CROP BREEDING AND APPLIED BIOTECHNOLOGY

CULTIVAR RELEASE

BRS Boa Renda and BRS Novo Rumo – new cassava cultivars for starch and flour production

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Abstract: *BRS Boa Renda and BRS Novo Rumo are new cassava cultivars with high starch yields, moderate resistance to leaf diseases, and erect plant. BRS Boa Renda yields 25.7 t ha^{-1} of fresh and 9.5 t ha^{-1} dry roots, while BRS Novo Rumo yields 22.6 and 8.9 t ha^{-1}, respectively.*

Keywords: Manihot esculenta *Crantz, industrial variety, root yield, mechanization, plant architecture*

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is one of the most important sources of carbohydrates for millions of people, particularly in tropical regions. Beyond its role as a staple food, cassava is highly valued for its versatility in various industrial applications (Scaria et al. 2024). Its remarkable ability to adapt to extreme climatic conditions makes it a crucial crop for global food security, especially as climate change continues to intensify its impact on agriculture (Pushpalatha and Gangadharan 2020).

Despite its significance, cassava production in Brazil has faced major challenges in recent years. While cassava production in Africa and Asia increased by 2.2- and 1.9-fold, respectively, between 2000 and 2023, Brazil's production declined by 20% over the same period (FAO 2025). This decline can be attributed to the country's growing agricultural diversification, with farmers shifting toward more profitable crops that compete with cassava for land and resources. Another critical factor is the stark contrast in productivity gains—while cassava root yields in Asia have increased by 52%, Brazil has only seen a 14% improvement. This disparity is likely due to substantial investments in research and development across Asian countries, particularly in genetic advancements and the adoption of modern production technologies.

To enhance cassava's competitiveness and reestablish its importance in Brazilian agriculture, greater investment in high-yielding and resilient cultivars is essential (Oliveira et al. 2023). The selection of improved cultivars plays a key role in modernizing the cassava production chain, boosting productivity, and adapting to the increasing demand for mechanization at various stages of the production process. The adoption of new cultivars tailored for efficiency, disease resistance, and industrial applications can significantly impact the long-term sustainability of cassava farming in Brazil.

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In this context, two new cassava cultivars - BRS Boa Renda and BRS Novo Rumo - have been developed specifically for the state of Bahia to meet the needs of the flour and starch industries. These cultivars were designed to enhance profitability and increase both root and starch yields while aligning with current mechanization trends.

CROSSING AND SELECTION

The BRS Boa Renda cultivar was developed through phenotypic selection in segregating populations derived from the polycross of accession BGM-1133, within a breeding field containing 44 additional genotypes. BRS Novo Rumo, in turn, was obtained from segregating populations derived from the cross between genotypes BGM-2097 (female) × Olho Junto (male).

The crosses were carried out in 2015/16, following the Embrapa Mandioca e Fruticultura's (Cruz das Almas, BA, Brazil – lat 12˚ 40' 42.4" S, long 39˚ 05' 27.8" W, alt 235 m asl) protocol. Physiologically mature male and female flowers were selected and covered with a voile bag to preclude unwanted pollination. Manual pollination was conducted within the timeframe of 10:00 am to 4:00 pm. Subsequently, the pollinated flowers were re-covered, and essential crossing data were recorded, including parental identification, crossing date, and flower count. After a maturation period of 60-80 days, the seeds were preserved at 4 ºC for two months prior to germination in trays with substrate composed of coconut fiber, vermiculite, and Plantimax®, in an equivalent 1:1:1 ratio in volume.

During the 2016/17 season, 6,535 seedlings were transplanted into a seedling evaluation trial (SET) without an experimental design (single-plant trials), focusing solely on plant growth and the development of F_1 plants for the next stages of clonal propagation. Twelve months after planting, plants were harvested and assessed for high-heritability traits, including leaf retention, plant architecture, root pulp color, skin and cortex color, and root shape (Sampaio Filho et al. 2023). Clones that failed to produce at least five viable cuttings were discarded.

The clonal evaluation trial (CET) was established during the 2017/18 growing season using a randomized block design with 16 replications. Each block contained approximately 120 clones, along with 10 improved varieties and landraces (BRS Formosa, BRS Kiriris, BRS Mulatinha, BRS Novo Horizonte, BRS Poti Branca, Cigana Preta, Correntão, Corrente, Salangor, and Vassoura Preta) used as controls. The landraces were included due to their widespread traditional cultivation in the region. At this stage, clones in their first phase of clonal propagation were planted in single rows with six to eight plants per plot. Clone evaluation was conducted based on key traits, including germination rate, plant vigor, and root quality. Both the SET and CET were carried out in Cruz das Almas, Bahia (BA).

