AGRONOMY SCIENCE AND BIOTECHNOLOGY

RESEARCH ARTICLE

Organic system and reflections on white oat grain productivity components

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ABSTRACT

The objective of the study was to evidence efficient management strategies in order to maximize the organic cultivation system promotes a new dynamic in the behavior of white oat genotypes, where it is necessary to evidence genotypes with superior performance. The study aimed to highlight the productive performance and genetic diversity of white oat genotypes in an organic system. The experiment was carried out in the municipality of Augusto Pestana - RS, in the 2021 crop year. The experimental design used was randomized blocks with four treatments arranged in five replications. The treatments correspond to the cultivars IPR Artemis, URS Taura, URS Corona and URS Brava. It is observed that there is a possibility of indirect selection of productive genotypes through the mass of grains per panicle and number of grains per panicle. Brava and Taura are the most divergent genotypes. Through the analysis of the white oat genotypes, it is highlighted that it is possible to promote the proper positioning of the genotypes in the organic system. In addition, the existence of genetic divergence between the genotypes is evidenced. The components that determined the productivity of white oat cultivars in organic system were number of plants per square meter, number and grain weight per plant. The cultivar IPR Artemis and URS Taura showed similarity for plant height and height of panicle insertion, tillering and grain yield, URS Brava and URS Corona are similar in terms of the number of grains per plant. IPR Artemis is recommended for grain yield in an organic system.

Keywords: *Avena sativa*, principal components, linear correlation, Euclidean distance, UPGMA, organic food, organic agriculture.

INTRODUCTION

The demand for high productivity crops, with high quality and wide commercial acceptance has been growing in the current scenario of world agriculture. White oat (*Avena sativa* L.) is assuming an important role in cropping systems as an alternative in the cold seasons, mainly in the southern states of Brazil. The chemical composition and structure of the grain is considered unique among cereals, which provides great suitability for use in human and animal food (Hawerroth, Carvalho, & Oliveira, 2013; Biel, Kazimierska, & Bashutska, 2020). Oat grains have a high protein quality, high lipid content with a predominance of unsaturated fatty acids and adequate carbohydrate content, in addition to having a high proportion of non-starchy polysaccharides, among which β-glucans can be highlighted, in addition to of components with antioxidant properties (Biel, Jacyno, & Kawecka, 2014).

The search for healthy food from sustainable production systems, such as organic methods, is characterized as a trend that is strengthened worldwide (Ferreira & Coelho, 2017). The current conventional agriculture adopted by most producers with the indiscriminate use of pesticides provides a depletion of natural resources, thus, a sustainable production system has been sought as an alternative to the dominant system (Moraes & Oliveira, 2017). Organic agriculture is an unconventional system based on food production through ecological balance (Finatto et al., 2013).

Giving importance to the world scenario, there was an increase in demand for organic food, in which expectations for the export of Brazilian products have been increasing, since organic agriculture has become part of the agribusiness chain. Product quality and lower impacts on the production environment stand out. Organic foods are those that, both in natura and processed, are based on techniques that do not use synthetic molecules, combined with soil management practices that consider regional particularities and the need to locally adapt production systems (Sousa, Azevedo, & Lima, 2012). For the insertion of genotypes in organic agriculture, characteristics such as high competitive capacity with weeds, tolerance to fungal diseases and nutritional deficiency, in addition to high nutrient absorption capacity, are required (Feledyn-Szewczyk & Jończyk, 2016).

Organic agriculture does not allow the use of transgenic cultivars, therefore, there is a need to evaluate genotypes that are superior and responsive to the edaphoclimatic conditions of the region (Sousa et al., 2012). In this context, the study aimed to highlight the productive performance and genetic diversity of white oat genotypes in an organic system.

MATERIAL AND METHODS

The experiment was carried out in the municipality of Augusto Pestana - RS, in the 2021 crop year. The soil of the area is classified as Typical Dystroferric Red Latosol, and the climate is characterized as *Cfa* humid subtropical according to the Köppen classification. The experimental design used was randomized blocks with four treatments arranged in five replications. The treatments correspond to the cultivars IPR Artemis, URS Taura, URS Corona and URS Brava. Sowing was carried out in the second half of April with a spacing of 0.18 meters between sowing rows, sowing density of 60 viable seeds per linear meter, the experimental units were six meters wide and fifteen meters long, totaling 90 square meters. All managements followed the pre-established technical recommendations in the organic system.

In the useful area of each experimental unit, ten plants were measured. The variables measured were: days between sowing and flowering (DF, days), days between sowing and maturation (DM, days), percentage of lodging (LOG, %), plant height (PH, cm), height of panicle insertion (HPI, cm), tillering (TILL, unit), number of plants per square meter (PSM, unit), number of panicles per square meter (PaSM, unit), number of grains per plant (NGP, unit), mass of grain per plant (MGP, grams), thousand grain weight (TGW, grams) and grain yield (GY, kg ha^{-1}). Through the Power Nasa® platform, meteorological data were obtained, distributed by the variables medium air temperature (Tmed, ºC), maximum air temperature (Tmax, ºC), minimum air temperature (Tmin, ºC) and precipitation (Prec, mm).

