

OVERSEEDING RATES FOR UROCHLOA SPECIES IN A SUBSTITUTIVE INTERCROPPING SYSTEM WITH SOYBEAN

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Abstract. This study aimed to evaluate the agronomic and morphogenetic characteristics of forage plants from the *Urochloa* genus under different overseeding rates in soybean cultivation. A 3x5 factorial experiment was arranged in a randomized block design with three replications. The forages tested were *Urochloa brizantha* cv. BRS Xaraés, BRS Ipyorã (a hybrid of *U. ruziziensis* and *U. brizantha*), and *U. brizantha* cv. BRS Piatã, which were overseeded into soybean at the R6 stage at seeding rates of 9.62, 12.5, 14.43, 16.83, and 19.24 kg ha⁻¹. Plant population increased linearly with increasing seeding rates, and a population of 10 plants per m² was achieved with 15.3 kg ha⁻¹ of seed. The initial establishment of the pasture, through increased plant density, contributed to a higher tiller density per m². No differences were found among the cultivars for forage yield, but BRS Piatã exhibited lower estimates for tiller number per m² and leaf contribution to forage yield. For morphogenetic variables, BRS Xaraés had fewer live leaves per tiller, a lower leaf appearance rate, and a higher phyllochron estimate compared to the other cultivars.

Keywords: overseeding; pasture; southern Amazon; *Urochloa brizantha*.

TAXAS DE SEMEADURA PARA ESPÉCIES DE UROCHLOA EM CONSÓRCIO SUBSTITUTIVO NA CULTURA DA SOJA

Resumo. Neste trabalho objetivou-se avaliar as características agrônômicas e morfológicas de plantas forrageiras do gênero *Urochloa* em diferentes taxas de sobressemeadura feitas na cultura da soja. O ensaio fatorial 3x5 foi delineado em blocos casualizados com três repetições. Foram testadas as forrageiras *Urochloa brizantha* cv. BRS Xaraés, BRS Ipyorã (híbrido de *U. ruziziensis* com *U. brizantha*) e *U. brizantha* cv. BRS Piatã, as quais foram sobressemeadas na soja no estágio R6, nas quantidades de 9,62, 12,5, 14,43, 16,83 e 19,24 kg ha⁻¹ de sementes. A população de plantas, aumentou linearmente com o aumento das taxas de sobressemeadura e a população de 10 plantas por m² foi obtida a partir do semeio de 15,3 kg ha⁻¹ de sementes. O estabelecimento inicial da pastagem, pelo aumento da população de plantas, contribuiu com o aumento do perfilhamento por m². Não houve diferenças entre as cultivares para o rendimento forrageiro, mas a BRS Piatã apresentou menores estimativas de número de perfilhos por m² e de participação de folhas no rendimento forrageiro. Para as variáveis morfológicas, a BRS Xaraés apresentou menor número de folhas vivas por perfilho, menor taxa de aparecimento foliar e maior estimativa de filocromo em relação as demais cultivares.

Palavras-chave: sobressemeadura; pastagem; Amazônia meridional; *Urochloa brizantha*.

1 INTRODUCTION

Brazil's vast land area and favorable edaphoclimatic conditions place it among the world's leading agricultural producers. The Central-West region, particularly the southern Amazon ecotone, is rapidly expanding in agricultural area and intensifying production systems. In this context, integrated crop-livestock systems (ICLS) have emerged as a promising strategy for optimizing land use (Skorupa; Manzatto, 2019).

Soybean cultivation and beef cattle ranching are the primary components of ICLS. Combining these commodities is a practical strategy that can be enhanced through the early seeding of pastures while soybean is still in the field, using an overseeding approach (Borghi *et al.*, 2017). Overseeding offers several advantages, such as weed suppression, prolonged soil cover, and early grazing with improved forage availability. However, challenges remain, such as the use of soybean-compatible herbicides, determination of optimal seeding rates, and understanding the morphological growth and dry matter production of forages (Volf *et al.*, 2021).

Broadcast overseeding at phenological stages close to soybean R5 benefits from favorable canopy conditions – reduced light incidence on the soil moderates temperature fluctuations and maintains soil moisture, aiding forage seed germination (Tozer *et al.*, 2016). Additionally, leaf drop from senescing soybean plants creates a favorable microenvironment for forage establishment (Fragoso *et al.*, 2017).

Regarding seeding rates, there is no consensus about the optimal amount of seed to broadcast. Souza Sobrinho (2022) recommends a wide range from 2 to 10 kg ha⁻¹ of viable pure seeds for *U. ruziziensis*, while Gontijo Neto *et al.* (2006) suggest 4.5 to 6.0 kg ha⁻¹ for line and broadcast sowing, respectively. Another key factor is the inclusion of forage cultivars adapted to integrated crop-livestock systems, such as *Urochloa brizantha* BRS Piatã, BRS Ipyporã (a *U. ruziziensis* × *U. brizantha* hybrid), and improved *U. ruziziensis* materials like BRS Integra (Rodrigues *et al.*, 2023). This study aimed to evaluate the agronomic and morphogenetic characteristics of *Urochloa* forage species at different overseeding rates in a substitutive intercropping system with soybean.

