AGRONOMY SCIENCE AND BIOTECHNOLOGY

RESEARCH ARTICLE

Agronomic performance of white oats in organic system in the northwest region of Rio Grande do Sul

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ABSTRACT

This work aimed to position white oat cultivars for the organic system, and to highlight which characteristics determine grain yield and their interrelationships. The research was conducted at Instituto Regional de Desenvolvimento Rural belonging to Universidade Regional do Noroeste do Estado do Rio Grande do Sul, located in the municipality of Augusto Pestana – RS. The experimental design used was randomized blocks with treatments arranged in four replications. The treatments corresponded to the cultivars: IPR Artemis, IPR Afrodite, URS Corona, URS Brava and URS Taura. The characters measured in the useful area of each experimental unit were: final plant population per square meter (PPSM, units), days between sowing and flowering (DF, days), days between sowing and maturation (DM, days) , number of tillers (TILL, units), percentage of lodging (LOG, %), intensity of diseases damage (INTD, %), plant height (PH, cm), height of panicle insertion (HPI, cm), number of panicles per square meter (NPSM, units), number of grains per panicle (NGP, units), grain weight per panicle (GWP, g), thousand grain weight (TGW, g), grain yield (GY, kg). The cultivar URS Afrodite is superior for plant height, height of panicle insertion, number of panicles per square meter. The cultivar URS Corona stood out for the number of grains per panicle, grain weight per panicle with a grain yield of 1885.08 kg ha^{-1} and low incidence of diseases, being recommended for the organic system in the Northwest region of Rio Grande do Sul.

Keywords: *Avena sativa,* linear correlation, dissimilarity, *UPGMA,* genotype, environmental.

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INTRODUCTION

White oat (*Avena sativa*) is a winter cereal, considered a multifunctional species due to its use in both human and animal feed as fodder, hay and silage (Hawerroth, Barbieri, Silva, Carvalho, & Oliveira, 2014). In addition, when inserted in the rural property, it becomes a viable alternative, capable of diversifying the production system and promoting greater economic security. Above all, oat is used by producers in the South of Brazil as a strategy in crop rotation and succession, as it promotes benefits to the physical and chemical properties of the soil, reduction in the incidence of weeds, consequently reducing the use of herbicides and lower incidence of insect pests and diseases (Lângaro & Carvalho, 2014).

In recent seasons, mainly in Brazil, the crop has become more commercially important due to the increase in consumption, thus, high quality plants and agronomic performance are necessary in response to the improvement of environmental stimuli (Silva *et al*., 2012). However, the culture of white oat has been attracting different sectors of society, due to its benefits for human consumption, in which the high percentage of protein (14%), lipids (6.9%), carbohydrates (66.3%) and starch (43.7 to 61%).

Added to this, the concern of society for health, since it has been adopting healthy foods, among the main approaches is the consumption of products of organic origin, due to the reduction of risks by contamination or intoxication by synthetic molecules. Therefore, organic cultivation receives great appreciation and appreciation from society, as this system seeks the best quality and safety of the final product. Unlike the conventional cultivation of white oat, which is *characterized* by the use of fertilizers and pesticides in order to enhance grain productivity, the organic system seeks to produce food using organic fertilizers and biological management in order to obtain a final product of high quality and safe for human consumption (Penteado, 2001). However, the production of white oat in an organic system presents difficulties in relation to high yields, grains with industrial quality and mainly the incidence of diseases.

According to Rozane, Prado and Romualdo (2008) there are management limitations that can influence the growth and development of plants. For Saminêz, Dias, Nobre, Mattar and Gonçalvez (2008), the adoption of a diverse and versatile crop rotation, green manures, plants with a vigorous root system, nutrient cycling species, minimal pest-insect interference and interspecific competition with weeds are considered determinants for the success of organic cultivation. Faced with the difficulty in selecting and indicating white oat cultivars to be cultivated under organic management, this work aimed to position white oat cultivars for the organic system, and to highlight which characteristics determine grain yield and their interrelationships.

