

## IRGA 431 CL, new rice variety for red rice management in Southern Brazil

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Crop Breeding and Applied Biotechnology  
18: 455-459, 2018  
Brazilian Society of Plant Breeding.  
Printed in Brazil  
<http://dx.doi.org/10.1590/1984-70332018v18n4c68>

**Abstract:** *IRGA 431 CL is an early rice variety, and its main characteristic is the resistance to Imidazolinones herbicides. The variety stands out for its excellent plant architecture, strong stems, high yield potential, good grain quality, and resistance to blast and high levels of toxic iron in the soil. It is recommended for exploitation in the rice fields of Rio Grande do Sul, Brazil.*

**Keywords:** *Breeding, flooded rice, herbicide-tolerant, imidazolinones.*

### INTRODUCTION

The irrigated rice acreage is of high expression in the state of Rio Grande do Sul (RS), Brazil, where more than one million hectares are cultivated annually (IRGA 2018), distributed in the southern region of the State.

In the past years, a notable progress occurred in red rice management with the delivery of new technologies used in different cropping systems in southern Brazil. The adoption of advanced management practices and high yielding varieties have revolutionized the rice production in the state of Rio Grande do Sul. However, some limitations must be overcome for the of rice varieties to achieve the yield potential. These field limitations are caused mostly by red rice or weed rice, which has currently damaged this crop in the state of RS. Breeding has contributed significantly by developing new varieties with characteristics that confer good adaptation to different environments and rice cropping systems.

Regarding the management of red rice, the breeding program of Instituto Riograndense do Arroz (IRGA) has pioneered the development of herbicide-resistant rice varieties in the state of RS as a genetic tool for red rice control. In recent years other breeding programs have also developed rice varieties herbicide-resistant, according to the work carried out by Rangel et al. 2018.

This milestone was achieved with the IRGA 422CL variety, released in 2002 (Lopes et al. 2003). This variety carries the technology developed by the Louisiana State University Agricultural Center (LSUAC), which means the first mutation in the ALS gene and confers resistance to the herbicide (Croughan et al. 1996). The IRGA 422CL variety has had a substantial impact on rice production in the state of RS by increasing the yield and improving grain quality of harvested rice, considering the reduction of red grains in the milled rice. Moreover, farmers recovered some crop lands that had become unprofitable due to the high incidence of red rice.

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**Received:** 07 June 2018  
**Accepted:** 11 September 2018

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The breeding activities at IRGA were successfully accomplished in the last decade with the delivery of IRGA 428 and IRGA 424 RI, both resistant varieties in the years of 2011 and 2013, respectively (Lopes et al. 2011). Within this same technology, IRGA, in partnership with Metropolitana Incorporações e Locações de Bens LTDA, also delivered two high yielding hybrid rice varieties (QM 1010 CL - intermediate cycle and Prime CL - early cycle).

In this context, the new variety IRGA 431 CL, developed by the IRGA's breeding program, is recommended for exploitation, especially in red rice-contaminated crop lands of the state of RS and in the southern region of Brazil. The main characteristic of this new variety is its resistance to Imidazolinones herbicides. Also, it stands out for the high yield potential, superior grain quality, and resistance to blast and toxic iron in the soil.

## APPLIED BREEDING METHODS

IRGA 431 CL derives from the inbred line IRGA 176 CL-6-9-4-1-5. This inbred line was developed by pedigree selection in a segregating population derived from the cross IRGA 2913-18-4-I-3Pg \* 1 / IRGA 420CL, performed at the Rice Experiment Station (RES), IRGA, Cachoeirinha, RS, Brazil. The initial cross-breeding between IRGA 2913-18-4-I-3Pg and IRGA 420CL lines was carried out in the 2006/2007 crop season, and the first backcross was conducted in the 2007/2008 season. The IRGA 420CL line carries the resistance gene to Imidazolinones herbicides. This resistance was transferred by backcrossing the herbicide-resistant line PCW16. The PCW16 breeding line was introduced to Brazil by IRGA; it came from the United States in 2000 for research purposes and has a mutation in the gene encoding the ALS enzyme (Ser653Asp or S653D).

