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Yield of Whole, Polished Whole Grains and Degree of Whiteness of Rice for Japanese Cuisine Obtained in Flood Irrigation System

M. M. A. Pereira[1*], O. J. Smiderle[2], A. C. C. Cordeiro[2], R. D. Medeiros[2] and L. T. Souza[3]

[1] Department of Agriculture, Federal University of Lavras, Brazil.
[2] Department of Agriculture, Federal University of Roraima/Embrapa Roraima, Brazil.
[3] Department of Agriculture, Federal University of Roraima, Brazil.

Authors' contributions

This work was carried out in collaboration among all authors. Author MMAP, OJS, ACCC, RDM and LTS. All authors were involved in all stages of planning, execution, statistical evaluation and final writing of the article. All authors read and approved the final manuscript.

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ABSTRACT

New rice cultivars with grains for Japanese cuisine have been launched in order to add value to irrigated rice production systems in the country. The objective was to evaluate the yield of polished and whole grains of cultivar BRS 358, at harvest and at six months of storage grown under a continuous irrigation system. The experiment was conducted in a lowland area, in Cantá-RR, with application of 150 kg ha^{-1} of N, 50% at the base and 50% at 45 days after emergence. Three harvest seasons were carried out: 38 days after flowering - DAF (A01), 45 DAF (A1) and 52 DAF (A2), to evaluate the yield of whole and polished whole grains, at harvest and at 6 months of storage. The results showed that application of N, promoted higher yield of whole grains, with 65% yield at harvest, and when stored for six months at room temperature, yield above 75%. For the polished whole grain yield, the best harvest range is 38-45 DAF, with whole grain yield above 50% and regardless of the harvesting and storage time of the grains the total whiteness is above 55%.

**Corresponding author: E-mail: agro.maysa@gmail.com;*

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1. INTRODUCTION

Conventional rice is an important source of calories and protein in the Brazilian diet, contributing to the improvement of nutrition and quality of life [1], in addition to great social and economic importance. However, special grain lines have been gaining ground in the market and in research, due to their use in several dishes and their greater commercial value.

Among rice varieties grown in the state of Roraima according to [2] the RR 9903 strain has greater productive potential, with characteristics suitable for use in Japanese cuisine and adaptation to the conditions of cultivation in floodplains, being registered for cultivation in 2014 as Cv. BRS 358 with recommendation for several regions of Brazil, presenting whole grain yield in processing above 60% [3,4].

In Roraima state the rice is one of the products of greatest importance in the agricultural sector, with estimated production of 27 700 tonnes of paddy rice in the 2018/2019 crop and acreage of 6000 ha [5] and third largest producer of irrigated rice according to [6].

However, according to [7] rice cultivation in floodplains in the state need the application of high doses of nitrogen fertilization, in order for the crop to develop properly, in terms of tillering, productivity and grain quality [8,9], as well as the high volume of water used in biomass production, demands to identify alternatives for its reduction, increasing the rational use of water [10,11].

Thus, in order to make the rice market viable, it is necessary to produce seeds with high physiological, physical, genetic and sanitary quality. In order to have physical and physiological quality of the rice seed, several factors must be considered, such as maturation stage, humidity and mechanical damages (impacts, abrasions and stresses) that can occur during harvesting, drying, processing and even during storage [12,13].

In view of these factors, the degree of maturation is decisive in the yield of whole grains, since grains harvested late may be dry in the field, prone to cracking and damage in beneficiation. According to [14] high percentages of cracked grains significantly decrease the type and commercial value of the rice. Observed that harvests carried out at 15 and 22 days after flowering (DAF) are inappropriate, reducing the physiological quality of the seed and the yield of whole [15].

However, the influence of the harvest time on the grain maturation is not an isolated factor, the time of application of nitrogen fertilization, as well as the management adopted influence the industrial quality and yield of whole grains. Other important aspects to consider, such as the whiteness and translucency of the grains [16] visual characteristics, which do not affect the quality of the grains, but influence the demand of both the rice industries and consumers.

In view of the reduced studies on the influence of management, N dose and harvest times on productivity, the objective was to evaluate the polished, whole grain and total whiteness of the grains of cultivar BRS 358 based on the best management and nitrogen fertilization, at harvest and at six months of storage grown under continuous irrigation.

2. MATERIALS AND METHODS

2.1 Field Experimentation

The experiment was carried out at Fazenda Santa Cecília, in a lowland area of Rio Branco, municipality of Cantá, state of Roraima-Brazil (2°48'27'484"N and 60°39'17'564" W), December from 2013 to April 2014, in soil of the type Gleissolo Háplico Tb Distrófico, with the following chemical and physical characteristics: pH = 5.1; MO = 30.92; P = 12.12 mg dm^{-3}; K = 0.21 cmolc dm^{-3}; Mg = 0.38 cmolc dm^{-3}; Al = 1.83 cmolc dm^{-3}, Ca = 1.25 cmolc dm^{-3}; silt = 468.6 g kg^{-1}; sand = 278.5 g kg^{-1}; clay = 252.9 g kg^{-1}.

