

## BRS A501 CL: herbicide-tolerant upland rice cultivar

Paulo Hideo Nakano Rangel<sup>1\*</sup>, Adriano Pereira Castro<sup>1</sup>,  
Mabio Crisley Lacerda<sup>1</sup>, Isabela Volpi Furtini<sup>1</sup>, Daniel de Brito  
Fragoso<sup>1</sup>, Bernardo Mendes dos Santos<sup>1</sup>, Aluana Gonçalves  
de Abreu<sup>1</sup>, Antônio Carlos Centeno Cordeiro<sup>2</sup>, José Almeida  
Pereira<sup>3</sup>, Daniel Pettersen Custódio<sup>4</sup>, Marley Marico Utumi<sup>5</sup>  
and Inocência Junior de Oliveira<sup>6</sup>

Crop Breeding and Applied Biotechnology  
20(2): e29972024, 2020  
Brazilian Society of Plant Breeding.  
Printed in Brazil  
<http://dx.doi.org/10.1590/1984-70332020v20n1c20>

**Abstract:** *BRS A501 CL is the first upland rice cultivar with tolerance to the broad-spectrum herbicide Kifix<sup>®</sup>. It has a medium-length cycle, high stability of whole grain yield at processing, good disease tolerance and a high grain yield.*

**Key words:** *Oryza sativa L., grain yield, breeding, herbicide Kifix*

### INTRODUCTION

In Brazil, upland rice production is distributed mainly in the states Mato Grosso, Maranhão, Pará, Piauí and Rondônia (CONAB 2017). The country is one of few in the world where upland rice is essential for domestic supply with the cereal. This cultivation system acts as a price regulator, favoring a better distribution of rice production in the country by bringing producing and consuming regions closer together. In addition, it is an alternative income for growers, as in the state of Maranhão, where it is mostly produced on small farms.

In this cropping system, weeds are one of the main obstacles to sustainable cultivation. In no-tillage systems, the initial vigor of upland rice cultivars is low, resulting in low competitiveness with weeds and, consequently, possible crop failures.


The results of the herbicides used efficiently in irrigated (anaerobic) systems are usually unsatisfactory in the aerobic system, where phytotoxicity and reinfestation of the fields are common. This problem can be circumvented by planting rice cultivars that are tolerant to broad-spectrum herbicides.

Cultivar BRS A501 CL was developed by Embrapa. It is the first upland rice cultivar with tolerance to the broad-spectrum herbicide Kifix<sup>®</sup>, apart from having a medium cycle length and high stability of whole milled grain at processing.

The purpose of this study was to describe the agronomic and morphological characteristics of cultivar BRS A501 CL.

**\*Corresponding author:**

E-mail: paulo.hideo@embrapa.br

 ORCID: 0000-0002-5741-3426

**Received:** 25 June 2019

**Accepted:** 16 December 2019

**Published:** 24 March 2020

<sup>1</sup> Embrapa Arroz e Feijão, 75.375-000, Santo Antônio de Goiás, GO, Brazil

<sup>2</sup> Embrapa Roraima, 69.301-970, Boa Vista, RR, Brazil

<sup>3</sup> Embrapa Meio Norte, 64.008-780, Teresina, PI, Brazil

<sup>4</sup> Embrapa Pesca e Aquicultura, 77.008-900, Palmas, TO, Brazil

<sup>5</sup> Embrapa Rondônia, 76815-800, Porto Velho, RO, Brazil

<sup>6</sup> Embrapa Amazônia Ocidental, 69.010, Manaus, AM, Brazil

## BREEDING METHOD

Cultivar BRS A501 CL was developed to combine the good agronomic traits of the elite line BRA01545 with tolerance to the broad-spectrum herbicide Kifix® of the chemical group of imidazolinones. The cultivar was developed by Embrapa Arroz e Feijão, in Santo Antônio de Goiás, GO.

BRS A501 CL was developed by the backcross breeding method, selecting individual herbicide-tolerant plants in each generation, as proposed by Rangel et al. (2018a) and Rangel et al. (2018b). The elite line BRA01545 was used as recurrent parent and cultivar Cypress CL as gene donor of the tolerance gene. Three backcrosses with selection of individual plants in each generation were performed. In the segregating generations, Kifix® was applied to select the tolerant plants. After the progeny tests in the RC<sub>3</sub>F<sub>3</sub> generation, line AB112092CL was evaluated in preliminary yield trials in three growing seasons (2008/2009, 2009/2010 and 2010/2011) to analyze the agronomic performance in various environments. In the growing seasons 2011/2012 and 2012/2013, this line was evaluated with the checks BRS Esmeralda and AN Cambará in VCU (Value for Cultivation and Use) trials in the North, Northeast and Central-West regions. Aside from being Kifix®-tolerant, cv. BRS A501 CL also stood out with a medium-length cycle, a period of 77 days to flowering after emergence, partial resistance to diseases, high stability of whole milled grain and a mean grain yield of around of 4,000 kg ha<sup>-1</sup>, producing up to 8,200 kg ha<sup>-1</sup>.