MATERIAL AND METHODS

The research was conducted at Instituto Regional de Desenvolvimento Rural belonging to Universidade Regional do Noroeste do Estado do Rio Grande do Sul, located in the municipality of Augusto Pestana, Northwest region of the state of Rio Grande do Sul in the 2020 agricultural season. The geographical coordinates are: 28º 26' 25'' S and 54º 00' 07'' W with an altitude of 301 meters. The soil is classified as Typical Dystroferric Red Latosol, with a dark red color profile, deep, with high clay contents and well drained. The climate is characterized as humid subtropical Cfa according to Köppen. During the experiment, the averages of minimum and maximum temperatures were 15,7 and 16,7°C respectively, with relative humidity of 85% and an accumulation of 512,15 mm.

The experimental design used was randomized blocks with treatments arranged in four replications. The treatments corresponded to the cultivars: IPR Artemis, IPR Afrodite, URS Corona, URS Brava and URS Taura. Sown on June 15th in the direct system in experimental units composed of 17 lines spaced at 0,17 meters and 10 meters in length. A population density of three million seeds per hectare was used, with fertilization and cultural treatments based on the recommendation proposed by Gebana®.

The characters measured in the useful area of each experimental unit were: final plant population per square meter (PPSM, units), days between sowing and flowering (DF, days), days between sowing and maturation (DM, days) , number of tillers (TILL, units), percentage of lodging (LOG, %), intensity of diseases damage (INTD, %), plant height (PH, cm), height of panicle insertion (HPI, cm), number of panicles per square meter (NPSM, units), number of grains per panicle (NGP, units), grain weight per panicle (GWP, g), thousand grain weight (TGW, g), grain yield (GY, kg ha^{-1}).

The data obtained were submitted to the assumptions, normality and homogeneity of the residual variances and additivity of the model. Analysis of variance with significance at 5% probability was performed using the F test. Variables that showed significance were submitted to the Tukey test of multiple comparison of means at 5% probability. Mean effects were identified through descriptive trends as well as linear relationships between grain yield x lodging, intensity of diseases and tillering. In order to understand the trend of linear association between the variables, a linear correlation was applied with significance based on the T test at 5% probability. Afterwards, the average Euclidean algorithm and the UPGMA grouping were used to create the dendrogram of the genetic distances of the cultivars.

RESULTS AND DISCUSSION

In the analysis of variance (Table 1), cultivars are verified in relation to treatments. According to the results obtained, it can be seen that for the cultivar factor of variation, there was significance for all measured variables. In the interaction of the blocks in relation to the variables, it appears that the number of grains per panicle (NGP) exhibited significance. The coefficient of variation for plant population per square meter (PPSM) and thousand grain weight (TGW) was low, as for tillering (TILL), plant height (PH), height of panicle insertion (HPI) and panicle number per square meter (NPSM) represented an average value, and for number of grains per panicle (NGP), grain weight per panicle (GWP) and grain yield (GY) higher value.

The average effects (Figure 1) reveal that for plant population per square meter (PPSM) the cultivar URS Brava was superior, followed by IPR Afrodite and URS Corona, on the other hand for the cultivars IPR Artemis and URS Taura the final population was lower at 200 plants per m^2. For the variables days between sowing and flowering (DF) and days between sowing and maturation (DM), the results between cultivars were similar. The cultivar IPR Afrodite presented a greater number of tillers (TILL) resulting in greater tillering dynamics at the end of the production period, these changes visualized by URS Taura and IPR Artemis were due to the low final population of plants with greater probability of emitting and maintaining tillers during the cycle. For Cruz et al. (2003), the plant population directly affects the emission, survival and efficiency in the use of incident solar radiation, nutrients and water, which results in benefits for the maintenance of the tillers.

Lodging is one of the main events that affects the grain yield of white oats, especially when using high technologies aimed at nitrogen fertilization combined with favorable climatic conditions (Arenhardt *et al*., 2015), a scenario commonly seen in the conventional system. In addition, the intensity of lodging depends on genetic factors interrelated with environmental factors, such as wind, precipitation, highly fertile soils, diseases, plant arrangement and management techniques (Silva et al., 2015).

Table 1. Summary of the analysis of variance of the variables, referring to five genotypes of white oat in an organic system. Augusto Pestana, Rio Grande do Sul, Brazil.

