Carvalho APS, Sollenberger LE, Pereira DH, Euclides VP, et al. Herbage accumulation, nutritive value, and organic reserves of continuously stocked 'Ipyporã'and 'Mulato II'brachiariagrasses. Crop Sci. 2019 Nov/Dec;59(6):2903-14. doi: 10.2135/cropsci2019.06.0399