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Natural genotypic variation for morphological traits in upland rice grains

Variação genotípica natural para características morfológicas em grãos de arroz de terras altas

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Abstract

The aim of this work was to evaluate the morphological traits of the grains of upland rice genotypes and indicate genotypes with grains with characteristics that are preferable by rice consumers. The experiment was carried out in randomized blocks, with 42 upland rice genotypes and 4 replications, totaling 168 experimental plots. After harvest time, the following parameters were determined with digital caliper in a sample of 20 paddy rice grains per plot: GW= grain width (greater side dimension), GT= grain trickness (smallest side dimension), GL= grain length (distance between extremities) and GLGW= length-to-width ratio. The data were first submitted to the F-test ($p<0.05$) and, subsequently, to the Scott-Knott multiple comparison test at $p<0.01$ and $p<0.05$. The genotypes OSVR15029, OSVR15031 and OSVR15032 presented values of length greater than 6.0 mm, thickness less than or equal to 1.90 and length-to-width ratio greater than 2.75, interesting characteristics for the long and fine grain consumer market.

Additional keywords: Food, *Oryza sativa L.*, Grain quality.

Resumo

O objetivo deste trabalho foi avaliar as características morfológicas dos grãos de genótipos de arroz de terras altas e indicar genótipos com grãos com características preferíveis pelos consumidores de arroz. O experimento foi realizado em blocos casualizados, com 42 genótipos de arroz de terras altas e 4 repetições totalizando 168 parcelas experimentais. Após a colheita foram determinados com paquímetro digital em uma amostra de 20 grãos de arroz em casca por parcela: GW = largura do grão (maior dimensão lateral), GT = espessura do grão (menor dimensão lateral), GL = comprimento do grão (distância entre extremidades) e GLGW = relação comprimento-largura. Os dados foram submetidos ao teste F (p <0,05) e ao teste de comparações múltiplas de Scott-Knott (p<0,05). Os genótipos OSVR15029, OSVR15031 e OSVR15032 apresentaram valores de comprimento maior que 6,0 mm, espessura menor ou igual a 1,90 e relação comprimento x largura maior que 2,75, características interessantes para o mercado consumidor de grãos longos e finos.

Palavras-chave adicionais: Alimento, *Oryza sativa L.,* Qualidade do grão.

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereals in the world, being a staple food in the human diet in a large part of the world population (Xu et al., 2017; Fao, 2020). Thus, plant scientists need to develop high-yield cultivars with desirable grain quality, in order to meet the population's demand for food.

Grain shape is characterized by a combination of grain length, grain width, grain length-to-width ratio, and grain thickness diverge according to the cultivar (Yang et al., 2019). These traits are important in yield, harvest and quality of grains (Feng et al., 2016; Xu et al., 2020; Ferrari et al., 2022).

The shape and size of rice grains is an important component of rice production, which determines the level of yield and quality, affecting the market value and acceptance by consumers (Yang et al., 2019; Wang et al., 2019; Jeong et al., 2020). An ideal rice cultivar must have high potential for grain yield, with grains in good shape, nutritional value, resistance to diseases and stress (Huang et al., 2013; Zhao et al., 2018).

In view of the above, the aim of this work was to evaluate the morphological traits of the grains of upland rice genotypes and indicate genotypes with grains with characteristics that are predictable by rice consumers.

Material and method

Seeds of 41 upland rice genotypes were collected between January and June 2015 directly from rural properties located in the municipalities of Registro, Barra do Turvo, Eldorado, Iporanga, Iguape, and Cananéia, located in the São Paulo State, Brazil. These seeds were then sent to the Campus of Registro of the São Paulo State University, located in Registro, São Paulo State, at the geographic coordinates 24°31′ S and 47°51′ W, with an altitude of 25 m, a slope between 0 and 12%, mean temperature of 27 °C, and mean annual precipitation of 1500 mm.

The experiment was carried out in randomized blocks, with 41 upland rice genotypes, as follows: OSVR15001, OSVR15003, OSVR15004, OSVR15005, OSVR15006, OSRV15008, OSRV15009, OSVR15010, OSVR15011, OSVR15016, OSVR15018, OSVR15019, OSVR15020, OSVR15021, OSVR15023, OSVR15024, OSVR15026, OSVR15027, OSVR15029, OSVR15030, OSVR15031, OSVR15032, OSVR15033, OSVR15034, OSVR15035, OSVR15036, OSVR15037, OSVR15038, OSVR15039, OSVR15040, OSVR15041, OSVR15042, OSVR15044, OSVR15045, OSVR15046, OSVR15047, OSVR15048, OSVR15049, OSVR15051, OSVR15052, and OSVR15053. The upland rice cultivar IAC 202 was used as a control group, as it is a material widely used in commercial areas in Brazil. The maturation cycle of the genotypes is shown in Table 1.

The experimental design consisted of 42 treatments and 4 replications, totaling 168 experimental plots. Each experimental plot consisted of six sowing rows 4 m long with an inter-row spacing of 0.35 m, totaling 12.6 m^2 of total area. The useful area was composed of the 3 m of the four central rows, totaling 4.2 m^2.

