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PERFORMANCE OF UPLAND RICE CULTIVARS ON CERRADO SOIL

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ABSTRACT: The rice is a grain which belongs to the *Poaceae* family. It is produced in two ecosystems wich are the floodplain and the uplands. It is used as part of the daily diet of diferent populations. There is a growing demand for rice consumption around the world. That cereal has great socioeconomic importance. The State of Tocantins has a great productive potential. Therefore, the aim of the study was to evaluate the productive performance of upland rice cultivars in five years of evaluation in the cerrado of the southern state part of Tocantins. The experiments were conducted on the field at the Chaparral Farm and on the Experimental Station of the Federal University of Tocantins in the years of 2007/2008, 2008/2009, 2009/2010, 2010/2011 and 2011/2012. The experimental design was a randomized blocks with four replications in a 4 x 5 factorial scheme, consisting of four genotypes and five years. The evaluated characteristics were number of days to flowering, plant height, weight of hundred grains and grain yield. It was concluded that the 2007/08 crop year was where the cultivars presented the highest grain yields ranging from 2729 to 1716 kg ha^{-1}. The cultivars BRS-Bonança, BRS-Primavera and BRSMG-Conai reached the best averages of grain production on the five years of cultivation. Those cultivars can be indicated for use in the region. It is suggested that more studies have to be carry out on different planting periods for upland rice in Tocantins.

Key words: *Oryza sativa*. Uplands. Productivity. Stability.

COMPORTAMENTO DE CULTIVARES DE ARROZ DE TERRAS ALTAS EM SOLOS DO CERRADO

RESUMO: O arroz é uma gramínea pertencente à família *Poaceae* e o mesmo é cultivado em dois ecossistemas que são o de várzea e o de terras altas. É utilizado por populações que o mantém como parte integrante da alimentação diária. É crescente a demanda pelo consumo de arroz em todo mundo sendo um cereal que tem grande importância socioeconômica. O Estado do Tocantins possui grande potencial produtivo, sendo assim o objetivo do estudo o de avaliar o desempenho produtivo de cultivares de arroz de terras altas no cerrado do sul do Estado do Tocantins em cinco anos de avaliação. Os experimentos foram conduzidos em campo na Fazenda Chaparral e na Estação Experimental da Universidade Federal do Tocantins nos anos agrícolas 2007/2008, 2008/2009, 2009/2010, 2010/2011 e 2011/2012. O delineamento experimental foi de blocos casualizados com quatro repetições, num esquema fatorial 4 x 5, constituído por quatro genótipos e cinco anos. As características avaliadas foram número de dias para florescimento, altura da planta, massa de cem grãos e produtividade de grãos. Conclui-se que o ano agrícola 2007/08 foi onde os cultivares apresentaram as maiores produtividades de grãos variando de 2.729 a 1716 kg ha^{-1}. As cultivares BRS-Bonança, BRS-Primavera e BRSMG-Conai atingiram as melhores médias de produtividade de grãos nos cincos anos de cultivo, sendo indicadas para a utilização na região. Recomenda-se que mais estudos sobre diferentes épocas de plantio de arroz de Terras Altas no Tocantins sejam realizados.

Palavras-chave: *Oryza sativa*. Terras altas. Produtividade. Estabilidade.

INTRODUCTION

Rice cultivation is used worldwide since the dawn of populations, and is maintained as part of the daily diet, because provides energy, protein, vitamins and minerals. It is a grass that belongs to the *Poaceae* family, and it can be grown in two ecosystems. The lowland system which is irrigated by controlled flooding and the upland ecosystems, where cultivation can be conducted only with water originated from rain or supplemental irrigation (GUIMARÃES et al., 2006).

It is important to highlight that the upland cultivation system has the largest acreage nationwide. However, have low representation in national production due to low productivity. This can be explained by the rain´s irregularity, by the exposure to high temperatures and inadequate farming practices, resulting in several metabolic and physiological problems that reduce the production (TERRA et al., 2013; HEINEMANN, 2010).

At the national scenery, the production of upland rice has intensified in almost all regions of the country, in a wide variety of cropping systems ranging from large mechanized crops to small production areas for subsistence (SOUZA et al., 2007). In an attempt to increase productivity, researchers found that the use of selected cultivars is an easy technology for adoption by farmers and have the lowest cost of agricultural production (GUIMARÃES et al., 2008; CARGNIN et al., 2008; SOUZA et al., 2007).

