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AGRONOMIC PERFORMANCE OF IRRIGATED RICE HYBRIDS ON THE WESTERN BORDER OF RIO GRANDE DO SUL

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ABSTRACT - Rice crops are essential in World Food Security. Brazil is the largest rice producer outside Asia, with increasing research investments, including using hybrid cultivars with high productive potential**.** The objectives of this study were to compare the agronomic performance of three cultivars of irrigated rice, two hybrids and one conventional, in the municipality of Uruguaiana, on the western border of Rio Grande do Sul. The experiment was conducted in the 2017/2018 crop with four replicates in a completely randomized design. The three treatments consisted of the cultivar Guri Inta CL and the hybrids Titan CL and Lexus CL. Morphological characters (plant stature, panicle length, grain length, grain width, grain appearance) and yield components (weight of one thousand grains, number of grains per panicle, number of sterile grains per panicle, plant population, whole grain yield) were evaluated. The statistical analyzer S-21 was used to determine the variables of appearance and grain size. The agronomic performance of hybrid cultivars presents lower quality for whole grain yield and the percentage of chalky grains. The morphological characteristics of the plant indicate that hybrid cultivars compensate for the lower initial population by producing more branches and larger panicles without compromising grain yield. Grain yield showed no significant difference, demonstrating the lack of economic viability in this agricultural year for cultivating rice hybrids in Uruguaiana. Significant correlations were verified between the productive characteristics and rice grain quality, showing the relationships between grain productivity and rice grain quality.
Keywords: *Oryza sativa* L., agronomic characters, heterosis, grain quality, linear relationships.

DESEMPENHO AGRONÔMICO DE HÍBRIDOS DE ARROZ IRRIGADO NA FRONTEIRA OESTE DO RIO GRANDE DO SUL

RESUMO - A cultura do arroz tem grande importância na segurança alimentar mundial, o Brasil é o maior produtor de arroz fora da Ásia, sendo crescente os investimentos em pesquisas, dentre elas a utilização de cultivares híbridas com alto potencial produtivo**.** Os objetivos deste trabalho foram comparar o desempenho agronômico de três cultivares de arroz irrigado, duas híbridas e uma convencional no município de Uruguaiana, fronteira oeste do Rio Grande do Sul. O experimento foi conduzido na safra 2017/2018 em delineamento inteiramente casualizado, com quatro repetições. Os três tratamentos foram a cultivar Guri Inta CL e os híbridos Titan CL e Lexus CL. Foram avaliados caracteres morfológicos (estatura de plantas, comprimento da panícula, comprimento do grão, largura do grão, aparência do grão), componentes de rendimento (massa de mil grãos, número de grãos por panícula, número de grãos estéreis por panícula, população de plantas, rendimento de grãos inteiros). Para as variáveis de aparência e dimensões dos grãos foi utilizado o analisador estatístico S-21. Portanto, o desempenho agronômico das cultivares híbridas apresentam menor qualidade para os caracteres rendimento de grãos inteiros e porcentagem de grãos gessados. Os caracteres morfológicos da planta, indicam que as cultivares híbridas compensam a menor população inicial produzindo mais afilhos e panículas maiores não comprometendo o rendimento de grãos. O rendimento de grãos, não apresentou diferença significativa, evidenciando a falta de viabilidade econômica no presente ano agrícola, para o cultivo de híbridos de arroz em Uruguaiana. Foram verificadas correlações significativas entre os caracteres produtivos e de qualidade de grão de arroz, evidenciando as relações entre produtividade de grãos e qualidade dos grãos de arroz.
Palavras-chave: *Oryza sativa* L., características agronômicas, heterose, qualidade de grão, relações lineares.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereals used in human food, with Brazil being the 10th largest producer in the world and the largest outside Asia, with a production of 12,071.00 tons (CONAB, 2022). The trend indicates a 1.6% growth in production, with no increase in the Brazilian area between 2014 and 2024 (FAO, 2015). Therefore, this increase in production will be the result of increased grain productivity, which can be provided by new technologies.

The state of Rio Grande do Sul (RS) stands out as the largest producer of this cereal, accounting for 70% of the Brazilian production (MEUS et al., 2021). The irrigated rice cultivation method predominates in RS, with a water

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blade that saturates the soil during practically the entire cultivation (CONAB, 2022). The area of cultivation of irrigated rice in the last five years is approximately 1 million hectares. Only one hybrid appears among the ten most used cultivars, with an area ranging from 10,000 to 20,000 ha (IRGA, 2017). This fact is due to a supposed resistance of RS producers from adopting hybrid cultivars, either because they do not have the habit of cultivating hybrids or because of the higher cost of acquiring seeds.