2 MATERIAL AND METHODS

The experiment was carried out at the experimental site of the Instituto Federal de Mato Grosso, Guarantã do Norte campus (9°57'40"S, 54°52'11"W, 345 m), from October 2022 to June 2023. The climate is classified as AwA'a', super humid with moderate winter water deficit (Thorntwaite, 1948). Precipitation data were collected using a rain gauge located 100 m from the experimental site, and average temperatures were obtained from an INMET automatic weather station 6 km away. Data are presented in Figure 1.

Before trial establishment, chemical and granulometric analyses of the dystrophic Red-Yellow Argisol were carried out, with the following results: pH (CaCl₂) 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 cmol_c dm⁻³, base saturation 60%, organic matter 20 g kg⁻¹, and sand, silt, and clay content of 44%, 48.7%, and 7.3%, respectively. The field had been under a soybean-maize rotation for five years. Fifteen days before soybean sowing, glyphosate was applied at 1500 g ha⁻¹ to desiccate existing vegetation.

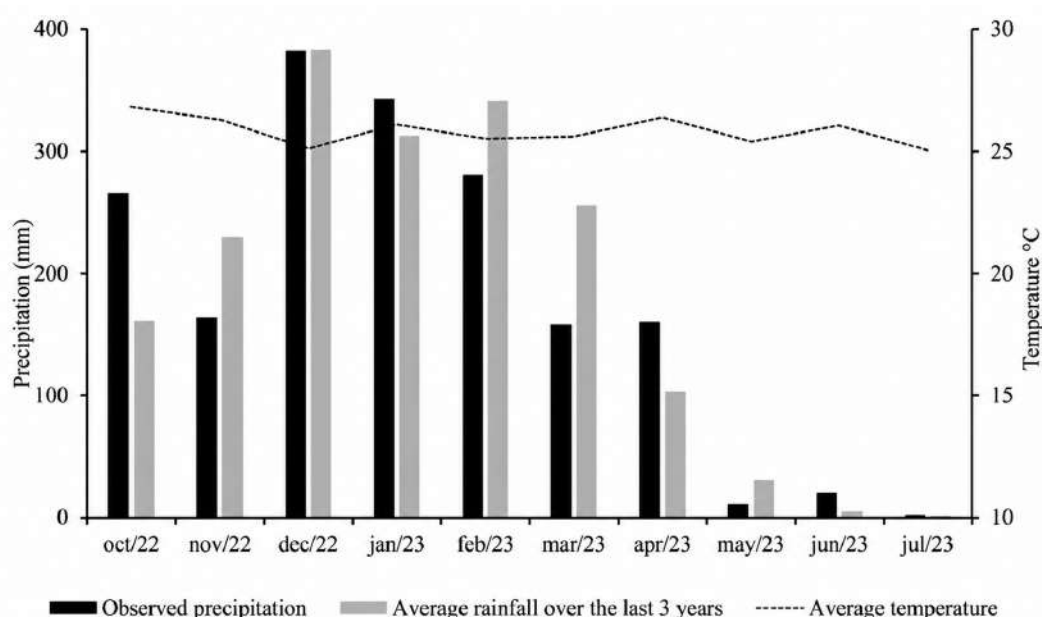
The soybean cultivar M8644 (long-cycle, determinate growth) was sown on October 19, 2022, under no-till conditions, with 0.65 m row spacing and a target density of 15 plants per meter. Seeds were treated with Vitavax-thiram 200 SC and inoculated with *Bradyrhizobium* (5×10⁹ CFU g⁻¹ at 1 g per seed). Seeding depth was 4 cm. Fertilization consisted of 50 kg ha⁻¹ of P₂O₅ and 20 kg ha⁻¹ of K₂O applied in-furrow, with an additional 20 kg ha⁻¹ of K₂O as topdressing.

The experiment followed a randomized block design in a 3 × 5 factorial arrangement with three replications. The three forage species: *Urochloa brizantha* cv. Xaraés, BRS Ipyporã (*U. ruziziensis* × *U. brizantha*), and *U. brizantha* cv. BRS Piatã were overseeded in soybean at five additional rates: 25%, 50%, 75%, and 100% of the recommended seeding rate of viable pure seed. Each plot measured 16 m² (4×4 m).

Germination tests (triplicate) determined an average of 56% germination and 96% purity. Based on 320 cultural value points (CVP ha⁻¹) as recommended by Dias-Filho *et al.* (2012), the recommended rate was 9.62 kg ha⁻¹, and the additional treatments were 12.5, 14.43, 16.83, and 19.24 kg ha⁻¹. Seeds were coated with an organo-mineral adhesive and graphite to facilitate sowing. Weed control was achieved with two glyphosate applications (960 g ha⁻¹) at 15 and 30 days after soybean emergence.

Forage overseeding was done on January 23, 2023, at the soybean R6 stage (94 days after sowing), when grains were fully developed and just before leaf senescence. No desiccation herbicides were applied to avoid interfering

Figure 1: Average temperature and precipitation in the experimental area of the Instituto Federal de Mato Grosso, Guarantã do Norte campus, from October 2022 to July 2023.



Source: Authors.

with forage establishment.

Soybean yield (kg ha^{-1}) was estimated by harvesting the central area of each plot. Plants were manually cut at 10 cm height, threshed, and dried at $\sim 15\%$ moisture. The remaining crop was harvested mechanically at a 20 cm cutting height.

