CULTIVAR RELEASE

URNRS22 – A white oat cultivar intended for grain production and soil cover

Ivan Ricardo Carvalho[1*], Leonardo Cesar Pradebon[2], Jaqueline Pieasanti Sangiovo[2], Gabriel Mathias Weimer Bruinsma[1], Murilo Vieira Loro[2], José Antonio Gonzalez da Silva[1] and João Pedro Dalla Roza[1]

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Abstract: *The cultivar URNRS22 is characterized by an early cycle, high grain mass per panicle and high grain yield, in addition to high biomass production, showing high stability of grain yield in the tested scenarios in the northwest of the state of Rio Grande do Sul, Brazil.*

Keywords: Avena sativa *L., innovation, high stability, agronomic ideotype*

INTRODUCTION

White oat (*Avena sativa* L.) is one of the main cereals cultivated in the world. This grass has great agronomic, social and economic importance, due to its broad abilities. Its grains are made up of 17% protein, 30% fiber, 3.5% *β*-glucan and 12% lipids (Maximino et al. 2021). In Brazil, the South Region has more than 520 thousand hectares of cultivated area and production of more than 984 thousand tons of grains (CONAB 2024).

The advancement of its production chain is due to farmers' adherence to the cultivation of white oats, resilient cultivars, high agronomic performance, high grain yield and nutritional quality. This highlights the great responsibility of genetic improvement programs in developing genotypes that meet the agronomic ideotype, maximize the cultural practices used and mitigate harmful effects on the environment. Selections based on agronomic precepts generate genotypes that are more responsive to environmental and productive stimuli (Pradebon et al. 2024a).

Therefore, the continuous obtaining of new cultivars of white oat is essential to guarantee the progress of this crop in Brazil. In this context, the Genetic Improvement Program of the Regional University of the Northwest of the State of Rio Grande do Sul - UNIJUÍ aims to develop resilient, stable cultivars with high grain yield and biomass productivity, which meet the edaphoclimatic needs of the Southern Region of Brazil. Given this, the objective of this work is to present the new white oat cultivar URNRS22, as well as its agronomic performance.

IMPROVEMENT METHODS

The URNRS22 cultivar was developed by the 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

***Corresponding author:**
E-mail: ivan.carvalho@unijui.edu.br
ORCID: 0000-0001-7947-4900

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[1] Universidade Regional do Noroeste do Estado do Rio Grande do Sul, Rua do Comércio, 3000, Universitário, 98700-000, Ijuí, RS, Brazil
[2] Universidade Federal de Santa Maria, Avenida Roraima, 1000, Cidade Universitária, Camobi, 97105-900, Santa Maria, RS, Brazil

and Sustainability. This cultivar was obtained through the cross between the maternal parent FAEM Brisasul and the paternal parent FAEM Barbarasul carried out in 2011 in Augusto Pestana – RS; the F_1 seeds generated were planted in the same location on spaced plants in 2012, with the purpose of maximizing the production of F_2 seeds.

The F_2 population was conducted again on spaced plants in 2013. In this situation, panicles from plants with rapid initial onset and early flowering were used as selection criteria. In the F_3 segregating generation implemented in 2014, the genealogical method was used, where each previously selected panicle was arranged in a sowing row. In this scenario, 1715 plants with smaller height and absence of lodging were selected.