The hypotheses of the exploitation of heterosis in rice have been published since 1926 (COIMBRA et al., 2006). However, as manual emasculation at a commercial level in rice is considered unfeasible, it was from the discovery of lines of the wild rice species (*O. glaberrima*) that express the male-cytoplasmic sterility that artificial hybridization in rice became viable (BRAGANTINI et al., 2001; COIMBRA et al., 2006).

In Brazil, the first research concerning the development of rice hybrids began in 1985 through an agreement between the Empresa Brasileira de Pesquisa Agropecuária (Embrapa) and the Institute of Recherches en Agronomie Tropicale (IRAT), in France. In 1994, with the support of FAO, Embrapa established the Work Group on Rice Hybrids for Latin America and the Caribbean. The first commercial rice hybrid launched in Brazil was Avaxi, in 2003 (SOSBAI, 2018; LIMA et al., 2020).

An important aspect of rice cultivation is the industrialization process, where the grain undergoes husking, polishing, and/or parbolization. Therefore, the industrial quality and the acceptance of the consumer market are as important as the volume of rice produced (CASTRO et al., 1999). The term “grain quality", in addition to the physical and chemical characteristics (gelatinization temperature), encompasses the processing yield (percentage of grains), whole grain yield (percentage of whole grains), dimension aspects (fine length, medium length, short, and mixed), translucency (white center) and appearance of the grain (related to defects, stains, or imperfections) (FERREIRA et al., 2005).

Grain quality is related to various management practices adopted by the producer, the choice of cultivar, cultural management, harvest planning, moisture content during harvest, drying process, storage, and processing (MEUS et al., 2021). The moisture differential in the grain mass during the harvest will be lower the higher the uniformity of the crop, which is a determining factor during the drying process to obtain a good processing income (FERREIRA et al., 2005; ALHENDI et al., 2019).

Among the factors that interfere with grain quality is the uniformity of the crop. The genetics of each cultivar and the amount of tillers issued by each plant determines this condition. Tillers are branches that develop in each unelongated node from the primary stem or other tufts during vegetative growth. The appearance of these branches, called tillers, is determined by solar radiation, nutrients, spacing, and other biotic or abiotic agents (YOSHIDA, 1981). Fertile tillers can partially compensate for crop failures in addition to providing greater phenotypic plasticity. The occurrence of specific stresses can be minimized due to variation in the growth and development of the tillers.

Mill yield is as important as grain productivity for rice cultivation in Brazil. Mill yield and other aspects that give what we call grain quality largely define the price of the product and the acceptance of the consumer market (MAGHELLY et al., 2020; FACCHINELLO et al., 2021). Several types of biotic and abiotic stresses, such as water variation amplitudes, pest and disease attacks, genetic potential, among others, can affect the yield of whole grains (CASTRO et al., 1999). Rice varieties have different genetic potentials for the production of whole grains due to their susceptibility to cracks or fissures when subjected to climatic variations during the grain maturation process (MAGHELLY et al., 2020).

The use of hybrid rice cultivars has already gained more space in other producing countries, mainly due to their greater productive capacity. In China, the hybrid is known as "China's super rice” (FAO, 2002). However, it does not have the same acceptance in Brazil due to commercialization characteristics and implementation costs. Therefore, it is necessary to study the real potentialities of the use of hybrid seeds in the region of the western border of Rio Grande do Sul. In this sense, the objective of this study was to evaluate the agronomic performance of hybrid and conventional cultivars of irrigated rice in Uruguaiana on the western border of Rio Grande do Sul.

MATERIAL AND METHODS

The field experiment was conducted in the 2017/2018 agricultural season, on the Granja Poriajú property, located in the municipality of Uruguaiana, RS, in the 5th District (Vertentes), in the location called Camoaty (30º01’29.76”S, 56º36’53.23”W, and 128 m altitude). The climate of the physiographic region of the western border of Rio Grande do Sul falls into the *Cfa* class, humid subtropical according to the Köppen climate classification (KÖPPEN, 1948).

The site of the experiment is located in the Uruguaiana unit. According to the Brazilian Society of Soil Sciences, it is classified as a Vertisol Carbonate Ebanic Chernosol (STRECK, 2008). Soil analysis performed before implementing the experiment showed the chemical characteristics in the layer of 0-20 cm: OM = 2.5%, pH (H_2O) = 5.4, H+Al = 6.2 $cmol_c$ dm^{-3}, P Melich) = 4.6 mg dm^{-3}, K^+ = 0.276 $mmol_c$ dm^{-3}, AC^{+2} = 13.9 $cmol_c$ dm^{-3}, and Mg^{+2} = 5.9 $cmol_c$ dm^{-3}. The soil was prepared on July 2017, in an area with a history of weed problems, with practices that include harrowing, planing, and sealing.

