

BRS Catiana: irrigated rice cultivar with high yield potential and wide adaptation

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Abstract: *BRS Catiana* is an irrigated rice cultivar with a medium cycle and excellent grain quality, suited for cultivation in 17 Brazilian states. It has a high yield potential (15,535 kg ha⁻¹) and a mean yield of 7,253 kg ha⁻¹, wide adaptation and late senescence (stay green trait).

Keywords: *Oryza sativa*, breeding, stay green, grain yield, wide adaptation.

INTRODUCTION

Rice is a staple food in the diet of most Brazilians. Domestic production is close to balance with domestic consumption. However, since the Mercosur agreement, which facilitated trade among the members, Brazil has been importing rice from Argentina, Uruguay and Paraguay. This has frequently led to a production surplus, which is being exported mainly to African countries (Wander 2015).

Of the 27 Brazilian states, Rio Grande do Sul is the largest rice producer (70.3%), followed by Santa Catarina (9.6%), Tocantins (5.3%), Mato Grosso (3.9%), and Maranhão (2.8%). In 2018, these states together accounted for almost 90% of the domestic rice production (CONAB 2018).

Over the past years, rice production in Brazil has increased from 9.5 million tons in 1991 to 12 million tons in 2018, i.e., an increase of around 30%. In the same period, the rice area decreased from 4.1 million hectares in 1991 to 1.9 million hectares in 2018 (CONAB 2018). Irrigated rice is the most important cropping system, planted on around 70% of the total cultivated area and accounting for almost 90.0% of the total production (CONAB 2018). The increase in irrigated rice production was due to a greater investment in technology and the use of more productive cultivars.

The annual gains in grain yield resulting from rice breeding at Embrapa were of the order of 1.44%, from 2002 to 2009, for upland rice (Bresseghele et al. 2013) and of 0.73%, from 1972 to 2016, for irrigated rice (Streck et al. 2018). This shows the efficiency of the program in developing higher-yielding cultivars.

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The choice of a cultivar is one of the decisive factors for the success of a rice plantation, influencing all management practices (Bresseghele et al. 1998) and the profitability of the investment. Characteristics such as duration of the life cycle, plant height, efficiency of nutrient uptake and utilization, resistance to biotic stresses, tolerance to lodging and environmental stresses are related to crop yield, whereas the grain quality traits define the market value. Hence the interest of the farmers in new cultivars with characteristics that optimize the success of rice production by reducing the cost per unit of harvested grains and/or by raising the market value with a better commercial acceptance of the grain.

The objective of this study was to describe the breeding method used to develop cultivar BRS Catiana and its specific morphological and agronomic traits. BRS Catiana is registered under No. 32292 by the National Register of Cultivars (RNC) of the Ministry of Agriculture, Livestock and Supply (MAPA), for cultivation as irrigated rice in the states of: Roraima, Pará, Tocantins, Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, Bahia, Goiás, Mato Grosso do Sul, São Paulo, Rio de Janeiro and Rio Grande do Sul.

BREEDING METHOD

Cultivar BRS Catiana was derived from a single cross between the cultivars IRGA 417 and BRS Jaburu, in 2000, at Embrapa Rice and Beans, in Santo Antônio de Goiás (GO), targeting higher lodging resistance, blast resistance, grain quality and yield potential. The breeding methodology was similar to that used in the development of cultivar BRS Pampeira (Magalhães Junior et al. 2017).

In August 2000, the F_1 seeds were propagated on the experimental field of the Fazenda Palmital, in Goianira (GO). In the first semester of 2001, the F_2 generation was also grown on the Fazenda Palmital, in an experiment known as Plant Selection Nursery 1 (VS1). In this assay, F_2 plants were transplanted into plots with twelve 5-m rows, spaced 30 cm apart. The plants were visually selected for qualitative, high-heritability traits (plant architecture, stay-green, shorter height, thick and hard stalks, long and heavy panicles, fine long grain class and straw-colored seed hull). Each selected plant generated one family in the following generation ($F_{2;3}$), constituting the EOFT (tropical family observation trial).

The EOFT was sown in the 2001/2002 growing season, in Goianira-GO, in plots of four 5-m rows, spaced 17 cm apart, without replications, and for every 19 plots, one check cultivar (Metica 1) was sown. Visual selection was repeated for the traits evaluated in VS1 as well as disease resistance. The entire plots of the selected families were harvested to provide enough seed for the subsequent tests and grains for the quality evaluations for head rice yield, chalkiness, grain size (length and width), and gelatinization temperature.

In 2002/2003, the selected progenies ($F_{2;4}$) were evaluated in the Yield Trial of Tropical Irrigated Rice Families (ERFT) in Goianira (GO), Formoso do Araguaia (TO) and Boa Vista (RR). In these trials, aside from grain yield, plant cycle and height, resistance to the main diseases (leaf and panicle blast, leaf scald, brown spot and grain spot), lodging tolerance and several characteristics related to grain quality were evaluated.