FV	DF	Pr<Fc								
		PPSM (units)[1]	TILL (days)	PH (cm)	HPI (cm)	NPSM (units)	NGP (units)	GWP (g)	TGW (g)	GY (kg ha^{-1})
Cultivars	4	0,0001*	0,0001*	0,0001*	0,0001*	0,0001*	0,0001*	0,005*	0,0001*	0,0001*
Blocks	3	0,0011	0,0011	0,001	0,0001	0,0001	0,0019*	0,1	0,0029	0,566
Residues	13									
CV (%)		9,42	12,19	11,27	12,13	11,33	31,40	31	6,58	20,86

[1]Factor variation (FV), plant population per square meter (PPSM), tillering (TILL), plant height (PH), height of panicle insertion (HPI), number of panicles per square meter (NPSM), number of grains per panicle (NGP), grain weight per panicle (GWP), thousand grain weight (TGW), and grain yield (GY).

A high lodging index (LOG) is observed for the cultivars URS Taura, URS Brava and IPR Afrodite, corroborating the highest final populations of these cultivars, being predisposed to lodging due to the dynamics of tillering and maintenance of plants throughout the cycle. For Sinniah, Wahyuni, Syahputra and Gantait (2012), plant height and arrangement are determinant for the susceptibility or tolerance of plants to lodging, the cultivar IPR Artemis showed greater tolerance to lodging and can be indicated for cultivation in an organic system in environments predisposed to climatic events that accentuate lodging.

Intensity of diseases (INTD) was higher in the cultivar IPR Artemis, followed by URS Taura, URS Brava and IPR Afrodite. On the other hand, the cultivar URS Corona was more resilient. For the variable plant height (PH), the IPR Afrodite genotype expressed the highest plant height, 70 cm on average, largely due to the high plant population. The cultivars URS Corona and URS Taura exhibited similar heights between 60 cm and 63 cm on average, as well as the cultivars URS Brava and IPR Artemis that were similar to each other, but showed the smallest height, with an average of 55 to 57 cm. The variable height of panicle insertion (HPI) had similar results with the variable PH, greater height in the cultivar IPR Afrodite, close to 60 cm, followed by the cultivars URS Taura, URS Corona, URS Brava and IPR Artemis respectively, both lower than 55 cm.

The cultivar IPR Afrodite had the highest number of panicles per square meter (NPSM), 250 panicles m^2, which can be explained by the fact that the genotype showed the highest plant population followed by the highest tillering capacity. The cultivars URS Corona and URS Brava resulted in 200 panicles per square meter, the cultivars IPR Artemis and URS Taura had a lower number, 180 and 165 panicles m^2, respectively.

When measuring the number of grains per panicle (NGP), the cultivar URS

Corona was superior (33 grains per panicle), a result expected by the lower production of tillers, causing a better distribution of photoassimilates that potentiates the number of grains per panicle in the main plant, followed by the cultivar IPR Afrodite with 28 grains per panicle. The cultivar URS Taura (25 grains per panicle) and URS Brava (23 grains per panicle), IPR Artemis presented the lowest result, about 20 grains per panicle, it is possible to have had this result because the genotype had the highest incidence of diseases.

When measuring grain weight per panicle (GWP), the URS Corona was higher, 0,09 grams per panicle, due to the higher number of grains per panicle, Caierão *et al*. (2001) report that there is a positive correlation between these characteristics. In addition, the genotype expressed the lowest intensity of diseases, a factor that favored the contribution of photoassimilates to the grains, the cultivars IPR Artemis (0,075 g), URS Taura (0,07 g), URS Brava (0,064 g) and IPR Afrodite (0,062 g), the latter showed lower grain weight per plant, although it had a high number of grains per panicle, the incidence of diseases may have impaired the supply of photoassimilates in the grains.

Martineli (2003) mentioned that the presence of diseases is a limiting factor in production, as it has the potential to reduce the mass, quality and number of grains. Another reason that may have affected this variable is the high density of plants in this genotype, which may have strongly influenced the partition of photoassimilates.

The cultivar URS Taura had a higher thousand grain weight (TGW) with 33 grams, which can be explained by the lower number of panicles per square meter, as well as a lower number of grains per panicle. The cultivars IPR Afrodite, IPR Artemis, URS Corona exhibited a thousand grain weight of 28 g, 26 g and 25 g, respectively, the cultivar URS Brava obtained 24 g, which may have been caused by the higher density of plants for this genotype. The partition is defined as the differentiated distribution of photoassimilates by the different organs of the plant and, therefore, determines the growth model, which can be balanced between shoots and root systems, in this way, the greater the number of drains, the smaller the contribution of photoassimilates to each organ that will be destined (Alexandrino, Gomide, Oliveira, Teixeira, & Lanza, 2005).

