CULTIVAR RELEASE

URNRS24 – A cultivar of *Setaria italica* (L.) intended for grain production and soil cover

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Abstract: *Based on trials conducted in 2023, 2024, and 2025, and on nine sowing dates in 2025, the URNRS24 cultivar is characterized by its 82day cycle, as well as its potential for grain production, with high biomass production of 10892 kg ha^{-1} and carbon sequestration capacity of to 4901 kg ha^{-1}.*

Keywords: *Biomass, innovation, carbon sequestration, agronomic performance*

INTRODUCTION

Setaria italica (L.) is a small-sized grass species belonging to the Poaceae family, with high nutritional relevance (Shobana et al. 2013). It is characterized by rapid growth, high photosynthetic efficiency, C_4 metabolism, and tolerance to insect pests and diseases (Shanthi et al. 2017). Its grains are rich in non-structural carbohydrates (60-65%), proteins (5–10%) and lipids (3-5%), and also provide essential amino acids, minerals, and vitamins, including iron, manganese, phosphorus, magnesium, and B-complex vitamins with antioxidant activity (Vinoth and Ravindhran 2017, Ambati and Sucharitha 2019, Rébora et al. 2025).

Despite its importance, there are currently no registered cultivars in Brazil according to MAPA (2025), which has driven the need for research in plant breeding programs. These programs must focus on developing genotypes that meet the agronomic ideotype and optimize crop management practices (Carvalho et al. 2025). Among the desired characteristics in *Setaria italica* L. genotypes are early cycle, high grain and biomass productivity, tolerance to pests and diseases, and responsiveness to management practices. However, studies evaluating the agronomic performance of *Setaria italica* L. under field conditions in Brazil are still scarce.

The benefits of introducing this crop into the Brazilian agricultural system are widely recognized, notably its rapid biomass production, adaptation to different sowing times and tropical and subtropical environments, as well as its versatility of use. Therefore, based on these arguments and the need to provide improvements and alternatives to producers, the Plant Breeding Program of the Regional University of the Northwest of the State of Rio Grande do Sul (UNIJUÍ) was directed towards the purpose of developing stable and resilient cultivars with high grain and biomass productivity, adapted to the challenging

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edaphoclimatic conditions of Brazil. Therefore, this study aims to present the first cultivar of *Setaria italica* L. in Brazil, named URNRS24, as well as to highlight its aptitudes and agronomic characteristics.

IMPROVEMENT METHODS

The URNRS24 cultivar was developed by the Plant Breeding Program of the Regional University of the Northwest of the State of Rio Grande do Sul - UNIJUÍ, within the scope of the university's Postgraduate Program in Environmental Systems and Sustainability. The development process, which involved several selection cycles, began in January 2019 using germplasm collected in Porto Lucena - RS, with mass, aiming at different panicle colors, in a population of 2000 plants, selecting 250 panicles. In April 2019, the populations were sown in São Luiz Gonzaga - RS, with a population density of 50 seeds per linear meter and a row spacing of 0.17 meters, with selection applied to reduce plant height.

In subsequent generations, carried out in the same municipality (September 2019 and January 2020), a method of mass selection and cultural practices similar to those of the previous generation were used. However, the selection aimed at homogenizing plant architecture, early flowering, genetic gain for cycle reduction, and low grain dehiscence. Selections in May 2020, in São Borja - RS, prioritized plants with high tillering; in October of the same year, the growth and selection of plants with a semi-erect habit was emphasized.

In February 2021, seeds were sent to the UNIJUÍ Farm School (lat 28º 43' 81" S, long 54º 00' 61" W, alt 328 m asl) and sown (50 seeds m^{-1}, row spacing of 0.17 m). The desired agronomic ideotype consisted of plants with high biomass production, as well as increased leaf and panicle size, using the population method. During this period, roguing was performed to eliminate atypical plants.

In October 2022 and 2023, distinctiveness, uniformity, and stability (DUS) tests were conducted for qualitative and quantitative characteristics, as well as the minimum descriptors required for cultivar protection (UPOV 2011, MAPA 2025), which were registered by the Ministry of Agriculture and Livestock (process 21806.000269/2024), which determined provisional protection. Concurrently with the aforementioned procedures, competition and positioning tests were carried out in the years 2023, 2024, and 2025, sown in the first half of November. In addition, in 2025, a sowing time trial was conducted to determine the best positioning of the URNRS24 cultivar.