The families selected in the ERFT were transplanted in the 2003/2004 growing season, constituting the experiment of Plant Selection Nursery 2 (VS2). The design and selection applied in this test were similar to that of VS1 and the selected plants ($F_{5;6}$) were planted in the EOLT (tropical line observation trial), in Goianira-GO, in 2004/2005, and managed as in EOFT.

The best-performing lines of the EOLT were used in the EPT (preliminary trial of irrigated rice yield of the tropics), sown in the 2005/2006 growing season, in Goianira (GO), in two environments, and in Formoso do Araguaia (TO). The mean grain yield of the EPT was 9,275 kg ha⁻¹, exceeding that of the check Metica 1 by 7.6%, until then one of the highest-yielding irrigated rice cultivars for tropical regions. In addition, the grains had a similar amylose content and gelatinization temperature as cultivar IRGA 417, one of the reference cultivars in the ongoing selection process. This test consisted of 260 lines and 4 controls (Metica 1, BRS Formoso, BR IRGA 409 and Cica 8), and the experiment was arranged in Federer's augmented block design. The selected lines were evaluated in the ERT (regional irrigated rice yield trial of the tropics) in five environments, where BRA051077 was classified as the most productive line (mean yield 7,970 kg ha⁻¹). In the growing seasons from 2007/08 to 20012/13, BRA051077 participated in VCU (Value for Cultivation and Use) Trials in all Brazilian regions producing irrigated rice, except for Santa Catarina and Paraná. The combined analysis of these tests showed that BRA051077 produced 7.12 % higher yields than BRS Jaçanã in the tropical region, and was

more lodging and disease resistant. In Rio Grande do Sul, BRA051077 exceeded the yields of BRS 7 Taim and BR IRGA 409 by 10.87% and 12.59%, respectively. In the 2012/13 growing season, BRA051077 was evaluated on experimental fields in Miranda (MS), Lagoa da Confusão (TO) and Cantá (RR) and in 2011/12 in Roseira (SP). At all locations, BRA051077 performed better than the checks, especially with regard to disease resistance, lodging resistance and grain yield, and was chosen by the evaluators for an eventual use as commercial cultivar. The grain quality was also validated in evaluations with the milling industries, confirming the good industrial and culinary characteristics observed in the evaluations at the Laboratory of Grains and By-Products of Embrapa Rice and Beans.

In addition, BRA051077 was tested specifically for disease resistance and iron toxicity tolerance, in DUS (distinctness, uniformity, and stability) trials, and in the program of seed purification and genetic seed production. Some of the characteristics found by the DUS trials are listed in Table 1.

Finally, due to all the advantageous traits of line BRA051077 and in view of its promising opportunities detected by a market analysis, it was released under the commercial name BRS Catiana.

PERFORMANCE CHARACTERISTICS

BRS Catiana was evaluated in 81 VCU trials, 70 of them in the tropical (North, Northeast, Center-West and Southeast) and 11 in the subtropical region (Rio Grande do Sul). In these tests, BRS Catiana was compared (Tables 1 and 2) with check cultivars whose performances are widely acknowledged in each region. The grain yield, plant height and number of days until mean flowering were evaluated in all tests, while the head rice yield was only assessed at some sites where the necessary infrastructure was available. Observations of lodging resistance and disease severity were recorded in the environments where the environmental conditions favored their occurrence.

In the tropical region, the grain yield and cycle of BRS Catiana were similar to those of BRS Tropical, although the plants were slightly shorter and less prone to lodging. BRS Catiana produced significantly higher yields than BRS Jaçanã, perhaps for being about a week later. In Rio Grande do Sul (RS), the mean yield of BRS Catiana exceeded that of BR IRGA 409 by 7.15%, although the Tukey test did not reject the hypothesis of zero contrast ($p > 0.05\%$). In the mean, the cycle of the new cultivar lasted approximately 15 days longer in RS than in the tropical region, but in the South, it is only four days later than BR IRGA 409, with similar plant height and level of lodging resistance (Table 1).

BRS Catiana produces fine long class grains, as preferred by the Brazilian market. In the mean, the milled grains are 6.8 mm long (L) and 2.0 mm wide (W), have a L/W ratio of 3.4 and translucent appearance, i.e., with a low incidence of chalkiness. Another important industrial characteristic is the high head rice yield, 62.3% in the mean of all evaluations (Table 1), with high stability. In a specific study of whole grain stability, the results were highest when the grains were harvested at a moisture content of 19.6%, but even at a moisture of around 15%, as was the case in the 4th harvest, the head rice yield was still high.