The treatments used were T1 (hybrid Lexus CL), T2 (hybrid Titan CL), and T3 (cultivar Guri Inta CL). The sowing was performed on October 25th, 2017, using 45 kg ha^{-1} (Lexus CL hybrid), 40 kg ha^{-1} (Titan CL hybrid), and 80 kg ha^{-1} (cultivar Guri Inta CL), as recommended by the company that owns the hybrids and cultivar. The experimental units consisted of seven lines spaced at 0.17 m, with 6 m in length, totaling an area of 7.14 m^2. The

experimental design used was completely randomized, with four replicates. Base fertilization was 135 kg ha^{-1}, using the MAP (mono-ammonium phosphate) 12-52-00 formula, with 16.2 kg ha^{-1} of N and 70.2 kg ha^{-1} of P_2O_5. On the same day, the free application of 140 kg ha^{-1} of potassium chloride 00-00-60 was performed, with 84 kg ha^{-1} of K_2O, according to Fertilization and Liming Manual(CQFS-RS/SC, 2016).

Phytosanitary treatments were performed to control weeds, diseases, and pests. Weed control began with a desiccation on October 24th, 2017, using 1080 g ai (active ingredient) ha^{-1} of the herbicide glyphosate and the needle point application of the herbicide glyphosate, at a dose of 270 g ai ha^{-1} and clomazone at 576 g ai ha^{-1}. The herbicides imazapique (28 g ai ha^{-1}), imazapir (84 g ai ha^{-1}), pyrazosulfuron (17.5 g $aiha^{-1}$), and clomazone (32 g ai ha^{-1}) were applied during water intake. The herbicide bentazone (960 g ai ha^{-1}) was also applied on December 15th, 2017, 51 days after sowing (DAS).

The definitive irrigation began on November 27th, 2017, 33 DAS, along with the application of herbicides and the application of 81 kg ha^{-1} of N in the form of urea, in stage V4. Fungicides tricyclazole (225 g ai ha^{-1}) and propiconazole (150 g ai ha^{-1}) were applied in R2 at 93 DAS. The fungicide and insecticide were last applied on February 2nd, 2018, with the products tricyclazole (225 g ai ha^{-1}), methominostrobin (71.5 g ai ha^{-1}), tebuconazole (107.25 g ai ha^{-1}), diflubenzurom (32.5 g ai ha^{-1}), acetamiprid (30 g ai ha^{-1}), and alpha-cypermethrin (60 g ai ha^{-1}). The second nitrogen fertilization was performed at 62 DAS, in the amount of 36 kg ha^{-1} of N, also in the form of urea, when the crop was in stage R0 of the Counce scale (COUNCE et al., 2000).

The number of tillers of the primary stem (NTPS) was determined by Equation 1:

$$NTPS = \frac{NCF - PIP}{PIP} \quad \text{(Equation 1)}$$

Where:
IPP = initial plant population count and
NFS = number of final stems during harvest.

Grain yield (GY) was estimated after manual harvesting of a useful area of 2.26 m^2 (0.85 m x 5m) when the grains presented an average humidity of 23%. After tracking, cleaning, and weighing the grains with husks, the data were corrected to 13% moisture and converted to kg ha^{-1}. The weight of one thousand grains (WTG) was determined by weighing eight samples of 100 grains per experimental unit (MAPA, 2009), obtaining the average of the values and transforming them to a weight of one thousand grains. The number of branched of the primary panicle (NBPP), number of grains per panicle (NGP), number of failed grains per panicle (NFGP), and plant length (PL, cm) were determined by collecting 15 random plants per plot. The mean plot hight (MPH, cm) was measured using a measuring tape at the average height of the plants in the field. The industrial yield, which is the whole grain yield (WGY, %) and processing income (PI), which is the total grain yield, were determined by processing a sample of 100 g of paddy rice grains, per plot, in a Suzuki sample processor, model MT-88®.

The mean grain length (MGL, mm), mean grain width (MGW, mm), chalky grains (PCG, %), chalky area (PCA, %), and white belly (WB, %) were measured using a Rice Statistical Analyzer S-21, where the grains with chalky area equal to or greater than 63% are considered chalky grains and with chalky area between 33 and 63% are considered "white belly" grains.

The meteorological data were obtained through the National Institute of Meteorology (Inmet), choosing the Quaraí-RS automatic station, approximately 50 km away from the experiment site. The data obtained were submitted to the analysis of assumptions of the mathematical model of the analysis of variance. After fulfilling the assumptions, the data were submitted to the analysis of variance and the means compared by the Tukey test at 5% of error probability, analyzed using the Genes program (CRUZ, 2013).

RESULTS AND DISCUSSION

The experiment presented coefficients of variation (CV in %) between 10 and 20%, highlighting good experimental accuracy. MGW, WTG, PL, GY, WGY, MPH, and MGL presented low CV, while PCG, PCA, WB, NBPP, NGP, NFGP, NPS, and NTPS obtained an average CV, as described in Tables 1, 2, and 3.