In 2015, 1500 lines referring to the F_4 generation were conducted, using the genealogical method with selection pressure of 12%, aimed at obtaining a reduced size and angle of the flag leaf. In 2016, the F_5 generation was supported by the selection of plants that met the ideotype of architecture, shape and density of the panicle, as well as the absence of awns. On this occasion, a selection pressure of 33% was used, with only 1000 panicles being sent to the next generation. The strategy of conducting the genealogical method was maintained in 2017, and in the F_6 generation the selection was aimed at obtaining grains greater than 2.3 mm in diameter and the absence of shattering in the field; on this occasion, a selection pressure of 33% was used, with only 750 lineages being sent to the next generation. In 2018, the F_7 generation was conducted and in 2019 the F_8 generation was conducted, both kept in the Augusto Pestana - RS environment; they were subjected to selection to reduce foliar diseases, stem rust and panicles with grains greater than 2.3 mm in diameter. At the end of 2019, the superiority of a lineage that brought together all previously planned attributes, resilience to the environment, adequate grain and biomass production, was proven. Then, in May 2020, an internal competition test of the candidate lineage was carried out with commercial controls, once again, proving superiority for panicle grain weight and grains larger than 2.3 mm in diameter. In 2020 and 2021, Distinguishability, Homogeneity and Stability (DHS) tests were carried out in Augusto Pestana – RS, focusing on the characteristics previously established by the Ministry of Agriculture and Livestock. Therefore, on 06/19/2024, the Foundation for Integration, Development and Education of the Northwest of the State of Rio Grande do Sul was granted protection for the white oat cultivar URNRS22 (Process: N° 21806.000063/2023). Concomitant to the tests mentioned above, studies were carried out in Ijuí – RS, Augusto Pestana – RS and Campos Borges – RS in the years 2022, 2023 and 2024 with the purpose of understanding management techniques, agronomic recommendations and the yield potential of the cultivar URNRS22 against six commercial controls.

FEATURES AND PERFORMANCE

Given the morphological attributes of the cultivar, it is characterized by medium waxiness of the glumes and low control of the flag leaf sheath. The color of the lemma is evident as yellow, with low hairiness of the upper node of the culm, low twisting of the flag leaf, the glume is short and pointed, the grains are short with few basal hairs, the rachilla is medium, the grains are awnless, the plant has a medium and dense panicle with decumbent spikelets and the branches of the panicle are semi-erect.

URNRS22 belongs to the spring bioclimatic group, with upright plants, high biomass of up to 20 tons of green matter per hectare and more than three tons of dry matter. It shows excellent tolerance to the main foliar diseases in its plants, expressing in the last three years less than 10% incidence of *Bipolaris sorokiniana*, *Drechslera avenae*, *Puccinia coronata*, *Puccinia graminis*, *Ustilgo* sp. and *Fusarium graminearum*.

Positioning tests were carried out in the years 2022, 2023 and 2024 with sowings in the first half of May of each year, in the environments of Augusto Pestana – RS (lat 28º 26’ 03” S, long 54º 00’ 25” W, alt 286 m asl), Ijuí – RS (lat 28º 23’ 35” S, long 53º 56’ 38” W, alt 328 m asl) and Campos Borges - RS (lat 28º 58’ 13” S, long 53º 00’ 27” W, alt 513 m asl), the overall mean of all environments was considered for each agricultural year, with the aim of better defining the phenotypic stability of the cultivar. These environments were chosen because they have significant areas with white oat cultivation, both for grains and as cover, and because they are places with high cattle raising activity, as well as the largest dairy basin in RS.

For this trial, a randomized block design organized in an incomplete factorial scheme was considered, with treatments arranged in three replications, these being: URNRS22 and the controls FAEM Barbarasul (T_1), FAEM Brisasul (T_2), and URS Taura (T_6) in the years 2022 and 2023. In the year 2024, the cultivars IPR Afrodite (T_3), URS Altiva (T_4), URS Fapa Slava (T_5)

and URS Taura (T_6) were used as checks. Each experimental unit consisted of five rows of plants five meters long, spaced 17 centimeters apart and with a total area of 4.25 m^2. For all genotypes, a density of 50 seeds per linear meter was used, with basal fertilization of 300 kg of NPK (05-20-20) and 200 kg of urea with 45% nitrogen applied at full tillering. Phytosanitary management was carried out in order to minimize the biotic effects on the results of the experiment.