Given the demand for global rice consumption, the challenge is to find cultivars with high yield potential and adapted to the region. The state of Tocantins has great productive potential and is strategically located among a major road junction and also is an export passageway to various regions of the country (PIRES et al., 2012). Several authors have verified the importance of finding genetic materials adapted to various environment conditions and exhibit stability over the years of cultivation (SOUZA et al., 2007; CARGNIN et al., 2008; MORAIS et al., 2008).

According to what have being exposed, the aim of this study was to evaluate the upland rice cultivars behavior in the cerrado of the southern region of the state of Tocantins.

MATERIAL AND METHODS

To assess the rice cultivars behavior five experiments were settled in the cropping years of 2007/2008, 2008/2009, 2009/2010, 2010/2011 and 2011/2012. Two of the experiments were held on an upland farming system on the farm Chaparral (seasons 2007/2008 and 2008/2009) in the municipality of Gurupi, located at 11° 40' south latitude and 49° 01' west longitude and altitude of 280m. The soil was a haplustox yellow dystrophic with a sandy loam textural class. The other three experiments were conducted at the Experimental Station of the Federal University of Tocantins, in the city of Gurupi. The 2009/2010 experiment was installed at the Experimental Farm located at 11°46`12`` S latitude and 49°02`45`` W, at 286m altitude and the 2010/2011 to 2011/12 experimenst were located at 11°43`45`` S latitude and 49°04`07`` W longitude, at 280m altitude, all on soils classified as haplustox yellow dystrophic (EMBRAPA, 2006). According to the Köppen classification system (1948), the climate of the region has a mesothermal type with summer rains and dry winters. Climatic data for the implementation period of the experiments are shown in Figure 1.

The areas where the experiments were settled in the Chaparral farm (crops of 2007/08 and 2008/09) and the first crop at the Experimental Farm (2009/10) had been used for several years with pastures and were in a degraded condition. The areas where the experiments were carried out in the period of 2010/11 and 2011/12 were historically submitted to a crop rotation system, being the rice used in the harvest and the beans crop in the off season crop cycle.

In all planting sites liming was implemented to correct soil acidity, however, in 2009, lime had no time to react due to delays on its application, having been made upon the planting time as can be observed in the soil chemical characteristics at that moment (Table 1). Prior to the experiments installation, soil samples were collected at each year at 0-20 cm deep to characterize the chemical and physical attributes, which are presented in Table 1.