The final productivity is measured by the grain yield (GY), it is observed that the URS Corona had a grain yield of 1900 kg ha^{-1}, presented by the stability between the plant density, high number of grains and weight per panicle allied the low intensity of diseases and lodging, characteristics that according to Cruz, Regazzi and Carneiro (2012) are essential for the positioning of white oat genotypes. The cultivars URS Brava, IPR Afodite and IPR Artemis had yields of 1600 kg ha^{-1}, 1450 kg ha^{-1} and 1300 kg ha^{-1} respectively. The lowest result was found in the cultivar URS Taura with a grain yield of 1125 kg ha^{-1}, which reveals the importance of yield components, as low values of panicle numbers per square meter, number of grains per panicle and low values are observed grain weight per panicle, which may have been determinant in the expression of low performance in grain yield, in addition to the high lodging index.

The lodging intensity had a weak negative linear correlation with the grain yield, that is, as the lodging intensity increases, there is a reduction in the grain yield. Intensity of diseases has a negative correlation with grain yield, because the higher it is, the lower the grain yield. Lodging and disease incidence have similar responses according to their intensity in the cropping system. Because these factors directly affect the weight and number of grains per plant, since lodging causes the panicle to be close to the ground, exposed to variations in humidity. The intensity of diseases causes imbalances in plant development, resulting in quality depreciation and consequently lower final grain production (Silva *et al*., 2015).

When analyzing the tillering dynamics of white oat cultivars in the organic system, a negative response can be seen when correlating grain yield with the number of tillers. Thus, the higher the number of tillers produced by the plants, the lower the grain yield. This result can be attributed specifically to the organic system, due to the fact that it has limitations of inputs, whether fertilizers or substances used in pest control, initially the potential for increasing productivity of this system is more restricted than in the conventional system, especially when using a greater number of plants per unit of area (Mattos & Martins, 2009).