At full physiological maturity, 10 plants per experimental unit were randomly evaluated in the three central row. The traits measured were: plant height (PH, cm), panicle insertion height (PIH, cm), panicle length (PL, cm), panicle grain weight (PGW, g), number of panicle grains (NPG, units), hectoliter weight (HW, g cm^{-3}), panicle weight (PW, g), days from emergence to flowering (DEF, days), cycle duration (cycle, days), lodging (LOD, %), grain length (GL, mm), grain width (GW, mm), ratio between grain length and width (GLW, %), grain yield (GY, kg ha^{-1}) and thousand grain weight (TGW, g).

As it is a set of isolated experiments and with circulating controls in the three agricultural and local years, tests were carried out on the assumptions of the statistical model based on additivity, independence of errors, homogeneity and normality of residual variances. When they were met, the method based on Restricted Maximum Likelihood (REML) was used to estimate the variance components and genetic parameters through: $y = Xb + Za + Wi + e$, where *y* is the data vector; *b* is the vector of the block effects (assumed as fixed) added to the overall mean; *a* is the vector of individual genotypic effects (assumed as random); *i* is the vector of the effects of the genotype/environment interaction (with the environment corresponding to years); *e* is the vector of errors (random); and *X*, *Z*, and *W* represent the incidence matrices for the referred effects. The significance was obtained through the *Deviance* analysis at 5% probability level by the Chi-square test.

It was possible to estimate the components of phenotypic variance (σ^2F), broad-sense heritability (H^2) and residual coefficient of variation (Cvr), these being the basis for the best unbiased linear predictors (BLUPs) for each trait that demonstrated significance and biological meaning. Based on the predictions of the BLUPs and the definition of the agronomic ideotype aimed at high biomass and grains, the multitrait index of the genotype's distance from the intended agronomic ideotype (MGIDI) was used (Olivoto and Nardino 2021). With the purpose of selecting which cultivars jointly show an increase (positive direction) in panicle length (PL, cm), panicle grain weight (PGW, g), panicle weight (PW, cm), grain yield (GY, kg ha^{-1}) and thousand grain weight (TGW, g).

The variance components were estimated using Restricted Maximum Likelihood and confirmed by *Deviance* analysis at 5% probability level for all traits measured (Supplementary table 1). Significant effects of the agricultural year x white oat cultivar interaction were expressed for panicle length, panicle grain weight, panicle weight, days from emergence to flowering, days from emergence to maturity, grain yield and thousand grain weight. On the other hand, lack of significance was presented for the traits plant height, panicle insertion height, number of grains per panicle, test weight, hectoliter weight, lodging, grain length, grain width, ratio between grain length and width and days between flowering and maturity.

Reliable genetic parameters were presented only for days from emergence to flowering, days from emergence to maturity, panicle length, panicle weight, panicle grain weight, grain yield and thousand grain weight. Based on the broad-sense heritability parameter (H^2), which directly refers to the degree of variability available for the trait in question, it is evident that days from emergence to flowering, days from emergence to maturity, panicle weight, panicle grain weight and grain yields were lower than 15%, which indicates a high contribution of the growing environment, agricultural year and location in the phenotypic manifestation of these traits. Studies by Hartwig et al. (2007) postulate that characteristics related to the cycle and yield are determined by a high number of genes and a high effect of the environment in which the cultivar is grown. Pradebon et al. (2024a), based on estimates in 593 lines of white oat, defined that it is possible to obtain high heritability for days to flowering by controlling the residual variations of the experiments. Intermediate to high heritability was obtained for the attributes panicle length and thousand grain weight; these estimates are valid and repeatable in studies by Marchioro et al. (2003) and Klein et al. (2023), who defined magnitudes close to this parameter in selections of segregating lines of white oat and black oat, respectively.

Azevedo et al. (2022) project heritabilities of up to 58% for grain yield, days from emergence to maturity, thousand grain weight and test weight in studies of white oat, and this compilation of information validates the estimates obtained in the positioning of this new cultivar. The residual variation coefficient was acceptable for all measured traits, showing higher estimates for the panicle grain weight trait (16.53%), and the joint interpretation of broad sense heritability and the residual variation coefficient supports the results obtained, cultivar predictions and rankings.