Fifteen days after soybean harvest, forage plant density (plants m^{-2}) was assessed doing three randomly pitches of a 0.3 m^2 hollow quadrat per plot. At 90 days after overseeding (DAO), plant height was measured using a ruler from soil surface to the leaf canopy (average: 80 cm). Tiller number per m^2 was recorded, followed by cutting the forage at 25 cm residual height. The first of three uniform cuts was performed the next day and the others two cuts at 28-day intervals for morphogenetic evaluations.

Fresh mass was weighed in the field. A 0.4 kg sample was taken to the lab, where leaves and stems were separated, bagged, and dried at 65°C for 48 hours to determine dry matter, leaf and stem proportions, and leaf-to-stem ratio.

For morphogenetic traits, five tillers per plot were marked after each cut and evaluated weekly. They were color-marked and repositioned after each cycle. Variables assessed included: Number of live leaves per tiller (NLL): mean number of expanding and expanded leaves per tiller, excluding senescent leaves with more than 50% blade senescence. Stem elongation rate (SER, cm day^{-1}): stem length difference between two evaluations divided by the number of days. Leaf appearance rate (LAR, leaves day^{-1}): number of new leaves per tiller divided by days between evaluations. Tiller appearance rate (TAR): ((new tillers/total live tillers from previous marking) / number of days). Phyllochron (days leaf^{-1}): reciprocal of LAR. Number of senescent leaves per tiller (NSL): average number of leaves with over 50% senescence. Results were subjected to F-tests; regression analysis was applied to seeding rates, and Tukey's test to compare forage cultivars. All analyses were performed using SISVAR, with a 5% significance level.

3 RESULTS AND DISCUSSION

The results for soybean grain yield (GY), forage plant population (FPP) evaluated at 15 DAP (days after planting) of soybean, total dry matter (TDM), percentage of leaves (LP) and stems (SP), and the leaf/stem ratio (LSR) evaluated at 90 DAS (days after sowing) are presented in Table 1. The average soybean grain yield was $4,700 \text{ kg ha}^{-1}$.

Considering that the *Urochloa* cultivars were sown at the R6 stage of soybean, the crop's yield potential was already determined. Therefore, the forage species would only interfere if the coexistence occurred during the critical competition period, which occurs between 18 and 48 days after soybean emergence (Roncatto *et al.*, 2021).

Table 1: Mean squares for the variables soybean grain yield (GY), forage plant population (FPP), total dry matter (TDM), leaf percentage (LP), stem percentage (SP), and leaf/stem ratio (LSR) of forage materials under different sowing rates in soybean.

SV	D.F	GY (kg ha ⁻¹)	FPP (plants m ⁻²)	TDM (kg ha ⁻¹)	LP %	SP %	LSR
Block	2	8,463,395	6.1	45,945	40.76	40.8	0.36
FC	2	555,662	12.6*	60,843	94.6*	94.0*	0.50
SR	4	647,697	75.3*	45,839	28.7	28.7	0.31
FC×SR	8	675,484	3.9	483,013	16.8	16.7	0.41
Error	28	806,786	2.0	2,026,600	28.7	28.7	0.47
Average		4,700.4	9.4	989.6	64.8	35.8	2.04

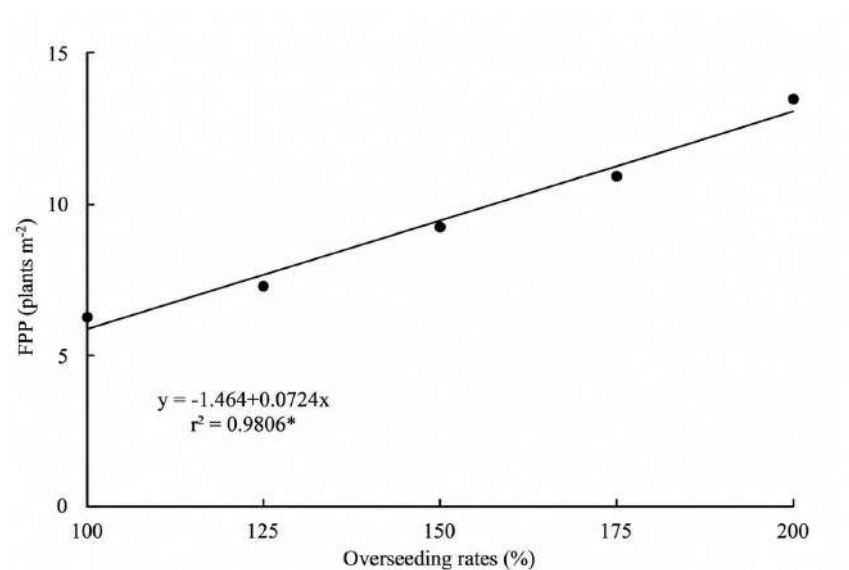
SV (Source of Variation); d.f. (degrees of freedom); FC (Forage Cultivars); SR (Sowing Rates); FC×SR (interaction forage cultivars × sowing rates); CV (coefficient of variation); *significant at 5% probability level. Source (Authors).