The experimental design was randomized blocks in a 3x2 factorial scheme (harvest times x storage), making three harvest times (A0 - 38 days after complete flowering (DAF), A1 - 45 DAF and A2 - 52 DAF) and two forms of storage, zero time at harvest time and six months of storage.

The experimental plot comprises 8 lines of 5 m in length, spaced 0.25 m apart, with a useful area corresponding to the six central lines, discarding 0.50 m from the ends. The soil was prepared before the flood, followed by the construction of the slabs to establish the irrigation system by continuous flood. The harvest was carried out in the best dose and management of fertilization, applying 150 kg / ha¹ of nitrogen, with 50% in planting and 50% in coverage at 45 days after emergence (DAE).

The cultivar evaluated was irrigated rice BRS 358, which has a short and rounded grain type, with low amylose content, and which, after cooking, are sticky and, therefore, suitable for use in Japanese cuisine. It features modern plant architecture, cycle around 100 days and was registered in 2014 at the Ministry of Agriculture, Livestock and Supply (MAPA) by Embrapa Rice and Beans for cultivation in the states of Goiás, Roraima, Tocantins, Mato Grosso do Sul, São Paulo, Rio de Janeiro, Rio Grande do Sul and Santa Catarina.

2.2 Whole Grain Yield Analysis

In the complete maturation stage of the culture, three samples were taken from each experimental unit, respecting the respective treatments, to evaluate the yield of whole and polished whole grains.

After homogenization of the samples, the grains were dried at 40°C for 48 to 72 h, until they reached a humidity of 13%, determined according to Brazil (2009), and then placed in a warehouse, for three days, for the uniformity of the moisture inside the grains.

The yield of whole and polished whole grains were evaluated in two 100 g subsamples per experimental unit, in a "Suzuki" test machine, right after the uniformity of humidity. First the grains were peeled, to obtain the whole grains, where they were separated for 30 seconds in whole and broken, then the grains were polished for 1 minute and separated again for 30 seconds, obtaining the yield of polished and integral integers [17].

The remaining grains were kept in storage (UR 65 ± 5% and 20 ± 5ºC) in paper containers. At 6 months, new grain yield tests were carried out to determine physical quality.

2.3 Percentage of Total Whiteness

The intrinsic physical quality attributes of the grains were evaluated by a S21 rice grain statistical analyzer (iSuzuki Software - S21 Solutions) based on the analysis of digital images of each sample.

Each sample containing 100 g of peeled and polished rice passed through a digital image grabber. A video of the grains being moved inside it was recorded and the images were transmitted to an automatic data processing software.

The total whiteness parameter was calculated from the report of the S21 whiteness scale, which ranges from 0 to 200, where 200 is the maximum whiteness value. In sequence, the value of 200 was considered as 100% of total whiteness and evaluated the percentage of whiteness for each harvest season and storage time.

2.4 Statistical Analysis

To compare the results, homoscedasticity and normality tests were performed using the ASSISTAT software [18] then the results were subjected to individual variance analyzes, on the variables that showed significant effect by the F test, polynomial and linear regression analyzes were performed. , using the SISVAR statistical program [19].

3. RESULTS AND DISCUSSION

The yield of whole and polished whole grains changed in relation to the harvest times and storage period (Figs. 1 and 2). For whole grain production (Fig.1) the harvest period can vary from 105 - 112 days without affecting the whole yield, but with storage for six months, the harvest after 45 (DAF) reduce the percentage of whole grains by 15%

The reduction in the physical quality of the grains in the harvest carried out at 52 DAF, may be due to the grains being very dry after full maturation in the field, being subject to cracks, which favors the break after abrasion in the husking.

According to Teló, et al. [20] evaluating irrigated rice cultivars (BR-IRGA 409, IRGA 417, IRGA 422CL and IRGA 423) found a reduction in the yield of whole grains after reaching a certain degree of ripeness as a function of grain moisture. Several authors report that harvesting below 20% humidity contributes to the reduction of whole grain yield, as well as nitrogen fertilization can influence industrial yield [21,22, 23,24].

The non-polishing of Japanese rice is a factor of economic and social importance, since the outer layers present higher concentrations of proteins, lipids, fibers, minerals and proteins, which can assist in controlling blood glucose, lowering blood pressure and diseases chronic [25]. After removing the caryopsis in the burnishing process, polished rice is obtained, consisting mostly of starch and small amounts of proteins, lipids, fibers and ashes.