Based on the ranking constructed by the best unbiased predictor combined with the agricultural years of 2022, 2023 and 2024 (Figure 1), it was observed that the traits days from emergence to flowering (Figure 1a) showed an overall mean of 75 days. In 2022 only the cultivar URS Taura (T_6) had a shorter than average vegetative period; however, in 2023 all cultivars revealed early flowering, and in 2024 early flowering was revealed for URS Altiva (T_4). In the three years of testing, URNRS22 expressed variation in vegetative period length of just 25 days, which is acceptable given the thermal fluctuations that have occurred in recent years in Rio Grande do Sul (Pacheco and Federizi 2020).

For the cycle (Figure 1b) there is an overall mean of 130 days. In 2022, all cultivars were lower than the overall mean, in 2023 the cultivars expressed prolongation of this attribute, and in 2024 only URNRS22 showed a cycle longer than the overall mean. In the three years of testing, the new cultivar expressed an average cycle of 135 days and a variation of just 25 days in the cycle between production environments. Greater variations were shown by the cultivar URS Taura (T_6), with earliness for the cultivar URS Altiva (T_4), with 105 days of cycle.

The cultivar URNRS 22 expressed variation in panicle length between 17 and 21 cm, in the respective years and environments evaluated; this characteristic confers greater biomass production, spikelet and grain potential per panicle (Figure 1c). Panicle weight refers to the biomass of plants and grains (Figure 1d), and the overall mean found was 1.25 grams, an attribute that results most in variability between cultivars. In 2022 and 2023, URNRS22 was superior to the others, and in 2024 most cultivars were superior to the overall mean, with the exception of the cultivar URS Altiva (T_4). The grain weight produced in the panicle (Figure 2a) is characterized as the most important selection attribute within the genetic improvement of white oats that prioritizes increasing grain yield, revealing an overall mean of 1.1 grams of grains per panicle over the years. URNRS22 expressed superiority in 2022 and 2023. In 2024, the cultivars URS Fapa Slava (T_5) and URS Taura (T_6) were superior to the others tested. In a study carried out by Pradebon et al. (2024b), they concluded that the weight of grains per panicle is due to a high genetic contribution, which indicates that the use of this trait is promising for the selection of genotypes with high grain yield.

The thousand grain weight (Figure 2b) revealed an average of 23 grams in the three years. It was identified that 2022 was not favorable for all cultivars; on the other hand, in 2023 all cultivars were superior, with URNRS22 expressing 25