Although increasing the seeding rate resulted in greater plant density, biomass production did not increase proportionally, highlighting limitations imposed by environmental factors (Wang *et al.*, 2025). Under higher plant densities, intraspecific competition for light, water, and nutrients intensifies, potentially restricting dry matter accumulation per plant and reducing resource-use efficiency. Recent studies indicate that forage productivity is determined by the interaction between plant density, resource availability, and environmental conditions, rather than by linear gains associated solely with increased population density (Lu *et al.*, 2024). Thus, higher seeding rates enhance initial establishment and soil coverage; however, final biomass accumulation remains strongly conditioned by prevailing edaphoclimatic conditions throughout the growing cycle.

No interaction was observed for forage plant population per m², but independent effects were found for both sowing rates and forage cultivars. A simple linear model was fitted for sowing rates, and for each 1% increase in seed rate, there was an increase of 0.072 plants per m². According to the literature, a forage plant population between 10 and 20 plants per m² is considered adequate for conventionally established *Urochloa* pastures (Dias-Filho, 2012). Therefore, seed rates starting from 15.3 kg ha⁻¹ were the most suitable for establishing the studied cultivars.

Higher overseeding rates are economically justified: seed costs represent less than 5% of total pasture establishment costs (IFAG, 2023), while improved plant density reduces stand failure risk and enhances uniformity. Overseeding also eliminates soil preparation steps (harrowing, seed incorporation), reducing machinery traffic and compaction risk; mechanization accounts for approximately 38% of establishment costs (IFAG, 2023). The soybean canopy at R6 also moderates near-ground temperature and humidity, favouring seed germination (Volf *et al.*, 2021; Oliveira *et al.*, 2022), making overseeding technically, economically, and environmentally advantageous.

The average results for forage plant population, leaf and stem percentages, total dry matter, and the leaf/stem ratio of the overseeded forage cultivars in soybean at 90 DAS are presented in Table 2. Although no differences were found for total dry matter among the forage cultivars, *U. brizantha* cv. Xaraés and BRS Ipyorã showed higher plant populations per m² regardless of sowing rate.

Figure 2: Forage plant population (FPP) after soybean harvest in *Urochloa* cultivars as a function of overseeding rates. *Significant at 5% probability.

Source: Authors.

Table 2: Forage plant population (FPP), total dry matter (TDM), leaf percentage (LP), stem percentage (SP), and leaf/stem ratio (LSR) under different sowing rates in soybean.

Urochloa cultivars	FPP	TDM	LP	SP	LSR
	plants m ⁻²	kg ha ⁻¹	%	%	
BRS Piatã	8.40 ^b	1,050.10 ^{ns}	52.95 ^b	37.90 ^a	1.95 ^{ns}
BRS Xaraés	10.20 ^a	995.80 ^{ns}	63.42 ^{ab}	36.60 ^{ab}	1.92 ^{ns}
BRS Ipyora	9.60 ^{ab}	923.12 ^{ns}	66.90 ^a	33.03 ^b	2.25 ^{ns}
LSD	1.26	243.3	4.84	4.86	0.62

Means followed by the same letter do not differ statistically at the 5% probability level (Tukey's test). ns = not significant. LSD = least significant difference. Source (Authors).

It is noteworthy that although BRS Piatã exhibited lower plant population per m², this cultivar produced greater total dry matter. This response may be associated with physiological and adaptive mechanisms related to intraspecific competition (Taiz *et al.*, 2017). At lower densities, individual plants have relatively greater access to limiting resources, which may favor increased individual growth, larger tiller diameter, and greater light interception per plant, ultimately enhancing biomass accumulation. Conversely, at higher densities, intense competition may restrict individual growth and compromise canopy structural efficiency, influencing the relationship between tiller number, canopy architecture, and biomass production per unit area (Tinos *et al.*, 2020). These findings reinforce that higher plant density does not necessarily translate into greater final yield.

Urochloa species typically reach a maximum height of 1.0 m near flowering. At this stage, the plant allocates more soluble solids to inflorescence formation, increasing stem mass and proportion compared to leaves (Ferreira *et al.*, 2016). At the first forage cut, plants averaged 80 cm in height, meaning that the evaluated materials were close to the recommended grazing height, indicating high productive potential and the possibility of multiple cuts

during the same growing season.

BRS Ipyporã, which is developed from a cross between a *Urochloa ruziziensis* genotype and a *Urochloa brizantha* accession, is highly adapted to local climatic conditions. It exhibits vigorous growth, high dry matter yield and forage quality, tolerance to spittlebugs, resistance to prolonged droughts, and rapid regrowth—all traits that contribute to its suitability in the Amazon environment (Avelino *et al.*, 2020; Camargo *et al.*, 2021). These reported traits align with the findings of this study, as BRS Ipyporã showed favorable results for FPP, LP, and SP compared to BRS Piatã, a more commonly used cultivar in the region.

FPP, LP, and SP were significantly influenced by the forage cultivars (Tables 1 and 2). Despite the interdependence between LP and SP, there were no statistical differences in TDM among cultivars or sowing rates (Tables 1 and 2). In contrast, Almeida *et al.* (2009), studying sowing methods and rates for BRS Piatã grass, observed a linear effect of sowing rate on forage TDM.

No significant interaction was observed for tiller number; only isolated effects of sowing rate were found (Table 3). Due to the higher number of plants per area, tiller number was influenced by sowing rate in all evaluations (Table 3). As sowing rates increased, tillering after each cut increased by 0.619, 1.143, and 1.372 tillers per m² in April, May, and June, respectively, for each 1% increase in sowing rate (Figure 3).