Another outstanding feature of BRS Catiana is the good cooking quality, compared to the best cultivars indicated by the industry. In the indirect tests of culinary quality, the grain amylose content was high (TA = 27.6%), according to Martínez et al. (1989) and the gelatinization temperature low (TG = 7.0), as is expected for an irrigated rice cultivar of the indica group, with a loose and soft grain consistence pattern after cooking.

Table 1. Grain yield (GY), head rice yield (HRY), number of days until mean flowering (FLO), mean plant height (PH) and lodging resistance (LR) of BRS Catiana and check cultivars in VCU trials in tropical (2007/2008 to 2012/13) and subtropical (2012/13 and 2013/14) regions

Region	Cultivar	GY ² (kg ha ⁻¹)	HRY (%)	FLO (days)	PH (cm)	LR ¹ (1-9)
Tropical	BRS Catiana	7253 a	60.91	89	103	1.6
	BRS Tropical	7113 ab	57.28	87	108	1.8
	BRS Jaçanã	6771 b	63.85	82	105	1.7
Subtropical (RS)	BRS Catiana	9050 a	-	104	94	2.0
	BR IRGA 409	8446 a	-	100	93	2.1

¹ Scores 1 to 9, where 1 indicates plots with no lodging and 9 completely lodged plots.

² Means of each region followed by the same letter did not differ significantly by the Tukey test at 5% probability.

Table 2. Mean severity¹ of leaf blast (LB), panicle blast (PB), brown spot (BS), leaf scald (LS) and grain spot (MG) observed in BRS Catiana and check cultivars of VCU, in tropical (2007/2008 to 2012/13) and subtropical (2012/13 and 2013/14) regions

Regions	Cultivar	LB ¹	PB ¹	BS ¹	LS ¹	MG ¹
Tropical	BRS Catiana	1.4	2.2	2.5	1.8	1.6
	BRS Tropical	1.6	2.3	2.7	1.9	1.6
	BRS Jaçanã	1.5	2.7	3.9	2.1	2.4
Subtropical (RS)	BRS Catiana	-	-	2.1	1.1	2.8
	BR IRGA 409	-	-	1.6	1.3	2.3

¹ Scores 1 to 9, where 1 indicates plots with no symptoms and 9 plots with disease symptoms on > 50% of the leaf area.

Rice blast, a disease caused by *Magnaporthe oryzae*, is one of the main factors affecting the yield of rice cultivars, and the resistance of a cultivar is the main component of integrated disease management. During the vegetative phase, leaf blast causes a reduction in plant height, number of tillers, number of grains per panicle and grain weight, and indirect effects on yield, resulting from reductions in photosynthesis and respiration rates. The direct effects on the panicles caused by rice blast include reductions in yield, grain weight, percentage of grains formed, number of grains per panicle and harvest index.

The specific resistance of BRS Catiana to blast was evaluated in long-term assessments of seven years, from 2008/09 to 2014/15 in the VBN (National Blast Nursery) tests carried out at nine locations in Brazil (Table 2). The cultivar was moderately resistant in the first years and susceptible in the last years of evaluation at some locations. In general, it performed better than the checks BRS Jaçanã and BRS Tropical. In other studies, e.g., focused on the temporal stability of resistance, in which rice was sown on six sequential dates at the same location, in 15-day intervals in the 2010/11 and 2011/12 growing seasons, BRS Catiana proved more resistant than the checks. The maximum leaf blast severity corresponded to score 4 (on a 1-9 scale) and the percentage of attacked panicles did not exceed 12% in the two study years. When cultivar BRS Catiana and the checks were inoculated with 100 *Magnaporthe oryzae* isolates that were highly aggressive to the cultivars from which they were collected, only 8% of these isolates were virulent to cultivar BRS Catiana, compared to 27% to check BRS Tropical. These results indicate moderate blast resistance of cultivar BRS Catiana, which, together with the preventive measures of integrated disease control, can ensure a good phytosanitary quality of the crops.

In RS, rice blast was not detected in any test, only low incidences of brown spot, leaf scald and grain spot, with no significant differences among the evaluated lines (Table 2).

Cultivar BRS Catiana has the stay-green trait, a remarkable characteristic, which delays leaf and stem senescence in relation to that of the grains. In the case of rice, even when the grains are ready for harvest, the plants remain green, increasing lodging resistance and allowing harvest delays, which makes this characteristic highly relevant in the tropical region of Brazil where rice is grown in the rainy season and delayed harvests are common.

SEED PRODUCTION

BRS Catiana was registered on May 30, 2014, under number 32292, by the Ministry of Livestock and Supply (MAPA). The Escritório de Negócios tecnológicos de Goiânia (GO) of Embrapa Products and Market was responsible for the production of basic seed of the cultivar.

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