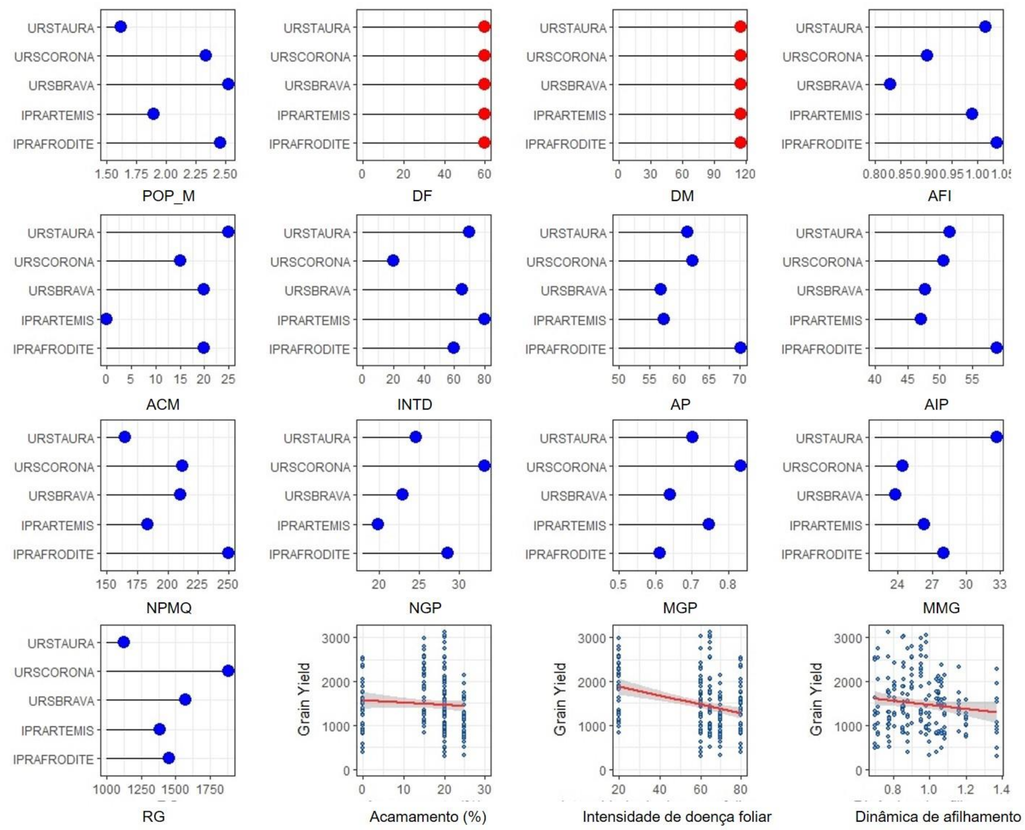

Figure 1. Descriptive analysis of the variables plant population per square meter (PPSM), days between emergence and flowering (DF), days between flowering and maturation (DM), tillering (TILL), lodging (LOG), intensity of diseases (INTD), plant height (PH), height of panicle insertion (HPI), number of panicles per square meter (NPSM), number of grains per panicle (NGP), grain weight per panicle (GWP), thousand grain weight (TGW) , grain yield (GY), lodging (%), intensity of leaf disease and tillering dynamics of the five white oat genotypes. Augusto Pestana, Rio Grande do Sul, Brazil.

The comparison of means (Table 2) shows that for the population of plants per square meter (PPSM) the cultivars URS Brava and IPR Afrodite showed higher values, but did not differ statistically from each other, the lowest result was found for the cultivar URS Taura. The highest number of tillers (TILL) was found in the cultivars IPR Afrodite, IPR Artemis and URS Taura, opposite to that found in URS Brava with a number of tillers of 0,82. In the variable plant height (PH), the cultivar IPR Afrodite was statistically different from all the other treatments, obtaining greater height, the cultivars URS Brava and IPR Artemis did not show statistical difference, these being the ones with the lowest height. For the variable height of panicle insertion (HPI), the cultivar IPR Afrodite differed from all the others, where URS Artemis and URS Corona expressed the lowest values for this characteristic. When analyzing the number of panicles per square meter (NPSM), the cultivars URS Afrodite and URS Taura stand out, with the highest and lowest number of panicles per square meter respectively.

When the number of grains per panicle (NGP) was evaluated, the cultivar URS Corona was superior and IPR Artemis presented a lower result. For the variable grain weight per panicle (GWP), it is observed that the cultivar URS Corona expressed superiority and URS Brava and IPR Afrodite presented lower weight. For the variable thousand grain weight (TGW), it can be seen that the cultivar URS Taura was statistically different from the other cultivars, followed by IPR Afrodite, IPR Artemis, the lowest thousand grain weight was found in the cultivars URS Corona and URS Brava. URS Corona stood out in terms of grain yield (GY), opposite to that found for URS Taura, which obtained a grain yield of 1121,70 kg ha^{-1}.

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

Cultivars	PPSM[1] (units)	TILL (units)	PH (cm)	HPI (cm)	NPSM (units)	NGP (units)	GWP (g)	TGW (g)	GY (kg ha^{-1})
URS Brava	252.94 a[2]	0.82 c	56.90 d	47.75 b	210.29 b	23.00 bc	0.64 b	23.77 d	1570.50 ab
IPR Afrodite	245.58 ab	1.03 a	70.22 a	58.82 a	250.00 a	28.67 ab	0.61 b	27.98 b	1450.29 bc
URS Corona	233.82 b	0.90 b	62.25 b	50.50 bc	211.76 b	33.30 a	0.83 a	24.45 d	1885.08 a
IPR Artemis	189.70 c	0.99 a	57.45 cd	47.10 c	183.82 c	19.87 c	0.74 ab	26.34 c	1388.30 bc
URS Taura	161.76 d	1.01 a	61.27 bc	51.55 b	164.70 d	24.70 bc	0.70 ab	32.74 a	1121.70 c

[1]Plant population per square meter (PPSM), tillering (TILL), plant height (PH), height of panicle insertion (HPI), number of panicles per square meter (NPSM), number of grains per panicle (NGP), grain weight per panicle (GWP), thousand grain weight (TGW), grain yield (GY). [2]Lowercase letters compare cultivars within the column.