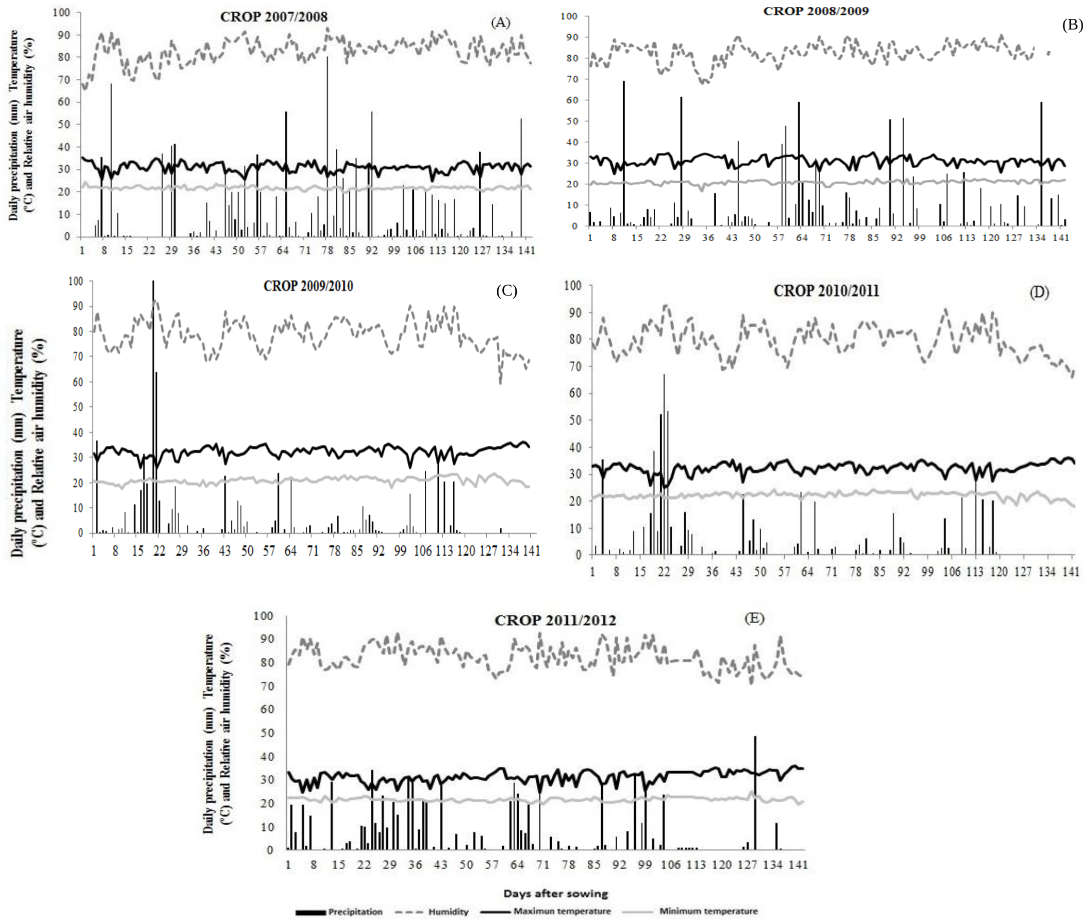

Figure 1. Precipitation (mm), humidity (%) and maximum and minimum temperatures (°C) occurred during the cultivation of upland rice cultivars in the seasons of 2007/2008, 2008/2009, 2009/2010, 2010/2011 and 2011/2012 (BDMEP, 2012).

The experimental design was a randomized block with four replications, in a 4 x 5 factorial scheme, consisting of four genotypes and five years of cultivation. In the cropping season 2007/2008 and 2008/2009, each experimental plot consisted of five rows with 5.0 m long spaced by 0.45 m and with 60 seeds per linear meter, following the recommendation for the region for upland rice cultivation. The useful area of the experiment were the three central lines, disregarding 0.5 meters from each end and the two lateral lines thus obtaining 5.4 m^2 of area. In others cropping seasons each experimental plot consisted of four rows with 5.0 m long, spaced by 0.45 m and with 60 seeds per linear meter. As the useful area, the two central rows with 4.0 meters in length were used, despising the two extreme lines and 0.5 m from each end thus totaling 3.6 m^2 of useful area.

For the study the BRS – Bonança. BRS - Sertaneja. BRS - Primavera and BRSMG - Conai cultivars were used.

Table 1. Chemical and physical soil attributes in a 0 – 20 cm depth in the experimental areas.

Soil attributes	Crops				
	07/08	08/09	09/10	10/11	11/12
Ca ($cmol_c\ dm^{-3}$)	0.90	3.20	4.80	1.72	1.08
Mg ($cmol_c\ dm^{-3}$)	0.40	1.70	0.10	1.41	0.60
Ca+Mg ($cmol_c\ dm^{-3}$)	1.30	4.90	4.90	3.13	1.68
K ($cmol_c\ dm^{-3}$)	0.06	0.40	0.44	0.37	0.06
SB ($cmol_c\ dm^{-3}$)	1.36	5.20	5.30	3.50	1.73
H+Al ($cmol_c\ dm^{-3}$)	2.90	3.30	3.60	2.65	0.95
pH ($CaCl_2$)	4.30	4.70	6.10	5.36	5.08
P-melich (mg dm^{-3})	2.40	5.30	3.40	1.70	4.35
T ($cmol_c\ dm^{-3}$)	4.26	8.60	8.90	6.14	2.67
V (%)	30.51	60.90	59.3	56.90	64.53
M.O (%)	0.20	2.20	2.50	1.20	1.45
Sand (g kg^{-1})	785.20	785.20	597.30	720.81	720.81
Silt (g kg^{-1})	38.30	38.30	47.70	90.53	90.53
Clay (g kg^{-1})	176.50	176.50	354.90	188.66	188.66

The main descriptions of rice cultivars evaluated in this study are:

- BRS - Bonanza: It presents a short cycle (112 to 118 days); Plant height: 90 to 100 cm; Flowering period: 85 days; Panicle length: 22.4; Weight of one thousand seeds: 25.9; Productive potential: 4,000 kg ha^{-1}; Lodging: moderately resistant; Brusone: Moderately susceptible; Natural degranation level: Intermediate; Grain grade: mixed.
- BRS - Primavera: Short cycle (112 days); Height of plant: 110.6 cm; Flowering period: 71.9 days; Panicle length: 25.7 cm; Weight of thousand seeds: 23.9 Productive potential: 3,649 kg ha^{-1}; Lodging: Resistant; Brusone: Moderately susceptible; Natural degranation level: Intermediate. Grain grade: long thin.
- BRS - Sertaneja: Has a short cycle (110 days); Height of plant: 107.4cm; Flowering: 76 days; Panicle length: 26.7 cm; Weight of thousand seeds: 26.7g Productive potential: 3,753 kg ha^{-1}; Lodging: Moderately susceptible; Brusone: Moderately susceptible; Natural degranation level: Intermediate. Grain grade: long thin
- BRSMG - Conai: Has a short cycle (108 days); Height of plant: 87 cm; Flowering period: 75.3 days; Weight of thousand seeds: 29 g Productive potential: 4,145 kg ha^{-1}; Lodging: Resistant; Brusone: Moderately susceptible; Level of natural degranation: difficult; Grain grade: long thin.

The tillage occurred in the conventional way at all years with a disk harrowing, leveling and grading. Sowing was done manually on December 13th, 2007. December 10th, 2008. December 12th, 2009, December 11th, 2010 and December 10th, 2011. The sowing fertilization was done in the sowing furrow at planting according to the soil analysis of each year and the recommendation used from the 5° Aproximação de Minas Gerais for the upland rice cultivation (RIBEIRO et al., 1999). In the harvests, P_2O_5 was applied in the form of single superphosphate (17%) and phosphorus (2007/08: 111 kg ha-^{1}, 2008/09: 109 kg ha^{-1}, 2009/10: 113 kg ha^{-1} and 2010/11: 117 kg ha^{-1}) thus discounting the P already present in the soil of each experiment. Thus, in the crops of 2007/08, 2008/09, 2009/10 and 2010/11, 120 kg.ha^{-1} of P_2O_5 as superphosphate (17% P_2O_5) were applied, discounting the P already present in the soil of each experiment. Potassium was applied at planting at a dosage of 60 kg.ha^{-1} of K_2O in the form of potassium chloride. The potassium was applied in planting at the dosage of 60 kg ha^{-1} of K_2O in the form of potassium chloride, following the recommendation of the 5° Aproximação de Minas Gerais to soils of medium texture (RIBEIRO et al., 1999). In the season 2011/12, 480 kg.ha^{-1} of NPK formulation (5-25-15) was applied, being applied 24 kg.ha^{-1} of N, 120 kg.ha^{-1} of P_2O_5, and 72 kg.ha^{-1} of K_2O. The top dressing fertilization of crops in 2007/ 08, 2008/09 and 2009/10 occurred with 90 kg.ha^{-1} of N as urea. In 2010/11 were applied 120 kg.ha^{-1} of N in the form of urea with boron and in the 2011/12 season 120 kg.ha^{-1} of N as urea were applied, discounting the nitrogen fertilization held in the furrow. In all crops coverage fertilization were carried out in two stages. The first made during the effective rice tillering about 30 days after planting and the second applied at panicle initiation, about 60 days after planting, was done by half the dose. The application of N was performed between the lines of planting and on the soil surface.

Crop pests and deseases controls were made in 2007/08 when necessary and weed control was accomplished by manual weeding always before fertilization. In 2008/09 there were cleaning procedures by manual weeding, also preceding the nitrogen applications. There was no need to use insecticides or fungicides during the experiment. In 2009/10, the crop managements controls occurred with the use of herbicides and insecticides when it was necessary. In the season of 2010/11 and 2011/12 cleanings occurred through use of manual weeding and herbicides, with products properly recommended for rice cultivation.