Table 3: Mean squares for the number of tillers per m² in April, May, and June 2023, respectively.

SV	G.L.	Number of tillers per m ²		
		(april/23)	(may/23)	(june/23)
Block	2	8,298.0*	6,617.0 ^{ns}	4,595.8 ^{ns}
FC	2	8,16.0 ^{ns}	1,232.0 ^{ns}	856.1 ^{ns}
SR	4	23,048.0*	32,043.0*	22,252.4**
FC*SR	8	16,686.0 ^{ns}	3,063.0 ^{ns}	2,141.6 ^{ns}
Error	28	32,395.0	2,673.0	1,856.6
Average		143.8	189.2	157.7

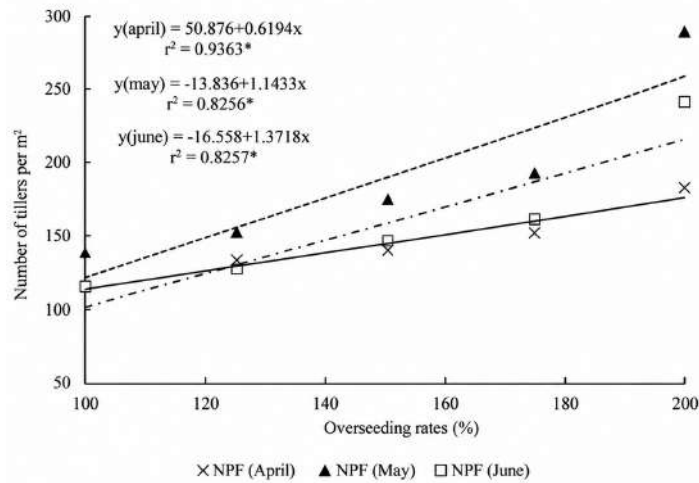
SV (Source of Variation); d.f. (degrees of freedom); FC (Forage Cultivars); SR (Sowing Rates); FC×SR (Forage Cultivar × Sowing Rate interaction); CV (coefficient of variation). *, **, and ns = significant at 5%, 1%, and not significant, respectively. Source (Authors).

The tillering response indicates the similar ability of the tested materials to the tiller under overseeding management. This trait is especially important for the Amazonian dry season, when rainfall decreases and forage productivity declines. Climate data from the past three years (Figure 1) shows that June typically receives less than 10 mm of rainfall, subjecting plants to water stress, which reduces tillering and the longevity of live tillers (Kramer; Boyer, 1995). The decline in productivity due to water stress was also noted by Souza *et al.* (2021), who evaluated *Urochloa* genotypes for drought tolerance in the Cerrado region of Minas Gerais.

For morphogenetic traits, statistical differences were only observed among cultivars for the number of live leaves per tiller (NLL), phyllochron, and leaf appearance rate (LAR) during the first cut in April 2023 (Table 4). The lack of significance in the May and June cuts (Table 4) is likely due to the evaluation period, as total rainfall during these two months was below 20 mm (Figure 1), indicating a water deficit period (Zimmerman *et al.*, 2004). Water-stressed plants show reduced photosynthetic rates and growth, as oxidative stress impairs solute translocation and metabolic processes, ultimately halting vegetative growth (Taiz *et al.*, 2017; Habermann *et al.*, 2019).

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Figure 3: Tiller number per m² evaluated in April, May, and June, corresponding to the 1st, 2nd, and 3rd cuts, respectively.
*Significant at 5% probability.



Source: Authors.

Table 4: Mean squares for number of live leaves per tiller (NLL); phyllochron; leaf appearance rate (LAR); stem elongation rate (SER); tiller appearance rate (TAR); and number of dead leaves per tiller (NDT) for forage cultivars evaluated at three cuts after soybean harvest.

SV	D.F.	NLL (leaves tiller ⁻¹)	Phyllochron (days)	LAR (leaves day ⁻¹)	SER (cm day ⁻¹)	TAR (tillers day ⁻¹)	NDT (leaves tiller ⁻¹)
April/2023 assessment (1st cut)							
Block	2	0.09	0.76	0.0001	0.053	0.005	1.76*
FC	2	2.64*	1,407.22*	0.0034*	0.024	0.026	0.14
SR	4	0.57	324.73	0.0008	0.013	0.042	0.22
FC×SR	8	0.22	228.91	0.0003	0.017	0.005	0.019
Error	28	0.29	254.03	0.0004	0.014	0.010	0.11
Average		1.55	24.21	0.055	0.14	0.18	0.71
May/2023 assessment (2nd cut)							
Block	2	0.174	3,664.0	0.0001	0.003	0.006	0.25
FC	2	0.080	1,534.0	0.0001	0.009	0.0001	0.262
SR	4	0.068	4,874.0	0.0001	0.001	0.0006	0.021
FC×SR	8	0.162	8,159.0	0.0003	0.003	0.0014	0.128
Error	28	0.192	11,105.0	0.0003	0.003	0.0012	0.091
Average		0.23	81.40	0.01	0.05	0.11	0.61
June/2023 assessment (3rd cut)							
Block	2	0.08	3,409.7	0.00008	0.0071	0.005	0.0968
FC	2	0.683	7,549.3	0.0008	0.0009	0.00001	0.0435
SR	4	0.187	12,320.4	0.00026	0.0021	0.00001	0.0413
FC×SR	8	0.333	7,137.97	0.00034	0.0032	0.00218	0.0313
Error	28	0.238	8,598.6	0.00031	0.001	0.0196	0.07
Average		0.084	135.8	0.001	0.001	0.14	0.63

SV (Source of Variation); d.f. (degrees of freedom); FC (Forage Cultivars); SR (Sowing Rates); FC×SR (Forage Cultivar × Sowing Rate interaction); CV (coefficient of variation). *, **, and ns = significant at 5%, 1%, and not significant, respectively. Source (Authors).