The  $RC_1F_1$  generation was cultivated in the seedling transplant system, and the generations  $RC_1F_2$ ,  $RC_1F_3$ ,  $RC_1F_4$ ,  $RC_1F_5$ , and  $RC_1F_6$  (Observation Plots) were grown in rows in a conventional soil preparation system. In each generation, individual plants were selected according to the pedigree method, considering the following characteristics: plant reproductive cycle; size and shape of panicles and grains; leaf and tiller's angle; shattering resistance; biotic and abiotic diseases and stresses; grain milling and cooking quality; among others. In all generations, herbicide resistance selection was performed by spraying plants at the vegetative stage (V3/V4) with the herbicides Onlyâ (1.0 L ha<sup>-1</sup>) or Kifixâ (150 g ha<sup>-1</sup>) and the Dash adjuvant (at a dose of 500 mL/100 L).

The Advanced Yield Trial (AYT) was carried out in the 2014/2015 crop season, in six locations all over the state of Rio Grande do Sul (Cachoeirinha, Cachoeira do Sul, Bagé, Uruguaiana, Camaquã, and Palmares do Sul). The Value of Cultivation and Use trials (VCU) were performed in the 2015/2016 and 2016/2017 crop seasons, in the same AYT locations plus Santa Vitória do Palmar, which is located at the extreme southern region of RS. In the 2016/2017 crop season, observation plots with larger areas (50 m<sup>2</sup>) were developed in the same locations as the VCU trials to evaluate the field performance of the improved lines.

Diseases and iron toxicity evaluations were carried out in some special nurseries for these purposes in the municipalities of Torres (RS) and Camaquã (RS), respectively, from the 2011/2012 to the 2016/2017 crop seasons. Milling and cooking quality were evaluated at the IRGA's Grain Quality Laboratory, located at the Rice Experiment Station, in Cachoeirinha (RS). Additionally, some Milling Companies from the state of RS have evaluated the grain quality in their own laboratories.

## PERFORMANCE CHARACTERISTICS

IRGA 431 CL is an early cycle variety; it carries the mutated gene (S653D) that confers resistance to Imidazolinone herbicides. This mutation event belongs to the second generation since the herbicide resistance degree is higher than that of IRGA 422 CL. This variety has excellent plant architecture, high tillering capacity, and strong

**Table 1.** Morphological and agronomic characteristics of IRGA 431 CL variety

Plant Characteristics	Description
Leaf color	Green
Leaf pubescence	Medium
Flag leaf angle	Upright
Stem length	Short
Tiller angle	Upright
Panicle size	Medium
Panicle type	Intermediate
Shattering	Intermediate
Awns	Absent
Glumella pubescence	Hairy
Glumella color	Straw color
Apex color at maturity	Yellow
Cycle to maturity	120 days
Thousand paddy grain weight	25 g

stem, which confer lodging resistance in dry soil seeding systems. IRGA 431 CL is resistant to soil iron toxicity (soluble iron in flooded rice - Fe<sup>2+</sup>) and leaf and panicle blast disease (*Pyricularia oryzae*); moderately resistant to grain spotting (*Bipolaris sp.* and *Phoma sp.*) and sheath blight (*Rhizoctonia solani*); moderately susceptible to brown spot (*Bipolaris oryzae*); and moderately resistant to leaf scald (*Microdochium oryzae*) (see notes in Table 1). Some morphological and agronomic characteristics of this new variety are presented in Box 1. Figure 1 shows a photograph of a genetic seed production plot in the Rice Experiment Station.

The mean paddy yield in VCU trials was 10.627 kg ha<sup>-1</sup>, surpassing the best check variety (Table 2). Table 3 shows that this new variety has a long slender grain and low levels of chalkiness (0.3). Milled grains are almost completely translucent, with an excellent visual appearance (Figure 2). The total milled grain was 70%, and head rice yield



**Figure 1.** Genetic seed production plot of the IRGA 431 CL variety at the Rice Experiment Station, Cachoeirinha, RS, Brazil, in the 2017/2018 crop season.