The cultural treatments in the 2007/08 harvest were carried out when necessary and weed control was carried out by manual weeding, always before fertilization. In 2008/09 there were procedures for cleaning by manual weeding, also preceding nitrogen applications, there was no need to use insecticides or fungicides during the conduction of the experiment. In 2009/10, the cultural treatments were carried out using herbicide when necessary, using the benzothiadiazinone chemical group (applied dose of 1.0 liters of the product per hectare) and the Oxadiazoles group (applied dose of 4.0 liters per hectare). per hectare). In the 2010 / 11e 2011/12 harvest, the cleanings occurred through the use of manual weeding and fungicide of the chemical group of strobilurin and triazole (applied dose of 0.5 liters per hectare), with products duly recommended for rice cultivation.

The evaluated characteristics were number of days to flowering - days to emission of 50 % of the panicles, from the date of sowing. Plant height - measured from the soil surface to the apex of the central stem panicle, excluding the awn, when present. Weight of a hundred grains - mass of a sample of one hundred healthy grains per plot. Grain yield - production of clean grain with 13 % moisture content in kg.ha^{-1}.

The experimental data were subjected to individual and joint variance analyzes, with the F test application. The joint analysis was performed under conditions of homogeneity of residual variances. For comparisons between treatments means the Tukey test at 5% probability was used using the computer application SISVAR (FERREIRA, 2008).

RESULTS AND DISCUSSION

It is evident that during the crop cycle there were differences in total rainfall precipitation and precipitation, with water deficit occurring at some important stages of the species development, resulting in low grain yield (Figure 1). There was a significant effect of the interaction between cultivar versus environment for all the evaluated traits (Table 2), indicating interdependence of factors, ie. the environment influenced differently in the expression of the studied cultivars, therefore, held the unfolding of a factor within the other. Similar results were found by Cargnin et al. (2008) evaluating cultivars of upland rice in different locations and years.

Table 2. Variance analysis summary of mean of days to flowering (DF), plant height (PH), weight of hundred grains (WHG) and grain yield (Yd), for four cultivars of rice crops grown in 2007/2008, 2008 / 2009, 2009/2010, 2010/2011 and 2011/2012, Gurupi-Tocantins.

Source of Variation	LF	Mean Squares			
		DF (days)	PH (cm)	WHG (g)	Yd (Kg ha^{-1})
Cultivar (C)	3	1525.61**	758.26**	0.93**	333801.36^{ns}
Year (Y)	4	112.34**	3865.15**	1.28**	8799181.55**
C X Y	12	63.41**	249.39**	0.07**	650525.50**
Repetition (Year)	15	12.25^{ns}	80.24^{ns}	0.03*	296894.40*
Residual	45	11.05	62.26	0.01	143276.85
CV (%)		4.19	9.16	5.34	35.73
General Mean		79.37	86.19	2.58	1059.45

^{ns} not significant; ** significant for $p \leq 0.01$; *Significant for $p \leq 0.05$ by the F test.

It is observed that there was a significant interaction effect for all characteristics evaluated, which is extremely important for studies when aiming to find genetic materials adapted to a region and a type of crop targeting their productive aspects (CANCELLIER et al., 2011). According to Melo et al. (2007), this environmental factor significance is important because it increases the need for studies like this.

The coefficients of variation were low (Table 2) showing good precision in conducting the experiments except for the grain yield characteristic (35.73 %). However, for Costa et al. (2002), this value is classified as medium in their studies, which suggest a coefficient variation classification according to the experimental design in upland rice crops. For Tonello et al. (2012) and Cancellier et al. (2011) this high coefficient is accepted for advanced studies in the field when the crop is subjected to some type of stress.

For the characteristic number of days to flowering (Table 3). can be noted for the crops of 2007/08 and 2008/09 that the cultivars BRSMG - Conai and BRS - Primavera were the early maturing cultivars, ranging between 70 and 76 days. In the other hand the BRS - Bonanza and BRS-Sertaneja cultivars were the late maturing cultivars ranging between 81 and 87 days. In the seasons of 2009/10, 2010/11 and 2011/12, again it is verified that the cultivar BRSMG - Conai was the early maturing cultivar as well as the BRS - Sertaneja the late maturing one, being expected this precocity of the Cultivar BRSMG-Conai, as can be observed in the main descriptions of the cultivars studied.