The data obtained were submitted to the assumptions of normality of errors by the Shapiro Wilk test and homogeneity of residual variances by Bartlett, and then, the analysis of variance at 5% of significance was performed using the F test and descriptive analyses. Significant variables were broken down by Tukey's complementary analysis at 5% probability. With the need to understand the linear relationships between the measured variables, a linear correlation analysis was performed with a significance of 5% by the T test.

The study of genetic divergence was carried out through cluster analysis, using the average Euclidean distance to obtain the matrix of distances between pairs of genotypes. For the construction of the dendrogram, the hierarchical UPGMA method (Unweighted Pair-Group method using arithmetic means) was applied. Furthermore, principal component analysis was used to study genetic dissimilarity and understand the relationships between variables and genotypes., The analyzes were performed using the R software (R Core Team, 2021) using the packages agricolae (Mendiburu, 2021), metan (Olivoto & Lucio, 2020) and ggplot2 (Wickham, 2016).

RESULTS AND DISCUSSION

White oat exhibits adequate development with air temperatures between 20 and 25 °C, however, it tolerates lower temperatures for emergence between 3 and 5.5 °C (Castro, Costa, & Ferrari, 2012). Lângaro and Carvalho (2014) mention that for its germination the temperature varies from 4°C to 31°C, air temperatures that are outside this thermal optimum impair the growth and development of the seedlings. In this study, minimum temperatures (Figure 1A) were observed between 7.5 °C and 14.9 °C, and maximum temperatures (Figure 1B) of 17.5 °C to 27.5 °C, in relation to precipitation (Figure 1, graph C) the lowest average was verified in July and the highest rainfall occurred in May. It was observed that in none of the months the air temperatures exceeded the recommended averages for the proper development of the culture, which can be seen in Figure 1 (Figure A and B), where the temperatures were not lower than 4°C nor even higher at 31°C. In this way, the average temperatures did not show negative interference throughout the development cycle of white oat cultivars.

Castro et al. (2012), mention that this species does not have great water requirements during its cycle, however, it needs at least 400 mm in the year for optimal growth and development, although it presents critical phases for water deficit (germination, booting, formation of grains). For the accumulated rainfall (Figure 1, graph C) that occurred during the white oat cycle, significant differences can be observed, in July the rainfall was less than 50 mm. Bacchi et al. (1996), stated that white oat needs 4 mm/day for proper plant development, which corresponds to 120 mm in a month, in April and July, there was a water deficit, where in April it was recorded 60 mm. and in July approximately 25 mm of precipitation. Water stresses that occur in the period of spikelet and panicle formation of white oat provide an effect on the number of panicles formed, average plant height, grains per panicle and average panicle size (Moreira, Angulo Filho, & Rudorff, 1999). The low rainfall in July may have caused a decrease in the grain yield of the cultivars.

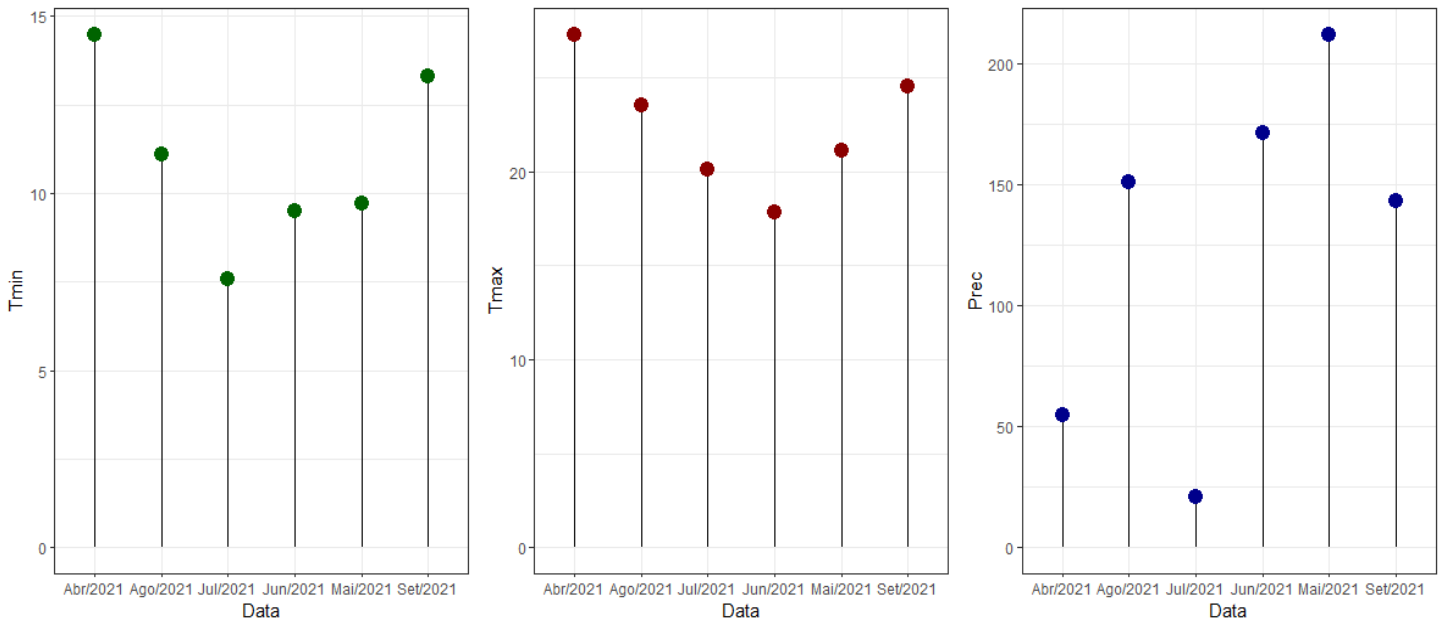

Figure 1. Average results of minimum (T min, ºC) and maximum air temperature (T max, ºC) and accumulated precipitation (Prec, mm) during the white oat development cycle.