In 2018/19, a preliminary yield trial (PYT) was established to select the best F_1 clones based on resistance to shoot diseases, dry matter content, and fresh and dry root yield. The PYT was planted in double rows with eight plants per row (16 plants per plot) in Cruz das Almas. In 2019/20, three advanced yield trials (AYT) were conducted across two locations - Laje (BA) and Cruz das Almas (BA) - to identify the best clones based on their fresh and dry root yields, compared with Embrapa's improved varieties (BRS Mulatinha and BRS Poti Branca) and widely used landraces (Cigana Preta, Corrente, and Vassoura Preta). Clones in this third phase of clonal propagation were planted in four rows of eight plants each (32 plants per plot).

The uniform yield trials (UYT) were designed to evaluate the productive performance and root quality of the new clones across multiple regions of Bahia. For both cultivars, 15 UYTs were set up over four crop seasons (2020/21, 2021/22, 2022/23, and 2023/24) in the following municipalities: Alagoinhas, Alcobaça, Bom Jesus da Lapa, Conde, Cruz das Almas, Entre Rios, Esplanada, Itamaraju, and Laje, as well as Serra dos Aimorés in Minas Gerais (MG). For BRS Boa Renda, 28 additional UYTs were conducted in the same locations, plus Cardeal da Silva, Coração de Maria, Jaguaripe, Santo Antônio de Jesus, Sátiro Dias, Teixeira de Freitas, and Vitória da Conquista. The locations of these sites, along with their key traits, are shown in Table 1.

Plots consisted of four to six rows, with 10 plants per row, and trials were harvested 11-12 months after planting. All trials followed a spacing of 0.90 m between rows and 0.80 m between plants, along with fertilization and crop management recommendations specific to the target region (Souza et al. 2006).

Throughout these trials, key traits analyzed included: starch content (Starch_g, %), plant height (PlH, m), dry matter content (DMC, %), shoot yield (ShY, t ha^{-1}), plant architecture (PlArc, scale 1–5), leaf disease resistance (LeDis, scale 1–5),

Table 1. Locations and soil characteristics for the trials used to release the BRS Boa Renda and BRS Novo Rumo cultivars

City	Altitude (m)	Coordinates	Soil classification
Alagoinhas	130	12°05'S, 38°21'W	Yellow Oxisol
Alcobaça	89	17°26'S, 39°35'W	Podzol
Bom Jesus da Lapa	442	13°15'S, 43°32'W	Red-yellow latosol
Cardeal da Silva	124	12°03'S, 37°55'W	Red-yellow podzol
Conde	22	11°57'S, 37°41'W	Red-yellow podzol
Coração de Maria	239	12°11'S, 38°41'W	Red-yellow eutrophic podzol equivalent
Cruz das Almas	225	12º40'S, 39º06'W	Yellow oxisol and argisol
Entre Rios	95	12°01'S, 38°04'W	Red-yellow podzol
Esplanada	46	12°02'S, 37°50'W	Red-yellow podzol
Itamaraju	211	17°05'S, 39°42'W	Red-yellow latosol
Jaguaripe	140	13°09'S, 39°03'W	Red-yellow latosol
Laje	190	12º36'S, 38º44'W	Red to red yellow oxisol - medium texture
Santo Antônio de Jesus	186	12°59'S, 39°11'W	Red-yellow latosol
Sátiro Dias	219	11°44'S, 38°33'W	Red-yellow eutrophic podzol equivalent
Serra dos Aimorés	209	17°48'S, 40°14'W	Red-yellow latosol
Teixeira de Freitas	90	17°31'S, 39°36'W	Red-yellow latosol
Vitória da Conquista	812	15°08'S, 41°02'W	Red-yellow podzol

anthracnose resistance (Ant, scale 1–5), leaf retention (LeRet, scale 1–5), harvest stand percentage (Stand, %), number of roots per plant (NRP), number of stems per plant (NSP), plant vigor (Vigor, scale 1–5), fresh root yield (FRY, t ha^{-1}), and dry root yield (DRY, t ha^{-1}). The traits scored using rating scales were evaluated according to Santos et al. (2023).