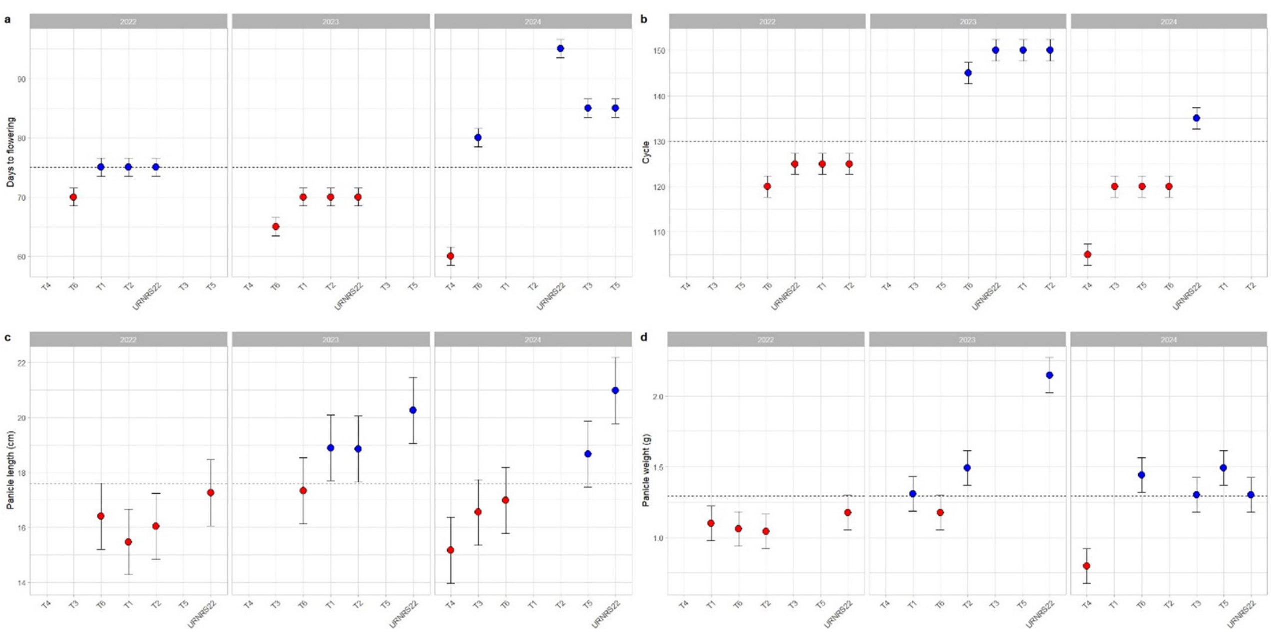

Figure 1. Estimates of the components of the averages for days to flowering (a), cycle (b), panicle length (c) and panicle weight (d) by *BLUP* measured in seven cultivars of white oat and three agricultural years. Cultivars: URNRS22, FAEM Barbarasul (T_1), FAEM Brisasul (T_2), IDR Afrodite (T_3), URS Altiva (T_4), URS Fapa Slava (T_5) and URS Taura (T_6). The dashed line represents the overall mean of the experiment. Cultivars with blue color scores represent high average, genotypes with red color represent low average.