The results obtained through the linear correlation (Figure 2), show a negative relationship of the plant population per square meter (PPSM), with tillering (TILL), intensity of diseases (INTD) and thousand grain weight (TGW), that is, the larger the population of plants in the organic system, the smaller these values tend to be. However, positive correlations of (PPSM) with the number of panicles per square meter (NPQM), number of grains per panicle (NGP) and also for grain yield (GY) can be seen. Tillling (TILL), has a positive correlation with intensity of diseases (INTD), plant height (PH), panicle insertion height (HPI), number of panicles per square meter (NPSM) and thousand grain weight (TGW).

For lodging (LOG), there was a negative correlation with intensity of diseases (INTD) and positive correlations with plant height (PH), panicle insertion height (HPI), number of grains per panicle (NGP) and thousand grain weight (TGW). According to Hawerroth et al. (2014), plant height strongly influences lodging. Intensity of diseases (INTD) had negative correlations with plant height (PH), number of panicles per square meter (NPQM), number of grains per plant (NGP), grain weight per plant (GWP) and grain yield (GY), that is, the occurrence of severe diseases drastically affect the yield components of white oat, resulting in a low agronomic performance, however, it exhibited a positive correlation with thousand grain weight (TGW).

Plant height (PH) showed a positive correlation with height of panicle insertion (HPI), number of panicles per square meter (NPSM), grain weight per plant (GWP), thousand grain weight (TGW) and grain yield (GY), in this sense, tall genotypes tend to show higher yields, this is explained by the high contribution in the production of photoassimilates by the higher proportion of green matter (Hawerroth et al., 2014). Results by Hartwig et al. (2006), corroborate those of the present study, as they showed a positive correlation between these characters and explain that genotypes of high stature exhibit physiological superiority over their competitors. This situation is similar to Nirmalakumari, Sellammal, Thamotharan, Ezhilarasi and Ravikesavan (2013), who showed a positive relationship between plant height and productivity.

For height of panicle insertion (HPI) there were positive correlations with number of panicles per meter (NPSM), number of grains per plant (NGP), grain weight per plant (GWP), thousand grain weight (TGW) and grain yield (GY). Analyzing the variable number of panicles per square meter (NPSM) positive correlations were observed with the number of grains per plant (NGP) and grain yield (GY), however a negative correlation is observed with the one thousand grain weight (TGW). For the number of grains per plant (NGP) it revealed positive correlations with grain weight per plant (GWP) and grain yield (GY). As for the variable grain weight per plant (GWP) there was a positive correlation with grain yield (GY). The thousand grain weight (TGW) showed a negative correlation with the grain yield (GY).