Considering days from emergence to flowering and days from emergence to maturation, all cultivars showed 84 and 150 days, respectively, for days to flowering and days to maturation (Figure 2). According to the technical indications, the cultivar IPR Artemis presents 76 days for flowering and 117 days for maturation of URS Taura with 79 days for flowering and 116 days for maturation, URS Corona has 84 days for flowering and 120 days for maturation and URS Brava presented 85 days for flowering and 135 days for maturation. This difference in the cycle observed in the field and in the technical indications may have occurred due to the influence of the environment throughout the species' development cycle, such as frost, low air temperatures, solar radiation and rainfall (Castro et al., 2012).

In the analysis of variance (Table 1), it was found that for the cultivar variation factor, there were significance for the variables, plant height, height of panicle insertion, grain yield, grain weight per plant, tillering, plants per meter square and panicles per square meter. In the interaction of the blocks in relation to the measured variables, it was possible to contact that there was no significance for any of the variables. Regarding the coefficient of variance for plant height, height of panicle insertion, thousand grain weight, plants per square meter and panicles per square meter, it was low, as for the variables number of grains per plant, grain yield, grain weight per plant and tillering represents a high value.

The comparison of means (Table 2) shows that for the height of plants the cultivar URS Brava differed statistically from the other cultivars obtaining greater height, the cultivars URS Taura, IPR Artemis and URS Corona did not show statistical difference, these being the ones that showed lower height. For the variable height of panicle insertion, the cultivar URS Brava differed from the other cultivars, being superior to them. Regarding the number of plants per square meter, URS Taura presented the highest number of plants per square meter and the cultivar URS Corona presented the lowest result.