Water deficit impairs key physiological processes (stomatal conductance, photosynthesis, cell turgor), reducing leaf elongation, tillering, and biomass accumulation, which can mask treatment differences (Flexas *et al.*, 2021). Advancing overseeding to wetter periods would promote deeper root development and improve physiological stability under subsequent drought conditions (Fariaszewska *et al.*, 2020).

NLL, phyllochron, and LAR are directly correlated (Ongaratto *et al.*, 2021), and significant differences were observed for these variables during the first forage cut, with BRS Xaraés underperforming compared to BRS Piatã and BRS Ipyporã (Table 5). Da Cruz Quintino *et al.* (2016) found no significant morphogenetic differences for BRS Piatã intercropped with sorghum under irregular rainfall. Similarly, Gurgel *et al.* (2022) reported no differences in leaf elongation rate, phyllochron, and NLL among BRS Paiaguás, BRS Ipyporã, and *U. brizantha* cv. Marandu in the Brazilian Cerrado. However, BRS Paiaguás and Marandu established by 44 days, while BRS Ipyporã took 58 days. The lack of morphogenetic differences may be due to the genetic similarity of these materials and their susceptibility to drought stress in their early development stages (Valle *et al.*, 2017).

Table 5: Number of live leaves per tiller (NLL), phyllochron, and leaf appearance rate (LAR) for forage cultivars evaluated at the first cut (April 2023) after soybean harvest.

Urochloa cultivars	NLL	Phyllochron	LAR
	leave/tiller	days	leaves day ⁻¹
BRS Piatã	1.78 ^a	17.02 ^b	0.067 ^a
BRS Xaraés	1.06 ^b	35.22 ^a	0.033 ^b
BRS Ipypora	1.80 ^a	20.39 ^b	0.064 ^a
LSD	0.49	14.40	0.018

Means followed by the same lowercase letter in the column do not differ statistically at the 5% probability level (Tukey's test). LSD = least significant difference. Source (Authors).

Comparative studies of *Urochloa* cultivars, especially hybrids such as BRS Ipyporã, show that most materials do not significantly differ in forage systems integrated with crops. They generally display similar forage production, leaf/stem ratios, and desiccation efficiency during the offseason (Valle *et al.*, 2017).

BRS Ipyporã combines traits from *U. ruziziensis* and *U. ruziziensis*, combining rapid establishment, shade tolerance, and broadcast seeding adaptation with vegetative vigor, drought tolerance, and pasture persistence from *U. brizantha*. This combination yields high soil-covering capacity, productive stability, and pasture longevity—strategic attributes for crop-livestock integration systems (Rodrigues *et al.*, 2023).

4 CONCLUSIONS

Overseeding of *Urochloa* forage species in the southern Amazon region is technically feasible; however, it requires a minimum rate of 15.3 kg ha⁻¹ of seed to ensure adequate establishment and compensate for losses inherent to broadcast distribution under the soybean canopy.

Sowing rates above 15.3 kg ha⁻¹ promote adequate plant population and tiller density, ensuring successful pasture establishment through overseeding.

BRS Xaraés and BRS Ipyporã are the most suitable cultivars for overseeding in soybean fields, regardless of the sowing rate.

Regarding morphogenetic characteristics linked to leaf flow, BRS Xaraés and BRS Ipyporã showed the best results.

Given the unique environmental conditions in the southern Amazon region, further research about *Urochloa* cultivars under diverse edaphoclimatic conditions is needed.