A few climatic factors are essential in determining the productive potential of rice crops, such as total rainfall, total incident solar radiation, and average temperature. Figure 1 shows the rainfall values, directly proportional to the incident solar radiation (Figure 2), and the average temperature values, influenced by the factors highlighted above, presenting an important action on the productive aspects of rice crops.

Table 1 presents the mean values for GY, noting that there was no statistical difference between cultivars but with an increase in grain productivity of 9.14% and 11.05% for the hybrid cultivars Titan CL and Lexus CL, in relation to the conventional cultivar, Guri Inta CL. According to Zhu (2016), hybrid rice cultivation leads to a great improvement in rice productivity. In general, there is a grain yield of more than 20% when using the hybrid, compared with conventional rice varieties. Ribas et al. (2016) observed that hybrids had a production potential 28% higher than conventional genotypes, different from that observed in the present study, according to the percentages of increase highlighted.

According to Yoshida (1981), grain yield is the product of the number of panicles per m^2, number of spikelets per panicle, percentage of fertile spikelets, and weight of one thousand grains. In this sense, the hybrids present different behavior from the conventional cultivar to compensate for a smaller population of initial plants. This was observed in the Titan CL hybrid, which produced more tillers per primary stem. The Lexus CL hybrid compensated with a greater number of grains per panicle (greater number of fertile spikelets), greater grain weight, and greater number of branches in the panicle.

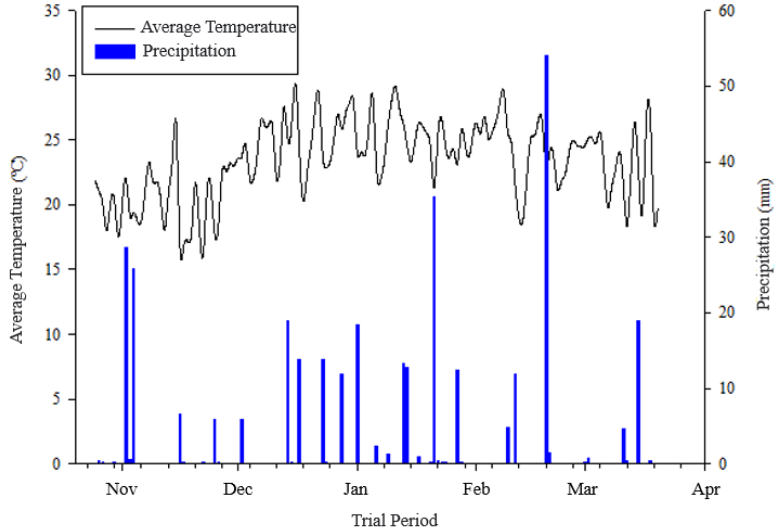

FIGURE 1 - Total rainfall from November to April and average temperature of the experimental period, according to data from the Meteorological Station of Quaraí (RS), in the agricultural year of 2017/2018.

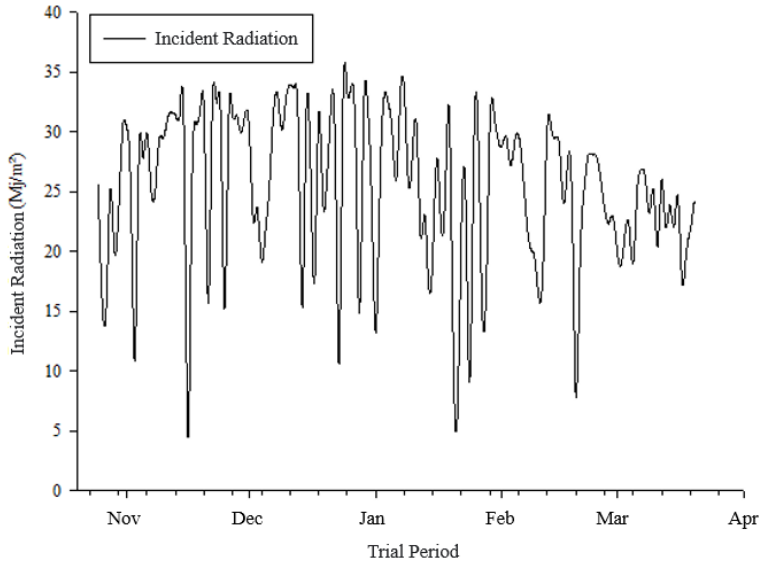

FIGURE 2 - Solar radiation of the experimental period, according to data from the Meteorological Station of Quaraí (RS), in the agricultural year of 2017/2018.

TABLE 1 - Average values for grain yield (GY), whole grain yield (WGY), number of tillers of the primary stem (NTPS), mean plot height (MPH), number of primary stems (NPS), and mean grain length (MGL) cultivated in Uruguaiana (RS), in the agricultural year 2017/2018.