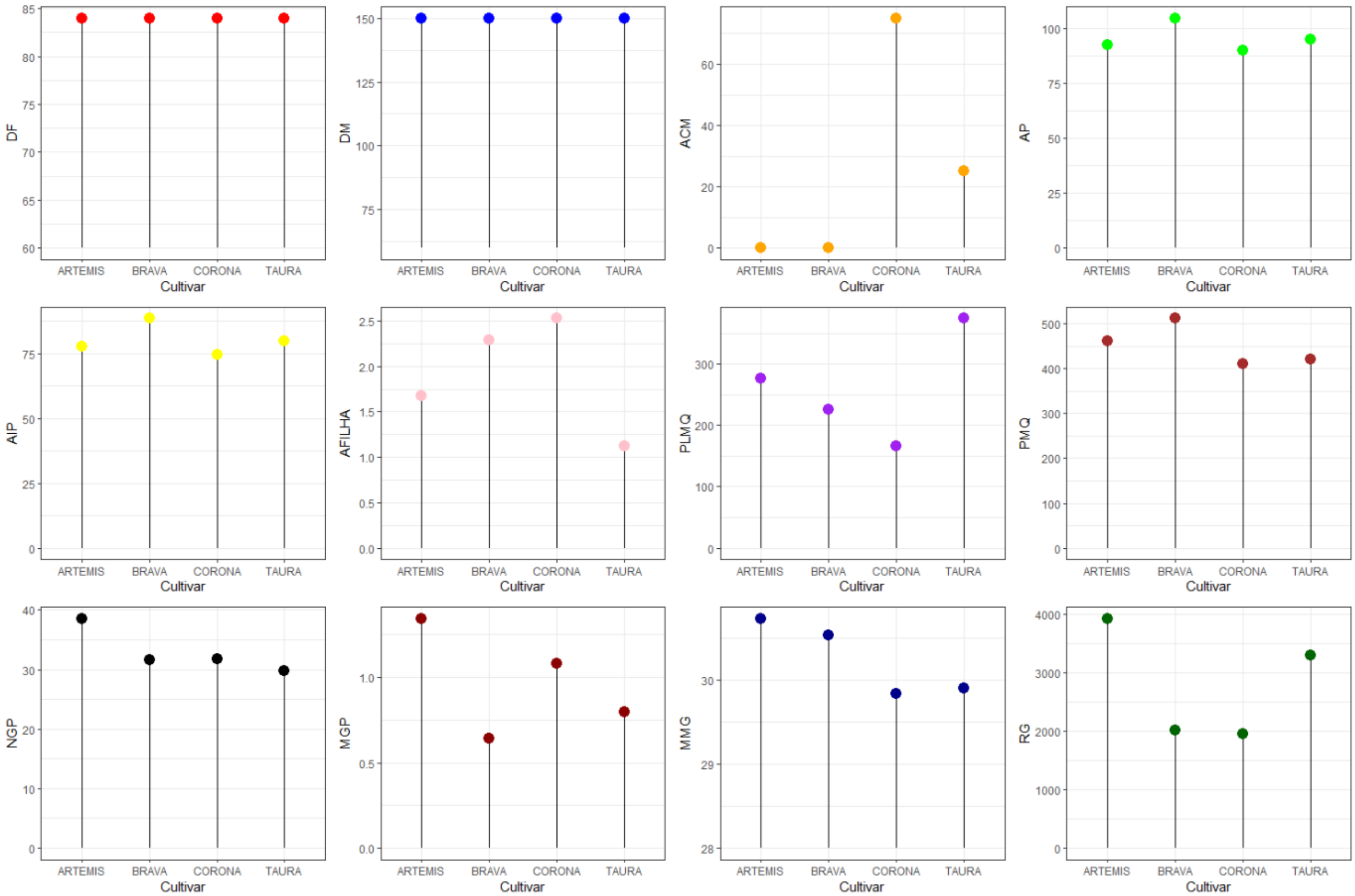

Figure 2. Results for days from emergence to flowering (DF), days from emergence to maturation (DM), lodging (LOG), plant height (PH), height of panicle insertion (HPI), tillering (TILL), plants per square meter (PSM), panicles per square meter (PaSM), number of grains per plant (NGP), mass of grain per plant (MGP), thousand grain weight (TGW) and grain yield (GY) of white oat cultivars.

Table 1. Summary of the analysis of variance (ANOVA) of the variables, referring to the four genotypes of white oat in an organic system.

FV[1]		QM[2]								
	DF	PH (cm)	HPI (cm)	NGP (units)	TGW (g)	GY (kg ha^{-1})	MGP (g)	TILL (units)	PSM (units)	PaSM (units)
Cultivars	3	0.0014*	0.0007*	0.251	0,9087	0.0007*	0.0259*	0.00017*	0.000*	0.0142*
Block	4	0.0754	0.0899	0.239	0,5528	0.6907	0.8234	0.14710	0.3221	0.0808
Residue	12									
CV (%)	-	4.78	4.86	20.95	7.79	22.87	34.37	18.52	8.4	9.95

[1]FV- Variation factor. [2]QM - Mean square. Plant height (PH), height of panicle insertion (HPI), number of grains per plant (NGP), thousand grain weight (TGW), grain yield (GY), mass of grain per plant (MGP), tillering (TILL), plants per square meter (PSM), panicles per square meter (PaSM) and coefficient of variation (CV%). *Significant by the F test at 5% probability

The highest number of tillers was observed in the cultivars URS Corona and URS Brava, opposite to what was observed in URS Taura with a number of tillers of 1.12. In the evaluation of the number of panicles per square meter, URS Brava stood out, however, it did not differ statistically from IPR Artemis, the cultivars URS Taura and URS Corona presented the lowest results, on the other hand, they did not differ significantly from the results observed by IPR Artemis.

Table 2. Mean comparison test for the 4 white oat cultivars analyzed. Augusto Pestana, Rio Grande do Sul, Brazil.

Treatment	Variables[1]								
	PH (cm)	HPI (cm)	NGP (g)	TGW (g)	GY (kg ha^{-1})	MGP (g)	TILL (units)	PSM (units)	PaSM (units)
URS Brava	104,9 a	88,6 a	31,59a	30,52ª	2020,1 b	0,63 b	2,29 ab	225,5 c	512,5 a
URS Taura	95,34 b	79,8 b	29,84a	29,9ª	3292,2 a	0,79 ab	1,12 c	374,5 a	420,39 b
IPR Artemis	92,8 b	77,6 b	38,58a	30,73ª	3923,9 a	1,3 a	1,68 bc	277 b	462 ab
URS Corona	90,7 b	74,7 b	31,78a	29,84ª	1945,5 b	1,1 ab	2,53 a	166 c	410,5 b
CV[3] (%)	4,78	4,86	20,95	7,79	22,87	34,37	18,52	8,4	9,95

[1]Plant height (PH), height of panicle insertion (HPI), number of grains per plant (NGP), thousand grain weight (TGW), grain yield (GY), mass of grain per plant (MGP), tillering (TILL), plants per square meter (PSM) and panicles per square meter (PaSM). [3]Coefficient of variation (CV).

For the grain weight per plant, it was observed that the cultivars IPR Artemis and URS Corona presented superior results, however, they did not differ statistically from the other cultivars evaluated. Regarding grain yield, cultivars IPR Artemis and URS Corona presented the best results, opposite to what was observed in cultivars URS Brava and URS Corona, which presented grain yields of 2020,1 kg ha^{-1} and 1945,5 kg ha^{-1} respectively.

Lodging in cereals is a complex phenomenon, resulting from factors intrinsic to the genotype, soil characteristics, climatic conditions and cultural practices adopted in cultivation, such as nitrogen application rate and timing (Hawerroth et al., 2015). The cultivars IPR Artemis and URS Brava did not show lodging (LOG), that is, fall or breakage of the stems, URS Taura showed 20% lodging and URS Corona was greater than 60%. Lodging reduces the quality and average grain weight, because when the break occurs, the translocation of photoassimilates to the panicle is interrupted (Silva et al., 2006).