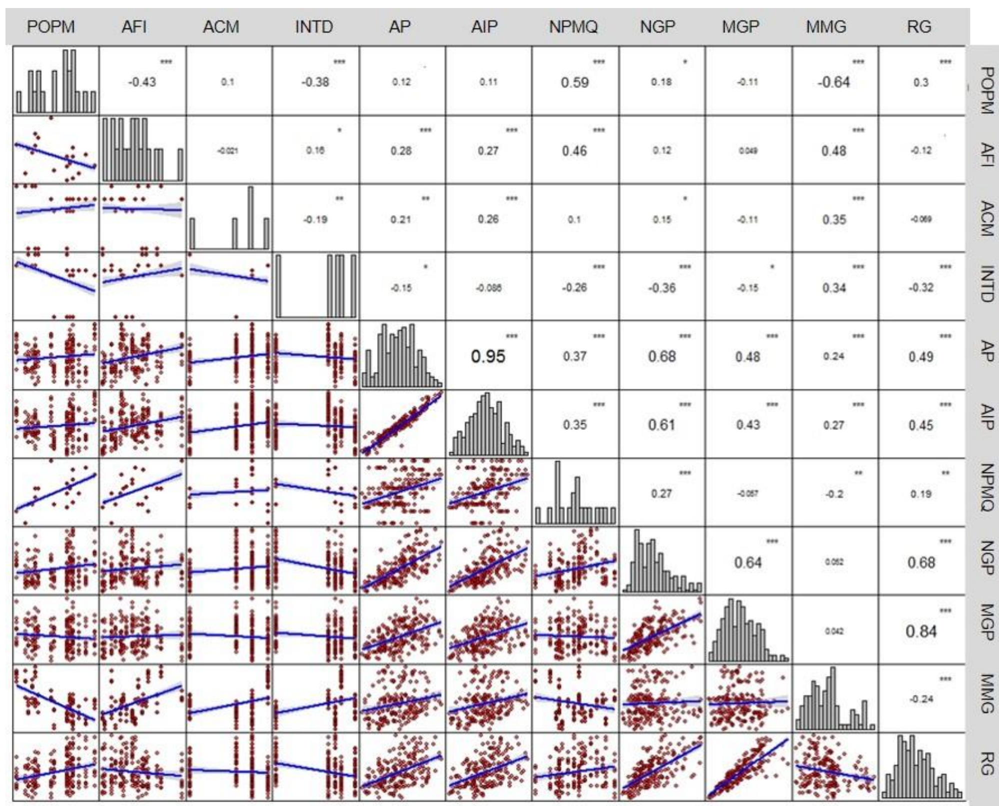

Figure 2. Pearson's linear correlation estimates (significant at 5,00% error probability) for characters: plant population per square meter (PPSM), tillers (TILL), plant height (PH), height of panicle insertion (HPI), number of panicles per square meter (NPSM), number of grains per panicle (NGP), grain weight per panicle (GWP), thousand grain weight (TGW), grain yield (GY) evaluated in five white oat genotypes. Augusto Pestana, Rio Grande do Sul, Brazil.

The average *Euclideano* algorithm and the *UPGMA* cluster were used to create the dendrogram, making it possible to visualize the genetic distances of the cultivars through the clusters' distances. The dissimilarity dendrogram (Figure 3) is composed of two large groups, in red color formed by the cultivar URS Corona, since it was the cultivar that presented the greatest dissimilarity among the others. In blue color, it is formed by the cultivars URS Taura, URS Brava, IPR Afrodite and IPR Artemis, showing greater similarity. However, the IPR Afrodite and IPR Artemis genotypes showed the greatest similarity between them in relation to the mean of the measured variables.

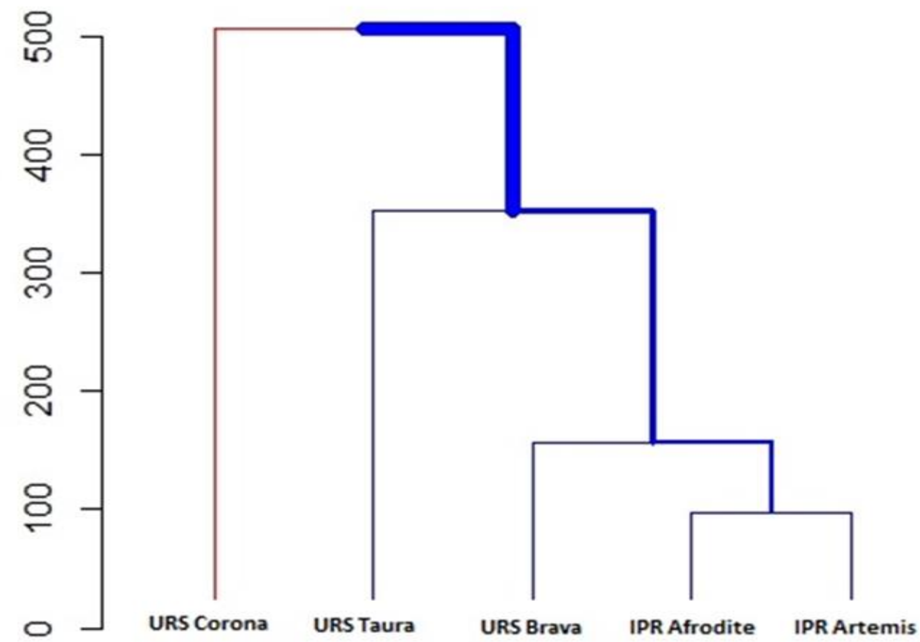

Figure 3. Dissimilarity Dendrogram. Augusto Pestana, Rio Grande do Sul, Brazil

CONCLUSIONS

The cultivar URS Afrodite is superior for plant height, height of panicle insertion, number of panicles per square meter. The cultivar URS Corona stood out for the number of grains per panicle, grain weight per panicle with a grain yield of 1885.08 kg ha^{-1} and low incidence of diseases, being recommended for the organic system in the Northwest region of Rio Grande do Sul.

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