FEATURES AND PERFORMANCE

The elite line named URNRS24, resulting from the breeding procedures described above, was subjected to agronomic performance and distinguishability, uniformity, and stability tests in 2023, 2024, and 2025. The soil is classified as a Typical Dystroferric Red Latosol (Santos et al. 2025) and the region's climate, according to the Köppen classification, is humid subtropical (Alvares et al. 2014). In these scenarios, the URNRS24 cultivar, the original population (control), and a variety commonly used by producers in the region (control) were used. Due to the absence of registered cultivars in Brazil, the original population was used to quantify the gains obtained throughout the selection cycles, as well as a variety (common variety), widely used by producers in the region, and for its performance under local conditions. In this way, it was possible to compare the performance of URNRS24 with a representative standard of the production system.

Additionally, in 2025, a sowing date trial was conducted, with the following dates: August 05, 2025 (E_1), August 20, 2025 (E_2), September 04, 2025 (E_3), September 09, 2025 (E_4), October 09, 2025 (E_5), October 24, 2025 (E_6), November 07, 2025 (E_7), November 20, 2025 (E_8) and December 17, 2025 (E_9), for the trials, a randomized block design with 10 repetitions was used.

Each experimental unit consisted of 20 sowing rows, spaced 0.17 m apart and 10 m long, totaling a useful area of 34 m^2. The sowing density was 50 seeds m^{-1} and the base fertilization was 250 kg ha^{-1} of 05-20-20 (NPK). At physiological maturity, 25 plants per experimental unit were randomly selected to measure the following variables: plant height (PH, cm), days from emergence to flowering (DEF, days), days from flowering to maturity (DFM, days), cycle (CYCLE, days), panicle length (PL, cm), number of grains per panicle (NGP, units), panicle weight (PW, grams), panicle grain weight (PGW, grams), thousand grain weight (TGW, grams), and grain yield (GY, kg ha^{-1}).

In addition to this, the minimum descriptors were measured, such as: cycle to emergence (days), flag leaf: blade length (cm), flag leaf: blade width (cm), stem: length (cm), stem: diameter (mm), plant: number of elongated internodes (units), plant: peduncle length (cm), panicle: length (cm), and panicle: number of grains on the primary branch (units). Subsequently, characteristics associated with biomass production and carbon partitioning in the plant were evaluated, such as total dry biomass (kg ha^{-1}), total carbon fixation (C) (kg ha^{-1}), root biomass (%), stem and leaf biomass (%), panicle biomass (%), root C fixation (kg ha^{-1}), stem and leaf C fixation (kg ha^{-1}), and panicle C fixation (kg ha^{-1}). The data obtained were subjected to descriptive analysis. Following this, the data were subjected to analysis of the assumptions of analysis of variance, such as homogeneity of residual variances using the Bartlett test and normality of errors using the Shapiro-Wilk test. With the proposed model met, analysis of variance with a probability of 5% was employed, as well as grouping by mean using the Scott-Knott method ($p < 0.05$).

The analysis of variance between agricultural years revealed significant effects for the variables PH, DEF, DFM, CYCLE, PL, NGP, and PGW at a 5% probability level using the F-test (Table 1). In contrast, the variable TGW did not show significance. The coefficients of variation ranged from 3.81 to 21.21% for PH, DEF, DFM, CYCLE, PL and NGP, which are low to moderate according to the classification of Pimentel-Gomes (2009). The TWG presented a CV classified as high (35.38%), as it is a complex characteristic resulting from the interaction between multiple components, such as the number of particles and individual weight, which contributes to higher coefficient of variation values.

Fluctuations in the performance of the URNRS24 cultivar were observed throughout the three growing seasons, indicating a strong influence of environmental conditions on phenological and productive characteristics. Greater plant height was observed in 2023 and 2024 (82.02 and 81.79 cm) (Table 1). However, in 2025, higher responses were observed for DEF, CYCLE, NGP, and PGW. Thus, the results show that 2025 presented smaller plants and a longer cycle, with an increase in the productive characteristics of NGP and PGW.

The analysis of variance between sowing dates in the year 2025 showed significance for the variables PL, NGP, PGW and GY, while the weight of one thousand grains (TGW) again did not show significant variation (Table 2). The coefficients of variation ranged from 6.61 to 13.46%, which reveals high precision and reliability in the results.

Sowing dates significantly influenced all evaluated characteristics of the URNRS24 cultivar, with direct effects on grain yield (GY). Although some sowing dates showed satisfactory responses for some yield components, such as date E_5 (October 9, 2025), for panicle length (PL), panicle mass (PW), number of grains per panicle (NGP), and panicle grain mass (PGW), grain yield (GY) was lower (951 kg ha^{-1}) (Table 2). However, superior responses for PW, PGW and GY were observed in sowing dates E_6 (October 24, 2025), E_7 (November 7, 2025) and E_8 (November 20, 2025), with averages between 0.49 and 0.57 grams. Lower PGW values than those in this study were observed by Ribeiro et al. (2026), with averages between 0.191 and 0.345 grams. The observed grain yields averaged 1323.86, 1269.28, and 1333.00 kg ha^{-1} for E_6 (October 24, 2025), E_7 (November 7, 2025), and E_8 (November 20, 2025), respectively. Early sowing dates, such