The cultivars IPR Artemis, URS Corona and URS Taura presented similar plant height, approximately 80 cm and the cultivar URS Brava presented plant height superior to the others, with 112 cm. For height of panicle insertion, cultivars IPR Artemis, URS Corona and URS Taura had height of panicle insertion of 76 cm and URS Brava with 85 cm, being superior to the others.

The tillers are the most important components for the production of grasses (Marques et al., 2014), the cultivar URS Corona had the highest number of tillering (TILL) with 2,7 tillers per plant, similar to URS Brava with 2,3. The cultivars IPR Artemis and URS Taura presented 1,7 and 1,2 tillers per plant, respectively. In the evaluation of the final number of plants per square meter, the highest density of plants was observed in the cultivar URS Taura with approximately 390 plants, IPR Artemis with 290 plants, URS Brava with 250 plants and the lowest density was for the cultivar URS Corona with 180 plants per square meter.

The cultivar URS Corona had the lowest final density of plants and the highest production of tillers, while the cultivar URS Taura had the highest density of plants and the lowest number of tillers, according to Zagonel, Venancio, Kunz and Tanamati (2002), plant population affects the number of tillers developed by plants. Santos and Munstock (2002) mention that competition between plants has greater effects on the development of tillers.

The variable panicles per square meter (PaSM) is a direct component of white oat yield. The cultivars URS Brava and IPR Artemis showed superior results, with 550 and 480 panicles per square meter, respectively. The cultivar URS Brava showed superiority for this variable and one of the lowest numbers of plants per square meter, corroborating studies carried out by Elsenbach et al. (2021), who cite that the lower density of plants provides a greater development of spikelets and panicles and a greater production of grains, conversely, the higher densities cause a lower production of panicles per area. The cultivars URS Taura and URS Corona showed lower values than the other cultivars, but similar, with approximately 400 panicles per square meter.

The highest number of grains per plant was obtained by the cultivar IPR Artemis with 40 grains per plant, the other cultivars showed a similar NGP, with about 33 grains per plant. The cultivar IPR Artemis also showed superiority for grain weight per plant, with 1,8 grams per plant, the other cultivars URS Corona, URS Taura and URS Brava, with 1,1 g, 0,75g and 0,60 g, respectively, a grain weight per plant.

The cultivars IPR Artemis and URS Brava had the highest thousand grain weight, 30,9g and 30,8g, respectively, the cultivars URS Corona and URS Taura had the lowest thousand grain weight, which were 29,7 g and 29,8 g respectively. Grain yield was higher for the cultivar IPR Artemis with 4000 kg ha^{-1}, followed by URS Taura with 3500 kg ha^{-1}, URS Brava and URS Corona showed grain yield of 2000 kg ha^{-1}. The low grain yield observed in URS Corona may have occurred due to the high intensity of lodging observed in this cultivar, the lodging prevents the filling of the grains, therefore, it causes a decrease in the growth of the culture and a reduction in the availability of assimilates to fill the grains, thus decreasing the yield.

The linear correlation of the yield components of the white oat crop showed that the height of panicle insertion and the number of panicles per square meter showed a strong positive correlation with plant height (Figure 3). The number of grains per plant showed a strong positive correlation with grain weight per panicle and grain yield. The grain weight per panicle expressed a strong positive correlation on grain yield. Therefore, it can be inferred that the indirect selection for grain yield can be performed through the number of grains per plant and grain weight per panicle.

The tillering had a strong negative correlation with the number of plants per square meter and the grain yield, this is explained by the fact that in a higher density of plants the number of tillers will be smaller due to greater competition among plants. Silveira et al. (2010), mentioned that the effect of competition among plants is decisive in the production of tillers, with a direct effect on the yield of grains and their components, a higher density of plants in the area will decrease the tillering, thus decreasing the final grain yield. The number of plants per square meter showed an average positive correlation with grain yield, the number of plants per square meter is one of the primary components of productivity, in this way it generates a direct effect on the other secondary and tertiary productivity components, among them the productivity.

The Euclidean average algorithm and the Unweighted Pair Group Method using Arithmetic averages (UPGMA) grouping showed through the dendrogram (Figure 4) the formation of two large heterogeneous groups. The group in red color is composed of cultivars URS Brava and URS Corona and in blue color are the cultivars IPR Artemis and URS Taura. The variables plant height, height of panicle insertion, tillering and grain yield are the yield components that provide this greater similarity between the cultivars IPR Artemis and URS Taura. The characters, tillering, plants per square meter, number of grains per plant and grain yield provided the similarity between the cultivars URS Brava and URS Corona. Valerio et al. (2008) reveal that tillering is directly linked to the number of plants per area, and indirectly to the number of grains per panicle and grain yield.