According to Fornasieri Filho (2006), the cultivar BRSMG - Conai is an early maturing cultivar, and has cycle differences compared to BRS – Primavera that range from 5 to 10 days, and the same time is classified as semi early maturing cultivar while the BRS-Bonança has a long flowering cycle, ranging around 88 days. Early maturing cycle genetic materials have been used for cultivation when seeking shorter exposure to adverse environmental factors, and when under favorable conditions allows producers to obtain two annually harvests compensating by capitalizing the ratoon crop. Guimarães et al. (2008) also found similar values for days to flowering for the above cultivars.

Table 3. Days to flowering means of four upland rice cultivars grown in the southern state of Tocantins, in the seasons of 2007/2008, 2008/2009, 2009/2010, 2010/2011 and 2011/2012.

	Days to flowering					
Cultivar	Crop 07/08	Crop 08/09	Crop 09/10	Crop 10/11	Crop 11/12	Mean
BRS-Bonança	81.00aAB	84.75aA	81.75bA	75.00bB	83.50bA	81.20
BRS-Sertaneja	85.00aC	87.00aBC	92.75aAB	95.00aA	91.00aABC	90.15
BRS-Primavera	74.50bB	75.75bB	86.50abA	75.00bB	73.00cB	76.95
BRSMG-Conai	70.00bAB	70.25bAB	74.75cA	66.00cB	65.00dB	69.20
Mean	77.62	79.43	83.93	77.75	78.12	

Means followed by the same lowercase letter in the columns and uppercase letters in the lines do not differ by Tukey test at 5% probability.

With regard to agricultural years of cultivation, all cultivars showed variation in the characteristic number of days to flowering, and the BRS - Primavera among them was the most stable, showing no significant differences between most crops, thus only in the season of 2009/10 had its cycle later. Rice cultivation is subjected to various abiotic stresses, which vary from year to year. During the five years of cultivation there is great variation in the occurrence, duration and intensity of rains (Figure 1), so that the cultivars responded to these changes with variations in their cycle. It is observed differences in rainfall during the five years of rice cultivation, with the highest rainfall volume in the years 2007/2008 and 2008/2009, with 1,153mm and 1,011mm, respectively. While in the years 2009/2010, 2010/2011 and 2011/2012 presented significant reduction with 787mm, 711mm and 796mm, respectively. When the plant undergo through stressful conditions, in this case, water deficit, cannot produce enough photoassimilates necessary to initiate flowering, thus, remains longer in the vegetative phase in response to stress, and has resulted in the postponement of the cycle (NUNES et al., 2012). Crusciol (2003) found in his studies that rice cultivation extends its cycle as it passes through water deficiency.

For plant height (Table 4), note that the BRS – Primavera cultivar was the only one to belong always to the statistical group of greater height plants, regardless of the year of cultivation, probably due to the genetic factor, which characterizes it as genotype with higher structure of plants. It is important to highlight that the plant heights are considered satisfactory for the region, since it allows mechanized harvesting. It is verified a change in the plant height of the studied cultivars. The cultivars BRS Primavera and BRSMG Conai presented alterations in plant height in all the years of cultivation. Only in 2007/2008 did plant height increase, whereas in the remaining cultivars there was a significant reduction. This can be explained by the amount of water in the harvest period, as well as the distribution of rainfall. Since rainfall throughout the crop cycle ranged from 1,155 to 711.4 mm in the five years of cultivation and the distribution of rain during the reproductive period (65 to 120 days after sowing) ranged from 577 to 179 mm.

Table 4. Plant height means of four upland rice cultivars grown in the southern state of Tocantins, in the seasons of 2007/2008, 2008/2009, 2009/2010, 2010/2011 and 2011/2012.

	Plant height (cm)					
Cultivar	Crop 07/08	Crop 08/09	Crop 09/10	Crop 10/11	Crop 11/12	Mean
BRS-Bonança	104.62bA	67.50bC	68.05bC	89.67 abAB	76.80 abBC	81.33
BRS-Sertaneja	123.97aA	80.75abB	75.95 abB	72.20cB	69.72bB	84.52
BRS-Primavera	110.52abA	84.50aC	87.85aBC	101.77aAB	91.35aBC	95.20
BRSMG-Conai	112.65abA	69.25bB	76.45abB	82.45bcB	77.75abB	83.71
Mean	112.94	75.5	77.07	86.52	78.9	

Means followed by the same lowercase letter in columns and uppercase letters in lines do not differ by Tukey test at 5% probability.