Table 1. Summary of the analysis of variance and grouping of averages between agricultural years for plant height (PH, cm), days from emergence to flowering (DEF, days), days from flowering to maturity (DFM, days), cycle (CYCLE, days), panicle length (PL, cm), number of grains per panicle (NGP, units), panicle grain weight (PGW, grams) and thousand grain weight (TGW, grams), of the URNRS24 cultivar in the years 2023, 2024 and 2025

SV	df	MS							
		PH	DEF	DFM	CYCLE	PL	NGP	PGW	TGW
Years	2	913.63*	667.56*	117.43*	257.76*	111.25*	470023.00*	0.13*	0.07
Block	9	17.13	23.58	31.28	33.87	2.17	8769.00	0.01	0.03
Error	18	8.48	18.22	14.98	24.53	2.24	4822.00	0.001	0.03
Total	29								
CV (%)		3.81	7.63	17.73	6.73	17.85	21.21	35.38	20.04

Grouping of averages							
Years	PH	DEF	DFM	CYCLE	PL	NGP	PGW
2023	82.02 a[1]	47.45 c	24.60 a	72.05 b	11.73 a	105.51 c	0.01 c
2024	81.79 a	56.60 b	22.90 a	79.50 a	8.32 b	337.95 b	0.09 b
2025	65.35 b	64.75 a	18.00 a	81.75 a	5.06 c	538.72 a	0.24 a

* Significant at 5% probability by the F-test. [1] Means followed by the same lowercase letter in the column do not differ statistically at a 5% probability level using the Scott-Knott mean grouping test.

as E_1 (August 5, 2025) and E_2 (August 20, 2025), showed the lowest grain yields, associated with lower NGP and MGP values. Similarly, planting date E_9 (December 17, 2025) showed a reduction in crop performance.

These results suggest that unfavorable environmental conditions during grain filling may limit crop productivity during this period. The periods with the highest productivity coincide with sowings carried out between the second half of October and the second half of November, indicating that this interval is more favorable for crop development. Low productivity in early sowings (August) indicates limitations in the initial reproductive development of the crop. Ribeiro et al. (2026) observed that early sowing affects crop establishment, growth irregularity, and the risk of stress. Therefore, sowing from September 24 onward is recommended for this crop. Delayed sowing (December) also compromises performance, reinforcing that the choice of sowing date is a determining factor in the agronomic performance of *Setaria italica* L. under subtropical conditions.

The URNRS24 cultivar stands out for having a shorter flag leaf (25.50 cm), a larger stem diameter (1.63 mm), a higher number of grains on the primary branch (228 units), and a higher thousand grain weight (0.500 grams) compared to other genotypes (Table 3). These results indicate a more compact plant architecture, with greater tolerance to lodging.

Table 2. Summary of the analysis of variance and grouping of averages for sowing dates in the 2025 agricultural year, for the variables panicle length (PL, cm), panicle weight (PW, grams), number of grains per panicle (NGP, units), panicle grain weight (PGW, grams) and grain yield (GY, kg ha^{-1}), of the URNRS24 cultivar

SV	df	MS				
		PL	PW	NGP	PGW	GY
Sowing seasons	8	19.28*	0.32*	2.54*	0.04*	199112.00*
Block	9	0.48	0.01	0.11	0.002	16465.00
Error	72	0.36	0.02	1.11	0.003	20178.00
Total	89					
CV (%)		6.61		13.40	12.46	13.46

[1]Sowing seasons	Grouping of averages				
	PL	PW	NGP	PGW	GY
E_1	7.96 c	0.88 b	235.97 d	0.43 c	1005.50 c
E_2	8.55 b	0.74 c	223.5 d	0.43 c	1022.02 c
E_3	10.32 a	1.04 a	273.43 c	0.47 b	1115.82 b
E_4	8.66 b	0.69 c	364.35 a	0.40 c	1145.78 b
E_5	10.52 a	1.01 a	362.54 a	0.56 a	951.42 c
E_6	8.13 c	1.07 a	220.04 d	0.49 b	1323.86 a
E_7	10.59 a*	1.08 a	319.08 b	0.54 a	1269.28 a
E_8	8.88 b	1.12 a	281.52 c	0.57 a	1336.00 a
E_9	6.40 d	0.68 c	259.96 c	0.46 b	1093.46 b

* Significant at 5% probability by the F-test. [1] Sowing seasons: August 05, 2025 (E_1), August 20, 2025 (E_2), September 04, 2025 (E_3), September 23, 2025 (E_4), October 09, 2025 (E_5), October 24, 2025 (E_6), November 07, 2025 (E_7), November 20, 2025 (E_8) and December 17, 2025 (E_9). * Means followed by the same letter in the column do not differ significantly from each other at a 5% probability level using the Scott-Knott mean grouping method.