**Table 2.** Rice field disorders and severity evaluated during three crop seasons (2014-2017) in the “Hot Spot Nurseries”, located in Camaqua (iron toxicity) and Torres (diseases), RS, Brazil, for the IRGA 431 CL variety

Disease	Scientific name	Note <sup>1</sup>	Severity	Class
Iron toxicity	---	1	Only old leaves	Resistant
Blast leaf	<i>Pyricularia oryzae</i>	1	0-3	Resistant
Blast panicle	<i>Pyricularia oryzae</i>	1	0-1	Resistant
Grain spotting	<i>Bipolaris sp.</i> and <i>Phoma sp.</i>	3	de 1 a 5 %	Moderately Resistant
Sheath blight	<i>Rhizoctonia solani</i>	3	de 11 a 25 %	Moderately Resistant
Brown spot	<i>Bipolaris oryzae</i>	7	de 26 a 50 %	Moderately Susceptible
Leaf scald	<i>Microdochium oryzae</i>	3	de 11 a 25 %	Moderately Resistant

<sup>1</sup> Notes according to Standard Evaluation System for Rice (IRRI 1996).

**Table 3.** Mean grain yield (kg ha<sup>-1</sup>) in VCU yield trials (Cachoeirinha, Cachoeira do Sul, Bagé, Uruguaiiana, Santa Vitória do Palmar, Camaquã, and Palmares do Sul) in the 2015/2016 and 2016/2017 crop seasons

Varieties	Crop seasons		Means
	2015/2016	2016/2017	
IRGA 431 CL	10.942	10.401	10.671
IRGA 424 RI	9.680	11.103	10.391
IRGA 428	9.765	9.642	9.703
Puitá INTA CL	7.731	7.811	7.771

was 65%, in an average from VCU trials. According to a field study carried out in the 2016/2017 crop season, the total panicle dry mass at the maturation stage was 2.61 g (Figure 3). In the same study, grain harvesting should begin at 30 days after full flowering when moisture is between 24 and 20% w. b. At this time, the head rice yield is 65%, depending on the environment. Grains must be harvested in a maximum period of three weeks since this variety is not so tolerant to late harvest.

The cooking evaluation was carried out at the IRGA's Quality Laboratory and showed that the grains have 29% of amylose content and low gelatinization temperature. These indirect cooking characteristics indicate that the grains have cooked entirely and remain loose and soft, even after cooling. These results corroborated with the sensorial evaluations performed at IRGA, which showed that cooking quality meets the consumption patterns of Brazilian consumers. The texture, aroma, and flavor of cooked grains are similar to and compatible with those of all commercial varieties cultivated in Brazil. IRGA 431 CL is adapted to flooded rice systems and is recommended to all rice regions of the extreme southern state of Rio Grande do Sul, according to the Agroclimatic Zoning Risk, Agriculture Department of Brazilian Federal Government.

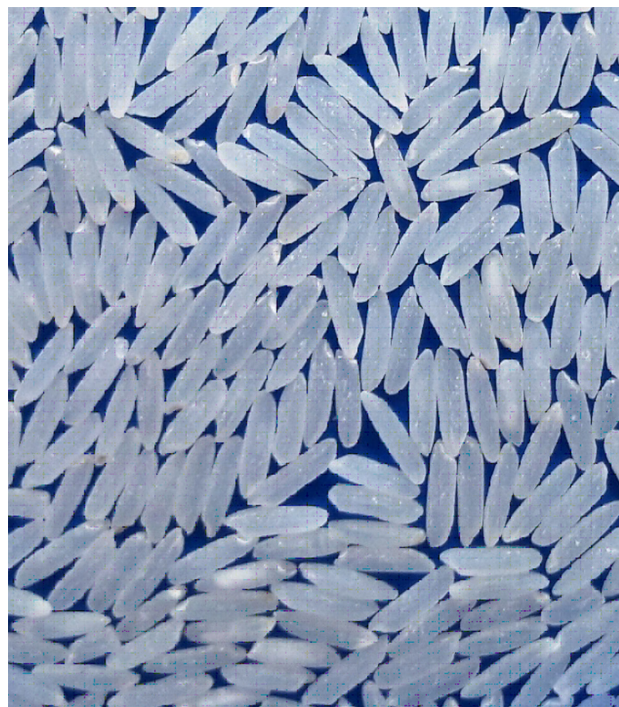


Figure 2. Visual appearance of milled grains (white polished) of the IRGA 431 CL variety harvested in the 2016/2017 crop season in Cachoeirinha, RS, Brazil.