It is observed that in the 2007/08 crop cultivars achieved the greatest heights of plants. ranging from 123.97 to 104.62 cm. From 2007/08 to 2008/09, crops cultivars showed large decreases in their stature, in about 38%, 36%, 35% and 24% for BRSMG – Conai, BRS – Bonança, BRS – Sertaneja and BRS – Primavera, respectively. For other crops, cultivars BRSMG – Conai and BRS – Sertaneja demonstrated feature stability, while BRS-Bonanza and BRS-Primavera were unstable. The characteristic height of plants is an agronomic variable, that is to say, quantitative, controlled by several genes that have low heritability, and thus greatly influenced by the environmental conditions by which the materials are subjected during cultivation. According to Terra et al. (2013), those climatic variations reflects many times as negative effects for the crop development, with production decreases in the biomass production, and that result come from the lesser photosynthetic activity which can be originated from hydric stress, as an example, resulting in lesser statures.

In the crop of 2007/08, the greatest heights of plants were obtained, just as the best rainfalls occurred (Figure 1). The total rainfall during the rice season in the 2007/2008, 2008/2009, 2009/2010, 2010/2011 and 2011/2012 crops was 1155mm, 1011mm, 787mm, 711mm and 796mm, respectively. According Taiz e Zeiger (2009), several anatomical, structural, physiological, biochemical and morphological changes occur when the plant is subjected to any kind of stress, and being the water stress which mainly affects cell growth, and which possibly explains the reduction in the height of plants in the subsequent years, which precipitations were smaller and had poor distribution.

In regards to the mass of a hundred grains (Table 5), can be observed that BRSMG – Conai always integrated the statistical group of higher averages independently of the cropping season, which is desirable, because the mass of one hundred grains correlates with grains productivity. The BRS – Sertaneja cultivar also showed high mass, not being part of the group only in the 2010/11 season. Those results confirm a made description of each cultivar regarding seed weight, where the BRSMG Conai and BRS Sertaneja cultivars exhibited higher seed weight, being a genetic characteristic of the cultivar itself.

Table 5. Mass of a hundred grains means of four upland rice cultivars grown in the southern state of Tocantins, in the seasons of 2007/2008, 2008/2009, 2009/2010, 2010/2011 and 2011/2012.

	Mass of a hundred grains (g)					
Cultivar	Crop 07/08	Crop 08/09	Crop 09/10	Crop 10/11	Crop 11/12	Mean
BRS-Bonança	2.72bA	2.28bB	2.34bcB	2.64bA	2.29aB	2.45
BRS-Sertaneja	3.07aA	2.52abB	2.46abBC	2.52bB	2.19aC	2.55
BRS-Primavera	2.72bA	2.26bB	2.17cB	2.71bA	2.19aB	2.41
BRSMG-Conai	3.30aA	2.68aBC	2.72aB	3.30aA	2.44aC	2.89
Mean	2.95	2.43	2.42	2.79	2.28	

Means followed by the same lowercase letter in columns and uppercase letters in the lines do not differ by Tukey test at 5% probability.

Analyzing the cropping seasons, there is a lack of stability among cultivars for mass of a hundred grains (Table 5), due to the strong influence of the environment. The low precipitations associated with a poor distribution during the rice cycle visibly affected the agronomic characteristics, decreasing their masses. The water factor is responsible for leaf expansion, which is directly related to the amount of photosynthesis performed by the plant. In general, the amount of photosynthesis is proportional to leaf area, so with less photosynthesis there will be less assimilates produced, reduction in its distribution in the plant and hence smaller grain filling (TAIZ e ZEIGER, 2009).

It is noticeable that the cropping years of 2007/08 and 2010/11 were better, as well as 2008/09, 2009/10 and 2011/12 were bad. A possible explanation is due to the fact that the mass of one hundred grains is a feature dependent of carbohydrates translocation which will fill the shell. In that process the water is of fundamental importance as it participates in the various and main activities of plant metabolism, since photo assimilates translocation in xylem and phloem transport, and in the process of photosynthesis are reduced or even inhibited when there is water deficiency (TAIZ e ZEIGER, 2009).