Although the benefits of whole grain production, for Japanese rice production the commercial demand is mostly for polished grains, so after the burnishing of the grains, there is a reduction of about 10 - 18% in the yield of whole grains regardless of the season of harvest, corroborating the results obtained by [26] and [27] with whole yields depending on the harvest and storage season, around 57%.

However, storage proved to be effective in maintaining the physical quality of the grains, maintaining the yield of whole grains above 65%, reaching the standards required by Brazilian legislation, which provides a base income of 40% of whole grains for sale [28], as well as allowing an increase in the harvest period in 15 days after full maturation.

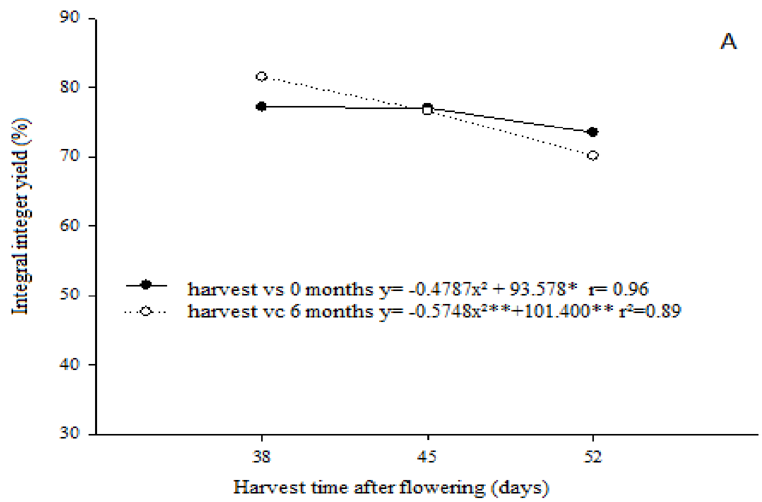

Fig. 1. Whole grain yield of Cv. BRS 358 according to harvest times after flowering (38, 45, 52 days) at harvest and with six months of storage at room temperature

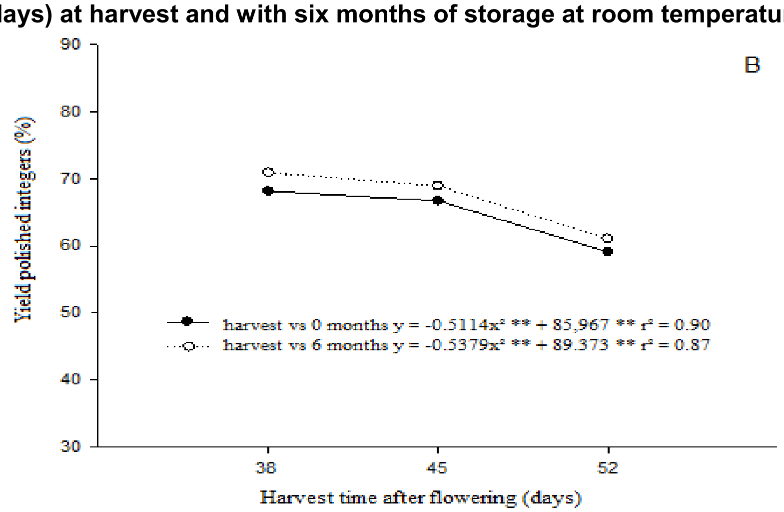

Fig. 2. Yield of polished whole grains from Cv. BRS 358 depending on harvest times after flowering (38, 45, 52 days) at harvest and with 6six months of storage at room temperature

For the polished whole grain yield, the best harvest range was 38-45 DAF, with whole grain yield above 50%, however when the grains were stored for six months, the whole grain yield at harvest at 52 DAF increased by 20%.

The yield of whole polished grains obtained for the cultivar BRS 358 corroborates the results obtained by [4], evaluating promising strains of special grains for Japanese cuisine in the state of Roraima that found whole grain yield ranging from 62 to 69 [29] also found a reduction in the yield of whole grains according to the harvesting seasons, varying from 29 - 50 DAF, as for [30] evaluating the cultivar BRS Talento, the harvest can be carried out between 20 and 30 DAF without interference in productivity and industrial quality.

The maintenance of the industrial quality of the grains depending on the storage period can be related to the aging of the grains since the starch granules submitted to storage become more resistant and stable to rupture, as well as the amylose content can influence more or less less break [31].

In this context, the cultivar BRS 358 presents competitive market potential, both in relation to other cultivars of special grains, as well as to cultivars with common grains, due to their added value, import and commercialization demand in the proportion of 2: 1 in relation to the common rice [2].

Thus, through the consulted literature, it can be inferred that the storage of grains in husks is beneficial for the yield of whole and polished whole grains to cultivate BRS 358, promoted stability in the moisture and maturation of the material, reflecting in percentage gains.