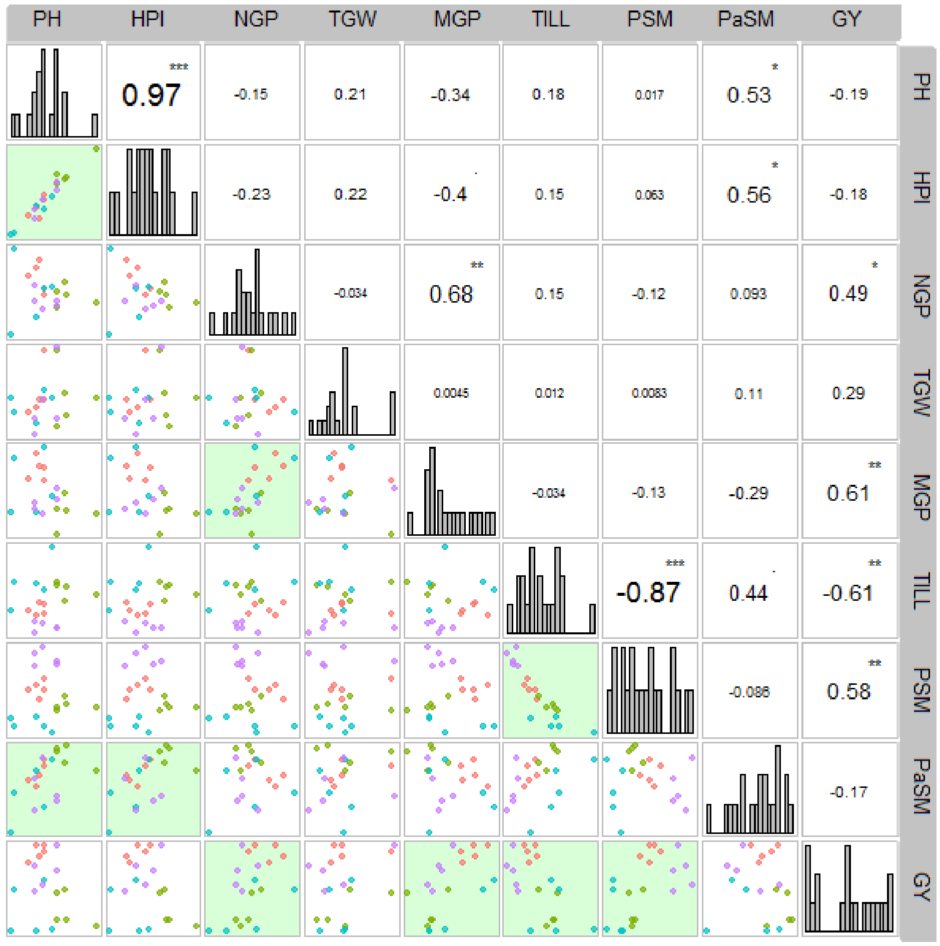

Figure 3. Pearson's linear correlation graph of the yield components evaluated in white oat. [1]Plant height (PH), height of panicle insertion (HPI), number of grains per plant (NGP), thousand grain weight (TGW), mass of grain per plant (MGP), tillering (TILL) plants per square meter (PSM), panicles per square meter (PaSM), and grain yield (GY) of white oat cultivars.

The cultivar IPR Artemis (1) showed high affinity for grain yield (GY), and average correlation with the number of grains per plant (NGP) and grain weight per plant (MGP) (Figure 5). The cultivar URS Corona (3) showed greater affinity for lodging (LOG), URS Brava (2) showed a greater relationship with plant height (PH) and height of panicle insertion (HPI), and the cultivar URS Taura (4) showed no strong correlation with the variables measured.

For the organic management system, the highest grain yields were observed in the URS Taura and IPR Artemis cultivars, with 3292.2 kg ha^{-1} and 3923.9 kg ha^{-1}, this grain yield was positively influenced by the number of grains per plant, grain weight per plant and plants per square meter and was negatively influenced by tillering. The dissimilarity dendrogram was separated into two distinct groups, where one was composed by the cultivars URS Taura and IPR Artemis and the other by the cultivars URS Brava and URS Corona. The cultivar IPR Artemis was the one that showed the greatest affinity for grain yield, number of grains per plant and grain weight per plant, while URS Corona showed a greater affinity for lodging, and it showed the lowest grain yield, which was 1.945.5 kg ha^{-1}.

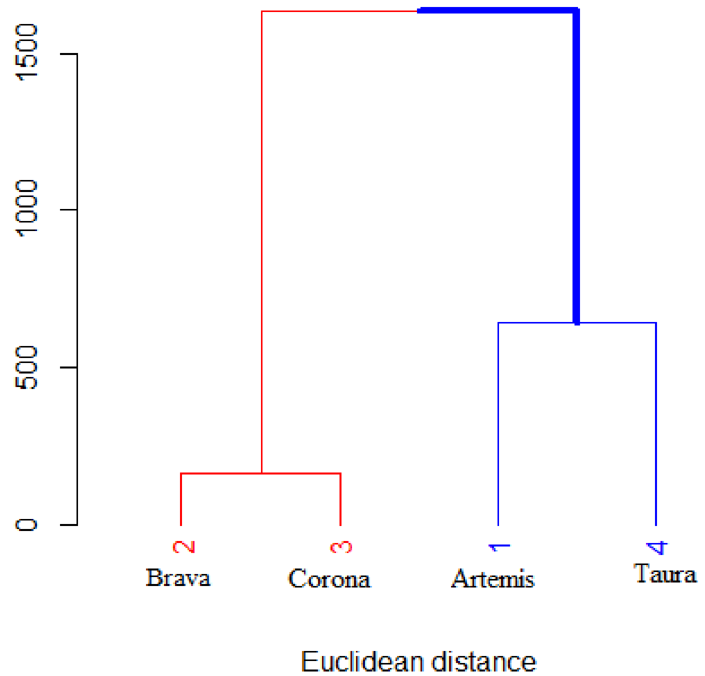

Figure 4. Dendrogram of dissimilarity between four white oat cultivars, obtained by the UPGMA method based on the average Euclidean distance.