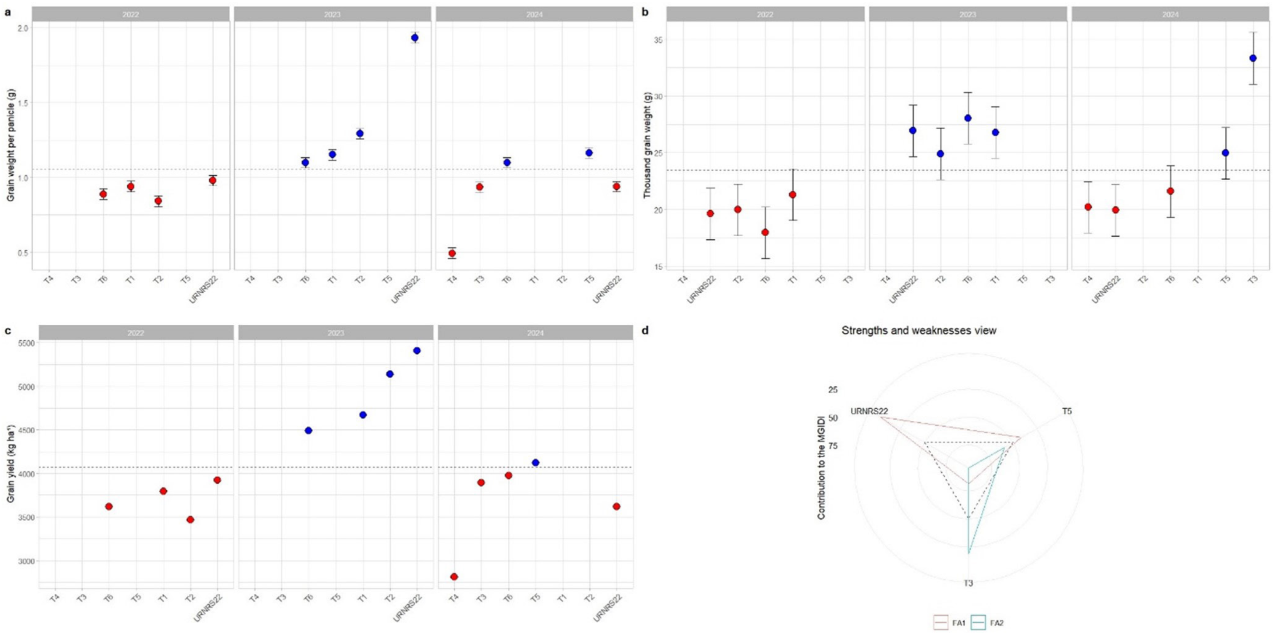

Figure 2. Estimates of the components of the averages for days for panicle grain weight (a), thousand grain weight (b) and grain yield (c) by BLUP measured in seven cultivars of white oat and three agricultural years. Cultivars: URNRS22, FAEM Barbarasul (T_1), FAEM Brisasul (T_2), IDR Afrodite (T_3), URS Altiva (T_4), URS Fapa Slava (T_5) and URS Taura (T_6). Classification of cultivars in ascending order for the MGIDI index, based on the quantitative characteristics of white oats (d). The dashed line represents the overall mean of the experiment. Cultivars with blue color scores represent high average, cultivars with red color represent low average.

grams for this trait. In 2024 superiority was observed for the control cultivars IDR Afrodite (T_3) and URS Fapa Slava (T_5) with up to 33 grams, and URNRS22 showed low variation, with just six grams in the thousand grain weight over the three years.

Grain yield (Figure 2c) is constructed by several aspects, particularly the final panicle population per unit area and the average stability of the panicle grain weight. In this context, the overall mean was established at 4050 kg ha^{-1}. 2022 was considered a challenging year for the crop, but it was in this year that URNRS22 was superior to the other cultivars; in 2023, with optimal conditions for cultivation, it enhanced its yield, expressing 5300 kg ha^{-1} of grains. In 2024, there were many difficulties for winter cereals, such as thermal fluctuations that exceeded the optimal limits of the crop, water excesses at the beginning and end of the cycle and frosts during the formation of panicles, which compromised the yield of the cultivars this year. Only the cultivar URS Fapa Slava (T_5) showed superiority compared to the overall mean. Pradebon et al. (2023) evaluated the performance of URNRS22 in preliminary trials conducted in 2021 and 2022 in the northwest region of the state of Rio Grande do Sul, proving the effectiveness of the genotype in contrasting environments.

The factor analysis carried out for the white oat cultivars (Supplementary table 1) highlighted two factorial groups, with the purpose of selecting the aptitude of the genotypes in reconciling plant biomass and grain yield, facts that would meet the demand of a cultivar for scenarios of grain production and soil cover. According to Klein et al. (2023), MGIDI was efficient in selecting the best genotypes, showing desirable selection gains. Within the traits presented, factor I is mentioned, which encompasses panicle length, panicle grain weight, panicle weight and grain yield with a positive direction (increment). Factor II is composed only of thousand grain weight with a positive direction (increment). The selection differential for the traits were all based on the intended agronomic ideotype. It was possible to identify (Figure 2d) the fulfillment of this assumption for multi-trait selection in white oat through the selected cultivars URNRS22, URS Fapa Slava (T_5) and IDR Afrodite (T_3), these being more productive for both grains and plant biomass. Based on the results presented and those expressed in the most varied production fields, the merit of URNRS22 is proven as an alternative for producers who position white oats in challenging environments. UNIJUÍ's genetic improvement program supports its research and purposes in improving the sustainability of production chains in Brazil.

SEED PRODUCTION

The (*Avena sativa*) cultivar URNRS22, intended for grain production and soil cover, was protected by the Ministry of Agriculture and Livestock (MAPA) on June 19, 2024 (Process: N° 21806.000063/2023). The procedures linked to the National Cultivar Registry (NCR) are underway, guided by the UNIJUÍ Innovation and Technology Agency, which promotes and enhances interactions between the public and private sector. Thus, the genetic category seed multiplication processes began with a final volume of 3 tons of seeds.

DATA AVAILABILITY

The datasets generated and/or analyzed in this study are available from the corresponding author upon reasonable request.

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