3.1 Percentage of Total Whiteness

For the degree of total whiteness of the cultivar BRS 358, there was no significant difference in relation to harvest times and / or storage time (Fig. 3). Regardless of harvest or aging storage of grains which, the percentage of overall brightness determined by the statistical analyzer Model grains S21 (S21 Solutions) The results were statistically similar, being above 55%.

The whiteness of the grains may vary according to the environment, cultivar and storage time [32, 33,21], observed an influence of the storage time on the whiteness of the grains, varying from 47.78 without storage to 41.86 when stored for 6 months, however for the cultivar BRS 358 there was no influence of the environment on the final product characteristic after beneficiation, as well as harvest time after flowering.

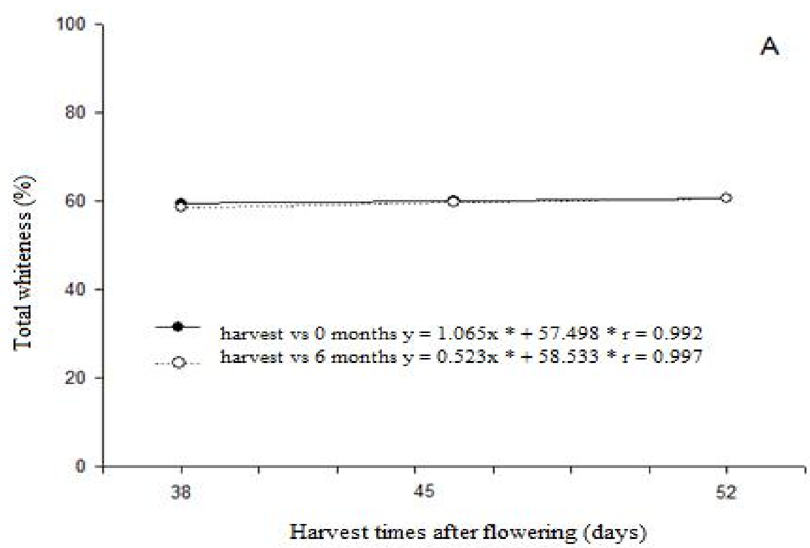

Fig. 3. Total grain whiteness of the BRS 358 cultivar determined by the S21 Solutions grain analyzer as a function of 3 harvest times after flowering (38, 45.52 days) at harvest and at 6 months of storage at environment temperature

According to Houston [34] the level of polishing is given in relation to the amount of bran removed from the grain, showing four degrees of polishing, between well polished and unpolished. However, there is no precise definition of these terms, thus, the degree of polishing (total whiteness) is determined by visual inspection or by means of optical devices according to a standard sample of the cultivar.

Studies carried out by Santos [35] found that the degree of whiteness of translucent and opaque grains was 41.13 and 49.57%, respectively. In this evaluation, the author used standardization of the degree of whiteness, according to the grain processing industry, which uses processing patterns ranging from 90 to 100 points as processing standards.

In view of the standardization used by Santos [35], it appears that for the cultivar BRS 358 the degree of polishing was higher than that found by the author, being above 55% regardless of the harvest time and storage time. According to Oliveira et al. [36], the degree of whiteness can various from 15 to 60% on average in rice grains. Studies by Rocha [37] and Paraginski, et al. [38], both with common and parboiled rice grains, observed a whiteness of 42.5 and 41.72, respectively.

Among the factors that influence the percentage of whiteness of the grains, nitrogen fertilization can change the amylose content of the grains, as well as the polishing of rice grains can increase the amylose content, with the increase of this content, greater whiteness is observed , since these factors are directly related to the degree of whiteness [21,39,40,41].

The whiteness of rice grains is important because it is related to the appearance of the grains, a determining factor in the marketing of rice that determines consumer preference [42], in addition to having technological, nutritional and culinary importance as it affects rancification lipid and structural changes [43,44] forming dark pigments such as melanoidins [45].

Based on the results (Fig. 3), the rice cultivar BRS 358 has a degree of whiteness adequate to the parameters inherent to the visual aspect and commercial impact on the preference of consumers of common and special rice grains.

The results corroborate with the studies carried out by [46] evaluating polishing times, where they observed that the degrees of whiteness varied from 19% to 34.1%, reaching values above 50% [47], obtained values approximately 19% higher for plastered grains, being 52.4% and 44.1% for translucent grains.

4. CONCLUSION

1. The harvest of the irrigated rice cultivar BRS 358, can be carried out between 38 and 45 days after flowering.
2. The storage for 6six months provided an improvement in the physical characteristics of the grains with higher whole grain yields regardless of the harvest season
3. The production of Japanese brown rice is an economic potential promoting higher whole yields in relation to the beneficiary
4. Whole grain yield, regardless of harvest and storage season, has a commercial standard above 60%
5. Total whiteness is not affected by the time of harvest and storage time remaining above 55%.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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