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REFERENCES

- ALMEIDA, R. G.; COSTA, J. A. A. d.; KICHEL, A. N.; ZIMMER, A. H. **Taxas e métodos de semeadura para Brachiaria brizantha cv. BRS Piatã em safrinha**. Campo Grande, 2009. 12 p.
- BORGHI, E.; BORTOLON, L.; BORTOLON, E. S. O.; CAMARGO, F. P.; SILVA, R. R. d.; AVANZI, J. C.; ANDRADE, C. A. O. d.; FIDELIS, R. R.; GUARDA, V. D. A.; SIMON, J.; CAMPOS, L. J. M.; CUNHA, M. K.; LIMA, A. d. O.; BARBOSA, R. P. P.; ROCHA, P. H. F.; AO, W. S. S. d. C.; JUNIOR, O. J. F.; SILVA, F. H.; SOUZA, O. R. d.; PEREIRA, M. H. M.; SOUZA, J. P. d. **Sobressemeadura de capins na soja para sistemas de integração lavoura-pecuária**. Palmas: Embrapa Pesca e Aquicultura, 2017. 34 p.
- CAMARGO, F. C.; DIFANTE, G. D. S.; MONTAGNER, D. B.; EUCLIDES, V. P. B.; TAIRA, C. D. A. Q.; GURGEL, A. L. C.; SOUZA, D. L. D. Morphogenetic and structural traits of Ipyporã grass subjected to nitrogen fertilization rates under intermittent grazing. **Ciência Rural**, v. 52, n. 5, p. e20201074, 2021. Available at: <https://doi.org/10.1590/0103-8478cr20201074>.
- FARIASZEWSKA, A.; APER, J.; HUYLENBROECK, J. V.; SWAEF, T. D.; BAERT, J.; PECIO, L. Physiological and biochemical responses of forage grass varieties to mild drought stress under field conditions. **International Journal of Plant Production**, v. 14, n. 2, p. 335–353, 2020. Available at: <https://doi.org/10.1007/s42106-020-00088-3>.
- FERREIRA, L. V.; PAROLIN, P.; MATOS, D. C.; CUNHA, D. A.; CHAVES, P. P.; NECKEL, S. O. The effect of exotic grass *Urochloa decumbens* (stapf) rd webster (poaceae) in the reduction of species richness and change of floristic composition of natural regeneration in the floresta nacional de carajás, brazil. **Anais da Academia Brasileira de Ciências**, v. 88, n. Suppl 1, p. 589–597, 2016. Available at: <https://doi.org/10.1590/0001-3765201620150121>.
- FLEXAS, J.; CLEMENTE-MORENO, M. J.; BOTA, J.; BRODRIBB, T. J.; GAGO, J.; YUSUKE, M.; NADAL, M.; PEREIRA-CASTRO, A. V.; ROIG-OLIVER, M.; SUGIURA, D.; XIONG, D.; CARRIQUI, M. Cell wall thickness and composition are involved in photosynthetic limitation. **Journal of Experimental Botany**, v. 72, n. 11, p. 3971–3986, 2021. Available at: <https://doi.org/10.1093/jxb/erab144>.
- FRAGOSO, R. O.; CARPANEZZI, A. A.; KOEHLER, H. S.; ZUFFELLATO-RIBAS, K. C. Barreiras ao estabelecimento da regeneração natural em áreas de pastagens abandonadas. **Ciência Florestal**, v. 27, p. 1451–1464, 2017.
- GONTIJO-NETO, M. M. **Recomendações de densidades de plantio e taxas de semeadura de culturas anuais e forrageiras em plantio consorciado**. Sete Lagoas, 2006. 6 p.
- GURGEL, A. L. C.; DIFANTE, G. d. S.; COSTA, C. M.; NETO, J. V. E.; AO, G. H. T.; ÍTAVO, L. C. V.; DIAS, A. M.; VILELA, I. M. M.; OLIVEIRA, V. C. d.; LIMA, P. C. S.; MIYAKE, A. W. A. Establecimiento de gramíneas forrajeras tropicales en el bioma del cerrado. **Revista Mexicana de Ciencias Pecuarias**, v. 13, n. 3, p. 674–689, 2022. Available at: <https://doi.org/10.22319/rmcp.v13i3.6039>.
- HABERMANN, E.; OLIVEIRA, E. A. D.; CONTIN, D. R.; DELVECCHIO, G.; VICIEDO, D. O.; MORAES, M. A. d.; PRADO, R. M.; COSTA, K. A. P.; BRAGA, M. R.; MARTINEZ, C. A. Warming and water deficit impact leaf photosynthesis and decrease forage quality and digestibility of a c4 tropical grass. **Physiologia Plantarum**, v. 165, n. 2, p. 383–402, 2019. Available at: <https://doi.org/10.1111/plp.12891>.
- IFAG – Instituto para o Fortalecimento da Agropecuária de Goiás. **Estimativa de custo de produção formação e manutenção de pastagem**. 2023.
- KRAMER, P. J.; BOYER, J. S. **Water relations of plants and soils**. San Diego: Academic Press, 1995. 495 p.
- LU, Y.; MA, R.; GAO, W.; YOU, Y.; JIANG, C.; ZHANG, Z.; KAMRAN, M.; YANG, X. Optimizing the nitrogen application rate and planting density to improve dry matter yield, water productivity and n-use efficiency of forage maize in a rainfed region. **Agricultural Water Management**, v. 305, p. 109125, 2024. Available at: <https://doi.org/10.1016/j.agwat.2024.109125>.
- OLIVEIRA, T. F.; SANTOS, H. O. D.; RIBEIRO, J. B.; PEREIRA, W. V. S.; PEREIRA, A. A. S.; CUNHA, A. R. D. Priming *Urochloa ruziziensis* (r. germ. & evrard) seeds with signalling molecules improves germination. **Journal of Seed Science**, v. 44, p. e202244044, 2022. Available at: <http://dx.doi.org/10.1590/2317-1545v44262484>.