Table 3. Morphological characteristics of three genotypes of *Setaria italica* L

Characteristics	URNRS24	Original population	Common variety
Cycle to emergence (days)	7	5	8
Flag leaf: blade length (cm)	25.50	27.40	31.30
Flag leaf: blade width (cm)	1.79	1.26	2.03
Culm: length (cm)	83.30	81.90	78.60
Culm: diameter (mm)	1.63	1.34	1.08
Plant: number of elongated internodes	4	5	4
Plant: peduncle length (cm)	8.83	8.10	7.00
Panicle: length (cm)	6.25	7.20	5.88
Panicle: number of grains on the primary branch	228	108	106
Grain: thousand grain weight (g)	0.500	0.181	0.360

The peduncle length (8.83 cm) is also greater, favoring better panicle exposure and potentially greater efficiency in light interception, an important aspect for grain filling. These qualities indicate high yield potential, making it a promising cultivar.

Table 4. Biomass accumulation and carbon partitioning in different plant components of the URNRS24 cultivar

Parameters	Units
Total Dry Biomass (kg ha^{-1})	10892.00
Total Carbon Fixation (kg ha^{-1})	4901.40
Root biomass (%)	16.62
Biomass in stems and leaves (%)	56.96
Panicle biomass (%)	26.41
C fixation via root (kg ha^{-1})	814.81
Carbon fixation via stem and leaves (kg ha^{-1})	2792.11
C fixation via panicle (kg ha^{-1})	1294.47

The URNRS24 cultivar exhibits high total dry biomass production (10,892 kg ha^{-1}) and significant carbon fixation (4,901.40 kg ha^{-1}), demonstrating strong potential for carbon sequestration (Table 4). Similar results for total dry biomass production were reported by Rébora et al. (2025) in Argentina, with productivities ranging from 7,605.00 to 14,098.00 kg ha^{-1}. The greatest allocation of biomass is observed in the stem and leaves (56.96%), also reflecting the greater fixation of C. This indicates a high capacity for radiation interception and accumulation of photoassimilates, which favors not only vegetative growth but also carbon cycling in agricultural systems. The panicle concentrates 26.41% of the biomass and accounts for 1,294.47 kg ha^{-1} of C fixation, associated with grain production. This balance between vegetative and reproductive growth demonstrates the potential of this crop for grain and biomass production. The roots, with a smaller proportion (16.62%), still play an important role in carbon fixation in the soil (814.81 kg ha^{-1}). The balance in biomass production among the different parts of the plant shows that the URNRS24 cultivar combines high aboveground phytomass production with a significant contribution of carbon to the soil, which expands its potential use in both grain productivity systems and conservation strategies, such as no-till farming and cover cropping systems.

Therefore, the URNRS24 cultivar exhibits an early cycle, high grain productivity, high dry biomass, and significant carbon sequestration, highlighting its potential for sustainable agricultural systems.

SEED PRODUCTION

The URNRS24 cultivar (*Setaria italica* L.), intended for grain production and soil cover, was protected by the Ministry of Agriculture and Livestock (MAPA) on March 17, 2026 (Process No. 21806.000269/2024). Registration with the Brazilian National Register of Cultivars (RNC) is underway with support from the UNIJUÍ Innovation and Technology Agency, which fosters public–private sector interaction. Seed multiplication for this genetic category has begun, resulting in a final seed volume of 200 kg.

DATA AVAILABILITY

The datasets generated and analyzed during this research are available upon request from the corresponding author.

CREDIT STATEMENT

The authors contributed collectively to the development and release of the new Setaria italica cultivar. Coordination of the breeding program and supervision of the experimental activities were carried out by Ivan Ricardo Carvalho and José Antonio Gonzalez da Silva. Field experiments, agronomic data collection, and statistical analyses were conducted by Ivan Ricardo Carvalho, João Pedro Dalla Roza, Jaqueline Piesanti Sangiovo, Pedro Modesto Fagundes Braga, Gabriel Mathias Weimer Bruinsma, and Thayane Beck da Silva. Cultivar selection, performance evaluation, and interpretation of results were performed by Ivan Ricardo Carvalho, Jaqueline Piesanti Sangiovo, Leonardo Cesar Pradebon, and Gabriel Mathias Weimer Bruinsma. Manuscript writing, revision, and formatting were carried out by Ivan Ricardo Carvalho, Leonardo Cesar Pradebon, Gabriela Bueno Luz, and José Antonio Gonzalez da Silva. All authors discussed the results, critically reviewed the manuscript, and approved the final version for publication.

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