Treatments	GY (kg ha¹)	WGY (%)	NACP	MPH (cm)	NPS	MGL (mm)
Lexus CL	11834a*	56.87ab	8.69b	81.25a	8.75b	6.725a
Titan CL	11630a	55.87b	14.57a	69.50b	6.00b	6.292b
Guri Inta CL	10656a	59.25a	9.09b	82.00a	11.75a	6.683a
Mean	11373	57.33	10.78	77.58	8.83	6.57
CV (%)	5.73	2.19	16.25	3.70	14.97	0.62

*Means followed by the same letter in the column do not differ from each other by the Tukey Test at 5% of error probability.

Another important character for determining grain quality is the WGY or percentage of whole grains in a sample of paddy rice. A sample that presents 59% of whole grains means that after processing 100 g of paddy rice, 59 g of rice will remain, with the remaining consisting of husk, bran, and broken grains. One of the factors that limits the acceptance of rice hybrids in Brazil is the difficulty in achieving a high WGY. Low WGY values were observed in the present study, with the Guri Inta CL obtaining higher values than the Titan CL and Lexus CL hybrids, although it

did not differ statistically. The results observed corroborate with Londero et al. (2015), who verified differences in WGY between the conventional cultivar Puitá Inta CL and the hybrid Inov CL when working with rice cultivars and hybrids.

Regarding the primary stems per linear meter, Guri Inta CL presented a statistically higher number than the others. This was due to the sowing density of 80 kg ha^{-1} used for this cultivar compares with the 40-45 kg ha^{-1} used for hybrid seeds. The hybrids compensated the low initial plant population with the expression of the other productivity components since the main difference observed in the present study between conventional and hybrid rice is attributed to heterosis, which is expressed through quantitative characters (CHIN et al., 2011).

There was a statistical difference for MPH between Titan CL, Guri Inta CL, and Lexus CL, with lower values for the Titan CL hybrid. The stature of rice plants is an important character, as it is a determining factor in the risk of lodging, although the three genotypes have stature below the average of cultivars from Rio Grande do Sul. Historically, plant height was one of the attributes most modified by rice breeding in Rio Grande do Sul, with average heights of 97.52 cm in 1972 and 83.44 cm in 2016 (STRECK et al., 2018).

Table 2 shows some physical attributes of grain appearance where the hybrids differed statistically from the conventional cultivar. Guri Inta CL was superior to the hybrids, with lower MGW, PCG, WB, and PCA but without a statistical difference for the last two variables. Thus, it can be inferred that the cultivar Guri Inta CL presents better values of characters linked to the industrial quality of the grains, although there are no statistical differences in relation to the Lexus CL and Titan CL hybrids for many of them. According to Streck (2018), the physical attributes of grain are essential since they provide important parameters for the appearance of the cereal after cooking.

TABLE 2 - Average values for mean grain width (MGW), chalky grains (PCG), chalky area (PCA), weight of one thousand grains (WTG), and white belly (WB) cultivated in Uruguaiana (RS), in the agricultural year 2017/2018.

Treatments	MGW (mm)	PCG (%)	PCA (%)	WTG (g)	WB (%)
Lexus CL	2.026a*	3.332a	18.895a	27.716a	11.177a
Titan CL	2.050a	4.165a	18.555a	25.312b	12.287a
Guri Inta CL	1.923b	1.290b	15.955a	26.112b	9.747a
Mean	2.00	2.93	17.80	26.38	11.07
CV (%)	0.68	15.41	11.46	1.54	21.12

* Means followed by the same letter in the column do not differ from each other by the Tukey Test at 5% of error probability.

The opaque or glassy appearance of the grain is determined by its chalky area. Glutinous rice has an opaque endosperm, which gives a sticky appearance after cooking. Grains with vitreous endosperm are looser after cooking and are appreciated by Brazilian consumers. The ratio of grain length and width can be used for its classification. The fine long grain, most commonly consumed in Brazil, should be around 6 mm long and 1.9 mm wide (FERREIRA et al., 2005). The two hybrids and the cultivar have mean MGL above 6 mm, considering the classification of long, fine grains, with emphasis on the hybrid and Lexus CL and cultivar Guri Inta CL, which were superior to the hybrid Titan CL.

Table 3 shows the characters related to the grain yield of the rice crop evaluated during the study, with no significant differences for PL between the Lexus CL and Titan CL hybrids in relation to Guri Inta CL. Regarding NBPP, NGP, NFGP, the Lexus CL hybrid was superior to Guri Inta CL. However, no statistical difference was observed, except for NFGP. It is worth noting that there was no difference between the hybrids for the variables presented in Table 3.