The values of the mass of a hundred grains found in this study ranged from 3.30 g for BRSMG - Conai on the seasons of 2007/ 08 and 2010/ 11 to 2.17 for BRS - Primavera in the season of 2009/10. Silva et al. (2009) found a mass of 2.39 grams for the cultivar BRSMG - Conai. Nunes et al. (2012) in an experiment with hydric deficit found little variation between the mass of a hundred of the evaluated materials, where the means ranged from 2.3 to 2.8 g in water stress conditions and without water stress respectively. The authors claim that genotypes vary widely both between and within the same genotype, depending on the crop conditions to which are subjected. According to Arf. et al. (2001) the mass of one hundred grains characteristic although considered a variable rather stable, it undergoes variations under different soil preparation systems and the availability of water in its development.

Table 6. Grain yield means of four upland rice cultivars grown in the southern state of Tocantins. in the seasons of 2007/2008. 2008/2009. 2009/2010. 2010/2011 and 2011/2012.

	Grain yield ($kg.ha^{-1}$)					
Cultivar	Crop 07/08	Crop 08/09	Crop 09/10	Crop 10/11	Crop 11/12	Mean
BRS-Bonança	2729.34aA	502.58aC	167.38aC	1711.63aB	499.96aC	1122.18
BRS-Sertaneja	1951.03bA	903.09aB	137.63aC	732.36bBC	607.18aBC	866.26
BRS-Primavera	1716.81bA	906.11aB	465.40aB	2066.59aA	406.83aB	1112.35
BRSMG-Conai	1875.22bA	943.01aB	831.06aBC	1855.78aA	179.93aC	1137.00
Mean	2068.1	813.7	400.37	1591.59	423.48	

Means followed by the same lowercase letter in columns and uppercase letters in the lines do not differ by Tukey test at 5% probability.

For grain yield (Table 6), can be perceived that the cultivars BRS-Bonança, BRS-Primavera and BRSMG-Conai cultivars presented the best means of the five years of cultivation, therefore, they are considered the most productive.

Among the crops of the different seasons, the period of 2007/08 was the most productive, followed by the 2010/11 season. The 2009/10 season followed by the 2011/12 season were the ones that had the lowest grain yield. However, those grain yields means are close to each other, and most are below the mean of the State, which was estimated at only 2009 $kg.ha^{-1}$ in in the cropping season of 2012/2013 (CONAB, 2013). A possible explanation for this fact is probably due to the distribution and quantity of precipitation during the period in which each crop was grown (Figure 1). It is noted that in the 2007/08 season, in addition to increased precipitations, the rain was also better distributed over the cultivation period, resulting in higher grain yields. Hydric deficit reduces the productive capacity of cultivars, with the period of flowering and grain filling, the most critical stage of the rice crops, because at this stage the lack of water can cause spikelet sterility, smaller panicles and smaller malformed and chalky grains. According to Heinemann (2010). losses due to drought stress on grain yield of rice cultivars can exceed the 50% mark. causing great harm to rice producers.

Large decreases in yield from the first to the second year of cultivation can be observed. reaching up to 80% reduction for the BRS – Bonança cultivar. That decrease remained almost at the same rate or even intensified, from the second to the third year of cultivation, for all cultivars. The 2010/11 season got good yields, but in the next cultivation turned to get drops in productivity of cultivars. Despite variations in the physical and chemical soil characteristics (Table 1) which may justify the low grain yields, as well as the fluctuations of each year, the water component has to be the main limiting rice production factor in these five crops. That factor had a major change in availability (Figure 1), modifying the characteristics of the cultivars, as this exerts a variety of physiological and metabolic functions in plants and in any ecosystem.

CONCLUSION

The cultivars showed the highest grain yield at the agricultural year of 2007/ 08 ranguing from 2729 to 1716 kg ha^{-1}.

The cultivars BRS-Bonança, BRS-Primavera and BRSMG-Conai achieved the best grain productivity averages on the five cultivation years, being indicated for use on the region.

It is recommended that more studies on diferent planting seasons should be implemented for the upland rice, thus allowing the production of higher yields in the region, as well as verifying the quality of the rice produced in Tocantins.

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