In addition, cv. BRS A501 CL was evaluated in specific tests for distinctness, homogeneity and stability (DHS). Some of the results of cv. BRS A501 CL in the DHS tests are shown in Table 1.

## PERFORMANCE CHARACTERISTICS

BRS A501 CL was evaluated in 48 VCU tests. Table 2 shows the main agronomic traits of the cultivar, in comparison with BRS Esmeralda and AN Cambará. The traits grain yield (4.017 kg ha<sup>-1</sup>), days to flowering (77 days) and plant height (107 cm) were similar to the checks. With respect to lodging (score 2.4), the cultivar was more susceptible than the checks.

In the field, a low disease incidence (scores ≤ 3) of leaf and panicle blast, leaf scald, brown spot and grain blight was observed on the new cultivar, classifying it as tolerant (Table 3). However, in specific rice blast tests, scores were higher (5.0 for cv. BRS A501 CL; 8.0 for cv. AN Cambará and 6.0 for cv. BRS Esmeralda). These results indicate the need to apply fungicides as a complementary disease control strategy, avoiding restrictions of the yield potential of the cultivar. Preventive fungicide spraying is recommended: once in the vegetative stage, according to the symptoms on the plants (open lesions), up to 45 days after sowing; twice in the reproductive phase, firstly at the end of the booting stage, before panicle emission, and secondly 10 - 15 days

**Table 1.** Main descriptors of cultivar BRS A501 CL, determined in Santo Antônio de Goiás, GO, growing seasons 2011/2012 and 2012/2013

Descriptor	Phenotypic expression
Leaf color	green
Angle of the flag leaf	upright
Pubescence of leaf blade	absent
Leaf: auricle color	light green
Leaf: ligule color	colorless to green
Stem length	long (96 cm)
Panicle length	short (18 cm)
Presence of awns	short
Spikelets: stigma color	light crimson
Spikelets: glume color	straw/golden
Spikelets: apicule color (maturity)	black
Milled grain (length)	long (8 mm)
1000-grain weight	27.1 - 28.5 g

**Table 2.** Means for grain yield (YLD), number of days to flowering (FLO), plant height (PH) and lodging incidence (LI) of cultivar BRS A501 CL and the check cultivars (BRS Esmeralda and AN Cambará), in VCU trials

Cultivars	YLD <sup>1</sup> (kg ha <sup>-1</sup> )	FLO (days)	PH (cm)	LI <sup>2</sup> (1-9)
BRS A501 CL	4017 a	77 a	107 a	2.4
AN Cambará	3965 a	76 a	105 a	1.6
BRS Esmeralda	3979 a	76 a	106 a	1.7
Mean	4013	75	105	
CV%	16.94	4.49	6.12	

<sup>1</sup> Data of 48 trials conducted in the growing seasons of 2011/2012 and 2012/2013. Means followed by the same letter are not significantly different by Tukey's Test at 5% probability; <sup>2</sup> Scores from 1 to 9, where 1- no lodging and 9 - fully lodged plants (Pinheiro et al. 2009).

**Table 3.** Mean scores of rice leaf blast (LB), neck blast (NB), leaf scald (LS), brown spot (BS), grain spot (GS) in field evaluations and of leaf blast in specific rice blast tests (LBS) with cv. BRS A501 CL and the checks (BRS Esmeralda and AN Cambará), in VCU trials

Cultivars	LB <sup>1</sup> (1-9)	NB <sup>1</sup> (1-9)	LS <sup>1</sup> (1-9)	BS <sup>1</sup> (1-9)	GS <sup>1</sup> (1-9)	LBS <sup>1</sup> (1-9)
BRS A501 CL	2.2	2.7	3.3	3.1	2.3	5.0
AN Cambará	2.1	3.2	2.9	2.9	2.2	8.0
BRS Esmeralda	1.8	2.3	2.5	2.7	1.9	6.0

<sup>1</sup> Scores 1 to 9, where 1 represents plots without symptoms and 9 plots with disease symptoms on more than 50% of the leaf area or panicles (Pinheiro et al. 2009).