TABLE 3 - Average values for panicle length (PL, cm), number of branches in the primary panicle (NBPP), number of grains in the panicle (NGP), number of failed grains in the panicle (NFGP), grown in Uruguaiana (RS), in the agricultural year of 2017/2018.

Treatments	LP	NBPP	NGP	NFGP
Lexus CL	62.10a*	16.32a	144.68a	24.49a
Titan CL	58.70a	11.00ab	128.21ab	19.47a
Guri Inta CL	58.08a	9.91b	102.01b	7.48b
Mean	59.63	12.41	124.97	17.14
CV (%)	3.27	22.60	15.57	24.23

*Means followed by the same letter in the column do not differ from each other by the Tukey Test at 5% of error probability.

In the observation of statistical differences established between hybrids and cultivar concerning numerous characters, it was important to determine the different interactions between the productive components, through Pearson's correlation (Figure 3), with significant negative interaction between RG and NAFC, diverging from the work on rice conducted by Streck et al. (2018), which verified a positive correlation between these characters. This study also presented a positive correlation between the RG and LMG to obtain an increase in grain productivity, with greater average grain widths.

Many variables established a significant correlation with the RGI, where there is a positive correlation with the NCP and negative correlations with LMG, PGG, PAG, and BB, thus determining that the quality of the grains produced strongly influences the RGI. Therefore, the increase in the percentage of grain defects results in a decrease in the RGI. There is a highlight in relation to AMP, where the height of the rice canopy establishes positive correlations with NCP, CMG, and PMG, with a positive relationship between AMP and PMG and greater heights, contributing with the weight of a thousand grains. There is also a negative correlation established between AMP and LMG. In other words, the increase in the rice canopy's height decreases the average width of the grains produced and increases the length of these grains.

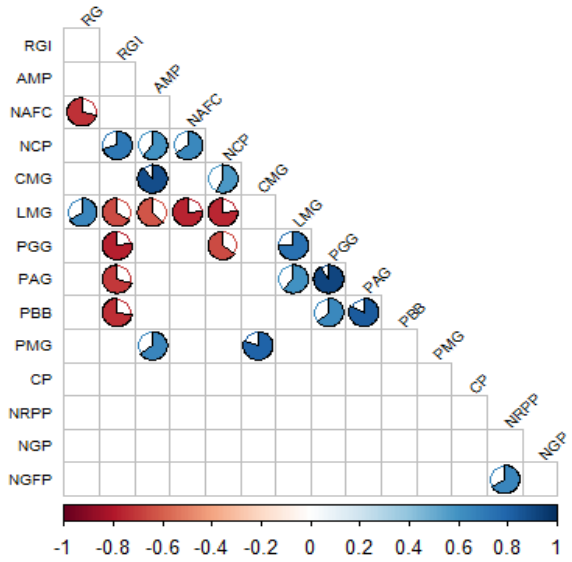

FIGURE 3 - Pearson's correlations significant by the t-test at 5% of error probability, established between grain yield (GY, in kg ha^{-1}), whole grain yield (WGY, in%), mean plot height (MPH, in cm) , number of tillers in the primary stem (NTPS), number of primary stems (NPS), mean grain length (MGL, in mm), mean grain width (MGW, in mm), chalky grains (PCG, in %), chalky area (PCA, in%), white belly (WB, in %), weight of one thousand grains (WTG, in g), panicle length (PL, in cm), number of branches in the primary panicle (NBPP), number grains in the panicle (NGP), and number of failed grains in the panicle (NFGP), in Lexus CL and Titan CL rice hybrids and cultivar Guri INTA CL, cultivated in Uruguaiana (RS), in the agricultural year 2017/2018.

Another important character that directly interferes with rice productivity is the NPSP, which also establishes correlations with other characters, in addition to those mentioned previously. Thus, there is a positive relationship of NPS with NTPS and MGL and negative correlations with PCG and MGW. In turn, the MGW is correlated to the PCG and PCA, indicating that larger grain widths bring higher percentages of problems related to the quality of rice grains.

The characters related to the possible defects presented by the rice grains are closely correlated, with positive correlation between PCA and PCG and between WB with PCG and PCA. Therefore, the increase in the percentage of one of these variables results in the increase of the others. Finally, there are still positive correlations established between MGW and NTPS and between WTG and MGL and NFGP and NBPP.

The technology of using hybrids has been gaining ground due to the greater productive capacity of its cultivars. However, seed quality and price, and the existence of non-hybrid plants with great productive potential result of decades of research for the development of cultivars may limit its acceptance in Brazil, also justifying the low area of cultivation of rice hybrids in the state of Rio Grande do Sul.

However, with the performance of genetic improvement, hybrid cultivars that meet the quality aspects expected by the producer and that are competitive with conventional cultivars can be obtained regarding the volume of grain production, similar to what is observed in China, which presents a massive use of hybrid cultivars of irrigated rice. There is a great potential to increase the rice crop area in Rio Grande do Sul using hybrid cultivars.