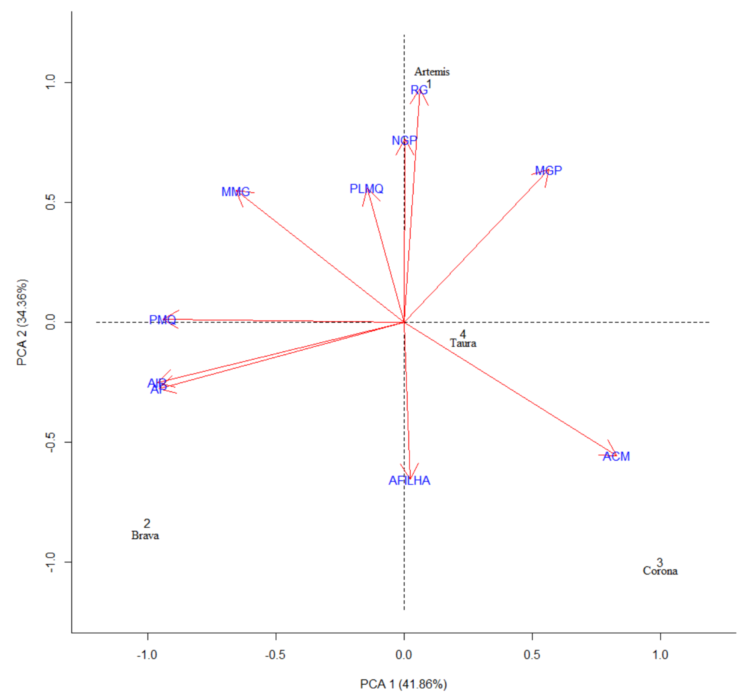

Figure 5. Dispersion of four genotypes in relation to the first two principal components. [1]Plant height: (PH), height of panicle insertion: (HPI), panicle per square meter: (PaSM), plant per square meter: (PSM), tillering: (TILL), lodging: (LOG), thousand grain weight: (TGW), number of grains per plant: (NGP), mass of grain per

plant (MGP) and grain yield: (GY), 1-IPR Artemis, 2-URS Brava, 3-URS Corona and 4-URS Taura.

CONCLUSIONS

The components that determined the productivity of white oat cultivars in organic system were number of plants per square meter, number and grain weight per plant.

The cultivar IPR Artemis and URS Taura showed similarity for plant height and height of panicle insertion, tillering and grain yield, URS Brava and URS Corona are similar in terms of the number of grains per plant. IPR Artemis is recommended for grain yield in an organic system.

REFERENCES

Bacchi, O. O. S., Godoy, R., Fante Junior, L., & Reichardt, K. (1996). Balanço hídrico em cultura de aveia forrageira de inverno na região de são Carlos-SP. *Scientia Agricola*, *53*(1), 172-178. https://doi.org//10.1590/s0103-90161996000100025

Biel, W., Jacyno, E., & Kawecka, M. (2014). Chemical composition of hulled, dehulled and naked oat grains. *South African Journal of Animal Science***,** *44*(2), 189. https://doi.org/10.4314/sajas.v44i2.12

Biel, W., Kazimierska, K., & Bashutska, U. (2020). Nutritional value of wheat, triticale, barley and oat grains. *Acta Scientiarum Polonorum Zootechnica*, *19*(2), 19-28. https://doi.org/10.21005/asp.2020.19.2.03

Castro, G. S. A., Costa, C. H. M., & Ferrari, N. J. (2012). Ecofisiologia da aveia branca. *Scientia Agraria Paranaensis*, *11*(3), 1-15. https://doi.org/10.18188/sap.v11i3.4808

Elsenbach, H., Sartori, D. B. S., Menezes, H. M., Marengo, R. P., Fontinelli, A. M., & Fonseca, D. A. R. (2021). Efeitos da densidade de semeadura sobre os componentes produtivos de cultivares de aveia branca. *Salão Internacional de Ensino, Pesquisa e Extensão – Siepe*, *1*(1), 1-7. Available in: https://guri.unipampa.edu.br/uploads/evt/arq_trabalhos/17769/seer_17769.pdf

Feledyn-Szewczyk, B., & Jończyk, K. (2016). Assessment of the suitability of oat varieties (*Avena sativa* L.) for cultivation in organic system. *Journal of Research and Applications in Agricultural Engineering*, *61*(3), 82-87. Available in: https://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-a678db69-d4bc-44aa-8ef0-31e8e5137d08

Ferreira, A. S., & Coelho, A. B. (2017). O papel dos preços e do dispêndio no consumo de alimentos orgânicos e convencionais no Brasil. *Revista de Economia e Sociologia Rural*, 55, 625-640. https://doi.org/10.1590/1234-56781806-94790550401