**Table 4.** Results of the whole milled grain (WG), broken grains (BG), total milled grain (TG) and chalky grains (ChG) after processing; grain length (L), width (W), L/W ratio, amylose content (AC) and gelatinization temperature (GT) of the cultivars BRS A501 CL and control cultivars (BRS Esmeralda and AN Cambará) in VCU trials

Cultivars	WG (%)	BG (%)	TG (%)	ChG (%)	L (mm)	W (mm)	L/W	AC <sup>1</sup>	GT <sup>2</sup>
BRS A501 CL	67	6	73	1.50	6.50	1.90	3.40	18.2	3.5
AN Cambará	61	10	71	1.30	6.20	1.80	3.40	17.5	3.6
BRS Esmeralda	55	15	70	1.90	6.50	1.80	3.50	17.7	3.4

<sup>1</sup> Values indicate a low amylose content; <sup>2</sup> Values indicate a high to intermediate gelatinization temperature.

later, depending on the fungicide applied. The spraying prevents the outbreak of epidemics in crops and contributes to prolong the blast resistance of cultivars (Filippi et al. 2015).

The industrial and culinary grain quality are key characteristics that should be taken into consideration for the release of a new rice cultivar. BRS A501 CL has a high yield of whole milled grain (67%) and total milled grain (73%), which are fundamental aspects in the marketing of the harvested product (Table 4). The processed grains are long and slender, as preferred on the Brazilian market, have a mean length (L) of 6.50 mm, mean width (W) of 1.90 mm, a L/W ratio of 3.40, a translucent appearance and a low incidence of chalky grains (1.50%). The amylose content is intermediate (18.2%) and the gelatinization temperature high (3.5 °C).

An extremely important characteristic for the farmer is the yield stability of whole milled grain, which is influenced by the harvest time. The yield of whole milled grain of cv. BRS A501 CL was over 60% in the five harvest times of this study, which were separated from each other by a seven-day interval, between 25 and 53 days after flowering. The cultivar can therefore be harvested at different grain moisture contents, without substantially affecting the yield of whole milled grain, widening the harvest window.

The main characteristic of this cultivar is the tolerance to the herbicide Kifix®, of the chemical group imidazolinones (525 g kg<sup>-1</sup> imazapyr + 175 g kg<sup>-1</sup> imazapique). This broad-spectrum herbicide controls nearly all weeds of upland rice. Thus, with this ease of control, it is expected that cv. BRS A501 CL will be grown in areas known to be infested with weeds tolerant to other herbicides, making the cultivar an important tool for upland rice management in the agrosystem.


## SEED PRODUCTION

BRS A501 CL was registered by the National Register of Cultivars (RNC) of the Ministry of Agriculture, Livestock and Food Supply under No. 34462, for cultivation in 12 states (Acre, Amapá, Amazonas, Maranhão, Piauí, Goiás, Mato Grosso, Mato Grosso do Sul, Pará, Rondônia, Roraima and Tocantins, as well as the Distrito Federal). Embrapa Arroz e Feijão, in partnership with BASF, are together responsible for the production of basic seed of the cultivar.

The dates 2011/12 and 2012/13 refer to the crops in which the Cultivation and Use Value Tests (VCU) were carried out. Due to bureaucratic obstacles, such as contractual signature and others, the cultivar was only registered in 2015 and was launched in the 2017/2018 harvest. The adoption of the cultivar by the producers only occurred from the 2018/2019 harvest.

## REFERENCES

- CONAB (2017) *Séries históricas de produção. Safras 1996/1997 a 2016/2017*. Available at <<http://www.conab.gov.br>>. Accessed on January 15, 2017.
- Filippi MCC, Lobo VLB, Nunes CDM and Ogoshi C (2015) *Brusone no arroz*. Embrapa, Brasília, 26p.
- Pineiro PV, Lopes Junior S, Oliveira JP, Guimarães CM, Stone LF, Madari BE, Filippi MCC, Pereira HS, Eifert EC, Silva JFA, Wendland A, Lobo Junior M and Ferreira EPB (2009) *Variáveis experimentais da Embrapa Arroz e Feijão*. Embrapa Arroz e Feijão, Santo Antônio de Goiás, 80p.
- Rangel PHN, Ferreira ME, Fragoso DB, Cordeiro ACC, Lacerda MC, Santiago CM, Torga PP, Moraes OP, Colombari Filho JM, Abreu AG, Santos BM, Custódio DP and Santos D (2018a) BRS A702 CL: new early-maturing irrigated rice cultivar with herbicide tolerance. *Crop Breeding and Applied Biotechnology* **18**: 446-449.
- Rangel PHN, Magalhães Junior AM, Fagundes PRR, Morais OP, Franco D, Colombari Filho JM, Torga PP, Nunes CD, Abreu AG, Petrini JA and Ferreira ME (2018b) BRS A701 CL: a new irrigated rice cultivar adapted to the clearfield production system. *Crop Breeding and Applied Biotechnology* **18**: 226-228.

 This is an Open Access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.