CONCLUSIONS

The agronomic performance of hybrid cultivars presents lower quality for whole grain yield and the percentage of chalky grains.

The morphological characteristics of the plant indicate that hybrid cultivars compensate for the lower initial population by producing more branches and larger panicles without compromising grain yield.

Grain yield showed no significant difference, demonstrating the lack of economic viability in this agricultural year for cultivating rice hybrids in Uruguaiana.

Significant correlations were verified between the productive characteristics and rice grain quality, showing the relationships between grain productivity and rice grain quality.

REFERENCES

ALHENDI, A. S.; AL-RAWI, S. H.; JASIM, A. M. Effect of moisture content of two paddy varieties on the physical and cooked properties of produced rice. **Brazilian Journal of Food Technology**, v.22, [s.n.], p.1-12, 2019.

BRAGANTINI, C.; GUIMARÃES, E.P.; CUTRIM, V.A. Produção de sementes macho-estéreis em arroz. **Pesquisa Agropecuária Brasileira**, v.36, n.2, p.273-277, 2001.

CASTRO, E.M.; VIEIRA, N.R.A.; RABELO, R.R.; SILVA, S.A. Qualidade de grãos em arroz. **Embrapa Arroz e Feijão.** Santo Antônio de Goiás, 1999. (Circular Técnica, 34).

CHIN, J.H.; CHU, S.H.; JIANG, W.; CHO, Y.I.; BASYIRIN, R; KOH, H.J. Identification of QTLs for hybrid fertility in inter-subspecific crosses of rice (*Oryza sativa* L.). **Genes and Genomics**, v.33, n.2, p.39-48, 2011.

COIMBRA, J.L.M.; OLIVEIRA, A.C.; CARVALHO, F.I.F.; MAGALHÃES JÚNIOR, A.M.M.; FAGUNDES, P.R.R.; KOPP, M.M. Heterose em arroz híbrido. **Revista Brasileira de Agrociências**, v.12, n.2, p.257-264, 2006.

CONAB. COMPANHIA NACIONAL DE ABASTECIMENTO. **Acompanhamento da safra brasileira de grãos.** CONAB, Brasília, v.9 – Safra 2021/22, n.6 - Sexto levantamento, p. 1-87, março 2022, 2022.

CONAB. COMPANHIA NACIONAL DE ABASTECIMENTO. **Acompanhamento da Safra Brasileira.** CONAB, Brasília, safra 2017/18 - n.12, setembro, 2018, 2018.

COUNCE, P.A.; KEISLING, T.C.; MITCHEL, A.J. A uniform, objective, and adaptive system for expressing rice development. **Alliance of Crop, Soil, and Environmental Science Societies**, v.40, n.2, p.436-443, 2000.

CQFS - RS/SC. COMISSÃO DE QUÍMICA E FERTILIDADE DO SOLO - RS/SC. Manual de adubação e calagem para os Estados do Rio Grande do Sul e Santa Catarina. **Sociedade Brasileira de Ciência do Solo**, Viçosa, 2016.

CRUZ, C.D. GENES - a software package for analysis in experimental statistics and quantitative genetics. **Acta Scientiarum**, v.35, n.3, p.271-276, 2013.

FAO. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS. **Perspectivas agrícolas 2015-2024.** 2015 Available in: <http://www.fao.org.br/download/PA20142015CB.pdf>. Access in: 10 nov. 2021.

FAO. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS. **Producción de arroz, cascara por región.** 2014. Available in: <http://www.fao.org/faostat/es/#data/QC/visualize>. Access in: 10 nov. 2021.

FAO. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS. **The second generation of hybrid rice in China.** 2002. Available in:< http://www.fao.org.docrep/006/y4751e0f.htm>. Access: 10 nov. 2021.

FERREIRA, C.M.; PINHEIRO, B.S.; SOUSA; I.S.F.; MORAIS, O.P. **Qualidade do arroz no Brasil:** evolução e padronização. Embrapa Arroz e Feijão. Santo Antônio de Goiás, v.18. 21ª edição. 2005.

FACCHINELLO, P.H.K.; CARVALHO, I.R.; STRECK, E.A.; AGUIAR, G.A.; OVEIA, J.; FEIJÓ, M.; PEREIRA, R.R.; OLIVEIRA, V.F.; FAGUNDES, P.R.R.; MAIA, L.C.; LAUTENCHLEGER, F.; MAGALHÃES JÚNIOR, A.M. Predicted genetic gains weighted by selection pressures for grain quality in irrigated rice. **Pesquisa Agropecuária Brasileira**, v.56, e02497, 2021.

INMET. INSTITUTO NACIONAL DE METEOROLOGIA. **Instituto Nacional de Meteorologia.** 2018. Available in: <http://www.inmet.com.br>. Access in: 05 dec. 2021.