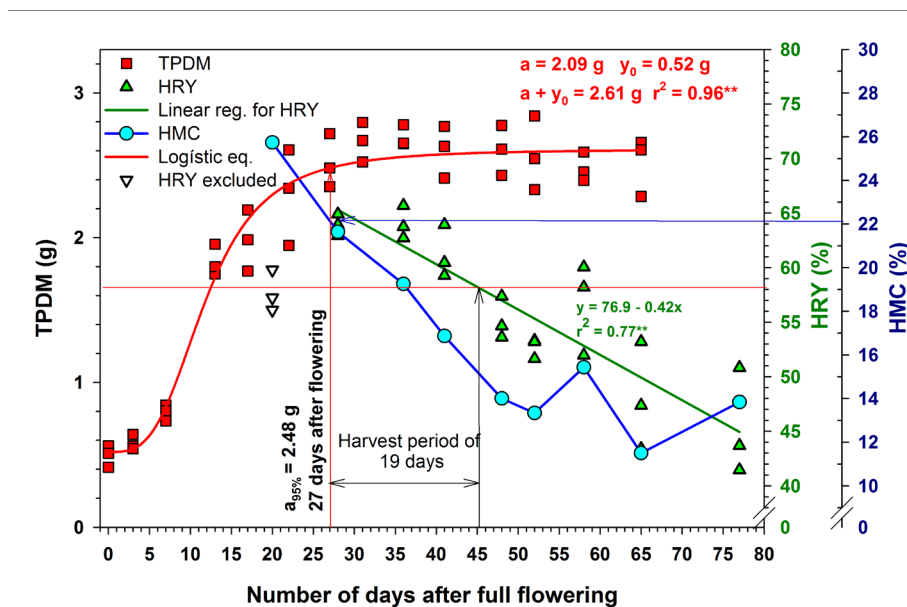


Figure 3. Total panicle dry mass accumulation curve (TPDM) adjusted by a logistic equation, head rice yield (HRY) adjusted by linear regression analysis, and harvest moisture content (HMC) in function of the number of days after full flowering, for the IRGA 431 CL variety.

**Table 4.** Grain dimensions of the IRGA 431 CL rice variety

Type	Dimensions <sup>1</sup> (mm)			C/L ratio
	Length (C)	Width (L)	Thickness	
Shelled	9.57	2.16	1.81	4.43
Peeled	7.43	1.95	1.63	3.81
Milled (Polished)	6.72	1.89	1.61	3.55

<sup>1</sup> According to official patterns to be classified as long and slender milled grain, the dimensions must be: length  $\geq$  6 mm; thickness  $\leq$  1.89 mm; and C/L ratio  $\geq$  2.75 mm (MAPA 2018)

## FOUNDATION SEED PRODUCTION

IRGA 431 CL is registered by the Ministério da Agricultura, Pecuária e Abastecimento (Ministry of Agriculture, Livestock and Supply) under the number 37568. Genetic seeds were produced in the 2017/18 crop season at the Rice Experiment Station, in Cachoeirinha. Foundation and certified seeds will be produced in the next seasons, in partnership with rice farmers, who must be licensed in advance by IRGA.

## ACKNOWLEDGMENTS

To the research staff on phytopathology, biotechnology, post-harvest, and seeds technology, for collaborative studies and activities; to the Regional Research Stations staff, for taking care of yield trials all over the state of RS; to Embrapa Rice and Beans, International Center for Tropical Agriculture (CIAT), and Miller PIRAHY Alimentos Ltda., for the sensorial analyses of the cooked grains.

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