- ONGARATTO, F.; FERNANDES, M. H. M. D. R.; DALLANTONIA, E. E.; LIMA, L. D. O.; VAL, G. A. D.; CARDOSO, A. D. S.; RIGOBELLO, I. L.; CAMPOS, J. A. A.; REIS, R. A. R.; RUGGIERI, A. C.; MALHEIROS, E. B. Intensive production and management of Marandu palisadegrass (*Urochloa brizantha* ‘marandu’) accelerates leaf turnover but does not change herbage mass. **Agronomy**, v. 11, n. 9, p. 1846, 2021. Available at: <https://doi.org/10.3390/agronomy11091846>.
- QUINTINO, A. d. C.; ALMEIDA, R. G. d.; ABREU, J. G. d.; MACEDO, M. C. M. Características morfogênicas e estruturais do capim-piatã em sistema de integração lavoura-pecuária. **Veterinária e Zootecnia**, v. 23, n. 1, p. 131–138, 2016.
- RODRIGUES, P. R.; PACIULLO, D. S. C.; SOARES, N. A.; GOMIDE, C. D. M.; MORENZ, M. J. F.; LOPES, F. C. F.; SOBRINHO, F. S.; LANA, A. M. Q. Productive traits and nutritional value of *Urochloa ruziziensis* submitted to different planting densities and defoliation intensities. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v. 75, p. 1005–1015, 2023. Available at: <https://doi.org/10.1590/1678-4162-12976>.
- RONCATTO, E.; BARROSO, A. A. M.; CALEGARIM, J.; LUCIO, F. R.; ADAMI, P. F. Control period and economic threshold level of glyphosate tolerant weeds in 2,4-d resistant soybean. **Australian Journal of Crop Science**, v. 15, n. 2, p. 297–304, 2021. Available at: <https://doi.org/10.21475/ajcs.21.15.02.p3085>.
- SKORUPA, L. A.; MANZATTO, C. V. Avaliação da adoção de sistemas de integração lavoura-pecuária-floresta (ilpf) no Brasil. In: SKORUPA, L. A.; MANZATTO, C. V. (Ed.). **Sistemas de integração lavoura-pecuária-floresta no Brasil: Estratégias regionais de transferência de tecnologia, avaliação da adoção e de impactos**. Brasília: Embrapa, 2019.
- SOBRINHO, F. D. S.; AUAD, A. M.; BRIGHENTI, A. M.; GOMIDE, C. D. M.; MARTINS, C. E.; CASTRO, C. R. T. d.; PACIULLO, D. S. C.; BENITES, F. R. G.; ROCHA, W. S. D. B. d. **BRS Integra: Nova cultivar de Urochloa ruziziensis para a ILPF**. Juiz de Fora, 2022. 11 p.
- SOUZA, E. M. B.; ROCHA, W. S. D. d.; SOARES, N. d. A.; MARTINS, C. E.; SOBRINHO, F. d. S.; ALMEIDA, M. I. V. d.; RODRIGUES, P.; MOREIRA, G. R. Water deficit tolerance in genotypes of *Urochloa* spp.: Water deficit in *Urochloa* spp. **Revista de Ciências Agrárias**, v. 44, n. 2–3, 2021. Available at: <https://doi.org/10.19084/rca.21314>.
- TAIZ, L.; ZEIGER, E.; MØLLER, I. M.; MURPHY, A. **Fisiologia e desenvolvimento vegetal**. Porto Alegre: Artmed Editora, 2017. 888 p.
- THORNTHWAITE, C. W. An approach toward a rational classification of climate. **Geographical Review**, v. 38, n. 1, 1948.
- TINOS, A. C.; PRADO, G. d.; FONSECA, B. F.; BUENO, J. Y.; BRUSCAGIN, R. R. Influência da densidade de plantas, cortes e doses de nitrogênio na produção de capim-piatã. **Nativa**, v. 8, n. 4, p. 523–532, 2020. Available at: <https://doi.org/10.31413/nativa.v8i4.8515>.
- TOZER, K. N.; BARKER, G. M.; CAMERON, C. A.; WILSON, D.; LOICK, N. Effects of including forage herbs in grass-legume mixtures on persistence of intensively managed pastures sampled across three age categories and five regions. **New Zealand Journal of Agricultural Research**, v. 59, n. 3, p. 250–268, 2016. Available at: <https://doi.org/10.1080/00288233.2016.1188831>.
- VALLE, C. B.; EUCLIDES, V. P. B.; MONTAGNER, D. B.; VALÉRIO, J. R.; MENDES-BONATTO, A. B.; VERZIGNASSI, J. R.; TORRES, F. Z. V.; MACEDO, M. C. M.; FERNANDES, S. D.; BARRIOS, S. V. L.; FILHO, M. B. D.; MACHADO, L. A. Z.; ZIMMER, A. H. **Ipyporã (“belo começo” em guarani): Híbrido de Brachiaria da Embrapa**. Campo Grande, 2017. 17 p.
- VOLF, M. R.; CRUSCIOL, C. A.; CUSTÓDIO, C. C.; BOSSOLANI, J. W.; MACHADO, F. G.; WRUCK, F. J.; COSTA, C. H. M.; RIBEIRO, J. F.; SILVA, L. S. Interseeding of ruzigrass into soybean: Strategies to improve forage cultivation in no-till systems. **Annals of Agricultural Sciences**, v. 66, n. 1, p. 16–24, 2021. Available at: <https://doi.org/10.1016/j.aos.2021.02.003>.
- WANG, X.; WANG, J.; LI, E.; GUO, Y.; LI, W. Plant height is the main factor driving forage yield of *Poa* species under different row spacings and seeding rates in the qilian mountains. **Frontiers in Plant Science**, v. 16, p. 1535937, 2025. Available at: <https://doi.org/10.3389/fpls.2025.1535937>.