A composite soil sample was collected in July 2015 from the experimental area at a depth of 0–0.20 m and the following soil chemical attributes were obtained: pH (CaCl2) = 4.5 ± 0.5; Presina= 18 ± 0.3 mg dm-3; M.O.= 14 ± 0.6 g dm-3; K= 1.3 ± 0.2 mmolc dm-3; Ca= 23 ± 0.5 mmolc dm-3; Mg= 11 ± 0.3 mmolc dm-3; H+Al= 50 ± 0.7 mmolc dm-3; Al = 2 ± 0.1 mmolc dm-3; CTC= 85 ± 0.9 mmolc dm-3; V= 41 ± 0.5 %; S= 3 ± 0.1 mg dm-3; B=0.26 ± 0.04 mg dm-3; Cu= 0.2 ± 0.03 mg dm-3; Fe= 257 ± 2.4 mg dm-3; Mn= 0,7 ± 0.04 mg dm-3 e Zn= 1.6 ± 0.1 mg dm-3.Subsequently, 1.0 t ha^{-1} of dolomitic limestone with a total neutralizing power of 75% was applied to the soil to increase base saturation to 50%.

Soil tillage of the experimental area was carried out in November 2015 using a chisel plow and harrow at a working depth of 0.30 and 0.20 m, respectively. Manual sowing of the mentioned rice genotypes was carried out at a density of approximately 1.72 million plants per hectare in December 11, 2015, according to Ferrari et al. (2018). Seeds were treated with carbofuran and carboxin + thiram at a proportion of 15 and 3.0 mL, respectively, of the commercial product per kilogram of seeds.

Base fertilization was carried out at the sowing furrows, with the application of 500 kg ha^{-1} of the fertilizer 04–14–08 (N–P–K). Plant emergence was collected at 7 days after sowing. Top dressing fertilization was performed at 30 days after seedling emergence using 120 kg N ha^{-1} (Ferrari et al. 2021), with ammonium sulfate (21% N and 24% S) and urea (45% N) as the fertilizer sources at a proportion of 1:1 (v/v).

Weeds were controlled with the pre-emergence application of an herbicide with the active ingredient pendimethalin at a dose of 3.0 L ha^{-1} of the commercial product, in addition to manual weeding. A sprinkler irrigation system with a water depth of 12 mm $hour^{-1}$ was used whenever necessary, meeting the crop demand. Fungicide was applied three times: two with azoxystrobin at 0.4 L commercial product (c.p.) ha^{-1} and one with tebuconazole at 0.15 L ha^{-1} for control of *Pyricularia grisea* and *Bipolaris oryzea*.

After harvest time, the following parameters were determined with digital caliper in a sample of 20 paddy rice grains per plot: GW= grain width (greater side dimension), GT= grain trickness (smallest side dimension), GL= grain length (distance between extremities) and GLGW= length-to-width ratio.

The data were first submitted to the F-test ($p<0.05$) and, subsequently, to the Scott-Knott multiple comparison test at $p<0.01$ and $p<0.05$.

Results and discussion

The grain length ranged from 9.00 to 10.50 mm (Figure 1). According to Scott-Knott test, grain length of the upland rice genotypes was divided in group a and b. The lower grain length was classified as group b ranged from 9.00 to 9.56 mm and group a from 9.68 to 10.50 mm. Similar results were found by Xiongsiyee et al. (2018) (8.61 – 11.6 mm, n = 60), Rathi et al. (2010) (5.0 – 7.5 mm, n = 100), Laenoi et al. (2018) (6.62 – 7.50 mm, n = 3) and Misra et al. (2017) (4.1 – 7.56 mm, n = 591) (Table 2).

The grain thickness ranged from 1.89 to 2.32 mm (Figure 2). Group b ranged 1.89 to 2.06

mm and group a ranged 2.10 to 2.32 mm.

There was a considerable genotype variation of grain width in upland rice grains. According to Scott-Knott test, the grain width was divided in grupo a, b and c. Group c ranged from 2.52 to 2.84 mm, group b ranged from 2.92 to 3.02 mm and group a ranged from 3.04 to 3.58 mm (Figure 3). The grain width is trait of high genotypic variance. Similar results on genotypic variation for grain width in rice grains were found by Xionsiyee et al. (2018) (1.97 – 2.47 mm, n = 60) and Rathi et al. (2010 (2.5 – 3.5 mm, n = 100) (Table 2).

The grain lenght/grain width ratio of upland rice genotypes ranged from 2.51 to 3.75. The lower grain lenght/grain width ratio was classified as group b ranged from 2.51 to 3.22 and group a ranged from 3.27 to 3.75 (Figure 4).

Grain thickness, grain width and length/width ratio are positively correlated with grain weight, which is an important determinant of rice silage capacity and yield and can vary dramatically depending on the genotype of rice. (Huang et al., 2013; Yang et al., 2019; Jeong et al., 2020).

Grain size is a trait of the grain quality targeted by rice breeders, as long, and slender grains are the preference of consumers of this cereal in many countries (Sun et al., 2018). The preference for consumers in Japan, Korea and northern China is for round and short rice grains, while consumers in Brazil, South China, USA and Southeast Asian countries have been for long and thin rice grains (Suwannaporn and Linnemann, 2008). Thus, breeding rice plants which will give rise to new genotypes with the preferences required by consumers in each country is a good strategy to supply the population's demand for food.

Conclusion

The genotypes OSVR15029, OSVR15031 and OSVR15032 presented values of length greater than 6.0 mm, thickness less than or equal to 1.90 and length-to-width ratio greater than 2.75, interesting characteristics for the long and fine grain consumer market.

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