Finatto, J., Altmayer, T., Martini, M. C., Rodrigues, M., Basso, V., & Hoehne, L. (2013). A importância da utilização da adubação orgânica na agricultura. *Revista Destaques Acadêmicos*, *5*(4), 85-93. Available in: http://univates.br/revistas/index.php/destaques/article/view/327/322

Hawerroth, M. C., Carvalho, F. I. F., & Oliveira, A. C., (2013). Adaptability and stability of white oat cultivars in relation to chemical composition of the caryopsis. *Pesquisa agropecuária Brasileira*, *48*(1), 42-50. https://doi.org/10.1590/S0100-204X2013000100006

Hawerroth, M. C., Silva, J. A. G., Souza, C. A., Oliveira, A. C., Luche, H. S., Zimmer, C. M., Hawerroth, F. J., Schiavo, J., & Sponchiado, J. C. (2015). Redução do acamamento em aveia-branca com uso do regulador de crescimento etil-trinexapac. *Pesquisa Agropecuária Brasileira*, *50*(2), 115-125. https://doi.org/10.1590/s0100-204x2015000200003

Lângaro, N. C., & Carvalho, I. Q. (2014). Indicação Técnica Para a Cultura da Aveia. XXXIV Reunião da Comissão Brasileira de Pesquisa de Aveia Fundação ABC. Passo Fundo, RS: Universidade de Passo Fundo.Available in: http://editora.upf.br/images/ebook/cultura_aveia.pdf. Acessed: november 08, 2022.

Marques, A.C.R., Krolow, R.H., Rigodanzo, E. L., Basso, L. J., Botta, R. A., & Missio, E. (2014). Desempenho da mistura de aveia preta e azevém em função da adubação orgânica e mineral. *Revista Ceres*, *61*(1), 112-120. https://doi.org/10.1590/S0034-737X2014000100015

Mendiburu, F. (2021). Agricolae: Statistical Procedures for Agricultural Research_. R package version 1.3-5. <https://CRAN.R-project.org/package=agricolae>

Moraes, M. D., & Oliveira, N. A. M. (2017). Produção orgânica e agricultura familiar: obstáculos e oportunidades. *Desenvolvimento Socioeconômico em Debate*, *3*(1), 19-37. https://doi.org/10.18616/rdsd.v3i1.3372

Moreira, M. A., Angulo Filho, R., & Rudorff, B. F. T. (1999). Eficiência do uso da radiação e índice de colheita em trigo submetido a estresse hídrico em diferentes estádios de desenvolvimento. *Scientia Agricola*, *56*(3), 597-603. https://doi.org/10.1590/s0103-90161999000300012

Olivoto, T., & Lúcio, A. D. (2020). Metan: an R package for multi-environment trial analysis. *Methods in Ecology and Evolution*, 11, 783-789. https://doi.org/10.1111/2041-210X.13384

Santos, H. P., & Mundstock, C. M. (2002). Parâmetros da habilidade competitiva no estabelecimento de populações caracterizam o potencial de produção individual em trigo e aveia. *Revista Brasileira de Botânica*, *25*(1), 43-53. https://doi.org/10.1590/S0100-84042002000100007

Silva, J. A. G., Carvalho, F. I. F., Oliveira, A. C.., Vieira, E. A., Benin, G., Valério, I. P., Carvalho M. F., Finatto, T., Busto, C. C., & Ribeiro, G. (2006). Correlação de acamamento com rendimento de grãos e outros caracteres de interesse agronômico em plantas de trigo. *Ciência Rural*, *36*(3), 756-764. https://doi.org/10.1590/s0103-84782006000300006

Silveira, G. D., Carvalho, F. I. F., Oliveira, A. C. D., Valério, I. P., Benin, G., Crestani, M., Luche, H. S., & Silva, J. A. G. da. (2010). Efeito da densidade de semeadura e potencial de afilhamento sobre a adaptabilidade e estabilidade em trigo. *Bragantia*, *69*(1), 63-70. https://doi.org/10.1590/s0006-87052010000100009

Sousa, A. A., Azevedo, E., & Lima, E. E. (2012). Alimentos orgânicos e saúde humana: estudo sobre as controvérsias. *Revista Panamericana de Salud Publica*, 31, 513-517. https://www.scielosp.org/pdf/rpsp/2012.v31n6/513-517/pt

Valério, I. P., Carvalho, F. I. F., Oliveira, A. C., Machado, A. A., Benin, G., Scheeren, P. L., Souza, V. Q., & Hartwig, I. (2008). Desenvolvimento de afilhos e componentes do rendimento em genótipos de trigo sob diferentes densidades de semeadura. *Pesquisa Agropecuária Brasileira*, *43*(3), 319-326. https://doi.org/10.1590/S0100-204X2008000300005

Wickham, H. (2016). Ggplot2: Elegant Graphics for Data Analysis. New York: Springer-Verlag. https://ggplot2.tidyverse.org

Zagonel, J., Venancio, W.S., Kunz, R. P., & Tanamati, H. (2002). Doses de nitrogênio e densidades de plantas com e sem um regulador de crescimento afetando o trigo, cultivar OR-1. *Ciência Rural*, *32*(1), 25-29. https://doi.org/10.1590/S0103-84782002000100005