INMET. INSTITUTO NACIONAL DE METEOROLOGIA. **Históricos de dados meteorológicos.** 2022. Available in: <https://bdmep.inmet.gov.br/>. Access in: 24 jan. 2022

IRGA. INSTITUTO RIO-GRANDENSE DO ARROZ. **As 10 cultivares de arroz mais plantadas no Rio Grande do Sul na safra 2016/17.** 2017. IRGA, Porto Alegre, 2017.

KÖPPEN, W. In: **Climatologia:** con un estúdio de los climas de la tierra. Fondo de cultura econômica, Mexico. Buenos Aires, 496p. 1948.

LIMA, G.G.; CASTRO PIAS, O.H.; MARTINS, A.P.; TIECHER, T.; CARMONA, F.C. Yield and profitability of flooded rice genotypes in relation to nitrogen doses and phosphorus and potassium application. **Pesquisa Agropecuária Tropical**, v.50, e64561, 2020.

LONDERO, G.P.; MARCHESAN, E.; PARISOTTO, E.; COELHO, L.L.; SOARES, C.F.; SILVA, A.L.; ARAMBURU, B.B. Qualidade industrial de grãos de arroz decorrente da supressão da irrigação e umidade de colheita. **IRRIGA**, v.20, n.3, p.587-601, 2015.

MAGHELLY, O.R.; OGLIARI, J.B.; SOUZA, R.; REICHERT JÚNIOR, F.W.R.; PINTO, T.T. Milling yield components of local dryland rice varieties. **Pesquisa Agropecuária Tropical**, v.50, e64561, 2020.

MAPA. MINISTÉRIO DA AGRICULTURA, PECUÁRIA E ABASTECIMENTO. Secretaria de Defesa Agropecuária. **Regras para análises de sementes.** Ministério da agricultura pecuária e abastecimento, Brasília, p.399. 2009. Available in: <https://www.gov.br/agricultura/pt-br/assuntos/insumos-agropecuarios/arquivos-publicacoes-insumos/2946_regras_analise__sementes.pdf>. Access : 24 jan. 2021.

MEUS, L.D.; SILVA, M.R.; RIBAS, G.G.; ZANON, A.J.; ROSSATO, I.G.; FOGLIATO, V.; PILECCO, I.B.; RIBEIRO, B.S.M.R.; SOUZA, P.M.; NASCIMENTO, M.F.; POERSCH, A.H.; DUARTE JUNIOR, A.J.; QUINTERO, C.E.; GARRIDO, G.C.; CARMONA, L.C.; STRECK, N.A. **Ecofisiologia do arroz visando altas produtividades.** 1a. ed. Santa Maria, 2021. v.1. 312p.

RIBAS, G.G.; STRECK, N.A.; ISABEL, L.; ZANON, A.J.; WALDOW, D.A.G.; DUARTE JUNIOR, A.J.; NASCIMENTO, M.F.; FONTANA, V. Acúmulo de matéria seca e produtividade em híbridos de arroz irrigado simulados com o modelo SimulArroz. **Pesquisa Agropecuária Brasileira**, v.51, n.12, p.1907-1917, 2016.

SOSBAI. SOCIEDADE SUL-BRASILEIRA DE ARROZ IRRIGADO. **Arroz irrigado:** recomendações técnicas da pesquisa para o sul do Brasil. Cachoeirinha: SOSBAI, 2018. 209p.

STRECK, E.A.; AGUIAR, G.A.; FACCHINELLO, P.H.K.; PERIN, L.; KRÜGER, T.K.; MAGALHÃES JÚNIOR, A.M. Correlations and path analysis for yield components in irrigated rice. **Comunicata Scientiae**, v.9, n.2, p.154-161, 2018.

STRECK, E.A.; MAGALHAES JUNIOR, A.M.; AGUIAR, G.A.; FACCHINELLO, P.K.H.; FAGUNDES, P.R.R.; FRANCO, D.F.; NARDINO, M.; OLIVEIRA, A.C. Genetic progress in 45 years of irrigated rice breeding in southern Brazil. **Crop Science**, v.58, n.3, p.1094-1105, 2018.

STRECK, E.V.; KÄMPF, N.; DALMOLIN, R.S.D.; KLAMT, E.; NASCIMENTO, P.C.; SCHNEIDER, P.; GIASSON, E.; PINTO, L.F.S. **Solos do Rio Grande do Sul.** Ed. Pallotti. 2008. 222p.

YOSHIDA, S. **Fundamentals of rice crop Science.** International Rice Research Institute: Manila, Philippines, 1981. 269p.

ZHU, Y. Fifty years of hybrid rice research in china. **Chinese Science Bulletin**, v.61, n.35. p.3740-3747, 2016.