Phenotypic selections were based on highest yield and root quality traits, as well as other agronomic and growth traits, in comparison with both landraces and improved varieties. A combined analysis of trait performance across different trials was used to calculate a selection index (SI), applying weightings according to breeding objectives: SI = (Starch_g, DMC, Stand, NRF, FRY) x 10 + (PlH, LeRet, NSP, Vigor) x 5+ (DRY) x 20 + (PlArc) x -10 + (LeDis, Ant) x -5.

ADAPTATION AND YIELD DATA

Growth parameters of the new cassava varieties

Regarding growth traits, the BRS Boa Renda and BRS Novo Rumo cultivars exhibited medium (mean of 2.2 m; range: 1.7–2.4 m) and tall plant heights (mean of 2.39 m; range: 1.95–2.84 m), respectively, with high vigor (score > 3.5) (Table 2). The BRS Novo Rumo and BRS Boa Renda cultivars averaged 2.1 and 1.7 stems per plant, respectively. Their plant

Table 2. Overall means of BRS Boa Renda and BRS Novo Rumo cultivars for several agronomic traits

Cultivars	Traits[1]													
	Starch_g	PlH	DMC	ShY	PlArc	LeDis	Ant	LeRet	Stand	NRP	NSP	Vigor	FRY	DRY
Vassoura Preta	20.3 ab	2.2 d[2]	35.2 cd	26.2 b	2.3 b	2.4 a	1.8 ab	3.0 c	77.2 ab	3.9 c	1.8 b	3.3 b	22.9 bc	8.3 bcd
Corrente	20.6 ab	2.3 c	35.6 bc	26.3 bc	2.5 a	2.3 a	1.8 ab	2.9 d	68.6 c	4.8 bc	2.1 a	3.0 c	21.6 bc	7.9 cd
Cigana Preta	20.4 ab	2.6 a	34.9 d	16.9 d	2.0 c	1.9 b	1.8 a	3.6 a	72.4 b	5.6 a	1.5 d	3.3 b	18.4 d	6.7 e
BRS Boa Renda	21 ab	2.2 cd	36.3 b	27 bc	2.6 a	2.4 a	1.8 ab	3.2 bc	75.1 ab	5.7 a	1.7 c	3.7 a	25.7 a	9.5 a
BRS Novo Rumo	21.7 a	2.4 b	35.7 bc	23.9 c	1.7 d	2.3 a	1.7 a	2.9 bc	83.4 a	4.4 bc	2.1 a	3.5 b	22.6 bc	8.9 abc
BRS Mulatinha	21.9 a	2.1 d	37.2 a	33.5 a	2.0 c	2.1 ab	1.6 b	3.4 ab	61.6 c	5.1 ab	1.8 b	3.3 b	24.3 ab	9.1 ab
BRS Poti Branca	19.3 b	2.4 b	33.9 e	30.6 a	2.2 b	2.4 a	1.8 a	3.0 bc	86.3 a	5.3 ab	1.8 bc	3.2 c	20.8 c	7.5 d
Mean	20.5	2.3	35.3	25.9	2.2	2.3	1.9	3	73.5	4.6	1.8	3.2	22.1	8.2
Coefficient variation (%)	10.9	23.7	7.7	35.9	35.9	44.3	34.4	40.1	37.9	44.9	30.9	24.2	47.7	36.6

[1] starch content (Starch_g, %), plant height (PlH, m), dry matter content (DMC, %), shoot yield (ShY, t ha^{-1}), plant architecture (PlArc, scale 1–5), leaf disease resistance (LeDis, scale 1–5), anthracnose resistance (Ant, scale 1–5), leaf retention (LeRet, scale 1–5), harvest stand percentage (Stand, %), number of roots per plant (NRP), number of stems per plant (NSP), plant vigor (Vigor, scale 1–5), fresh root yield (FRY, t ha^{-1}), and dry root yield (DRY, t ha^{-1}).

[2] Means followed by the same letter do not differ from each other by the LSD test at a 5% probability.

architecture scores were 1.7 and 2.6, indicating both cultivars are well-suited for mechanized planting. However, BRS Novo Rumo tends to have longer stems, which can contribute to higher yields at harvest and improve handling for mechanized planting. The average plant stand was 75% for BRS Boa Renda and 83% for BRS Novo Rumo, both above the overall trial average and higher than the averages of most control cultivars, except BRS Poti Branca.

Disease resistance and leaf retention

In terms of resistance to leaf spot and anthracnose, BRS Novo Rumo and BRS Boa Renda had intermediate scores (2.3 - 2.4 for leaf spot and 1.7 - 1.8 for anthracnose), performing similarly to the main control cultivars. The exception

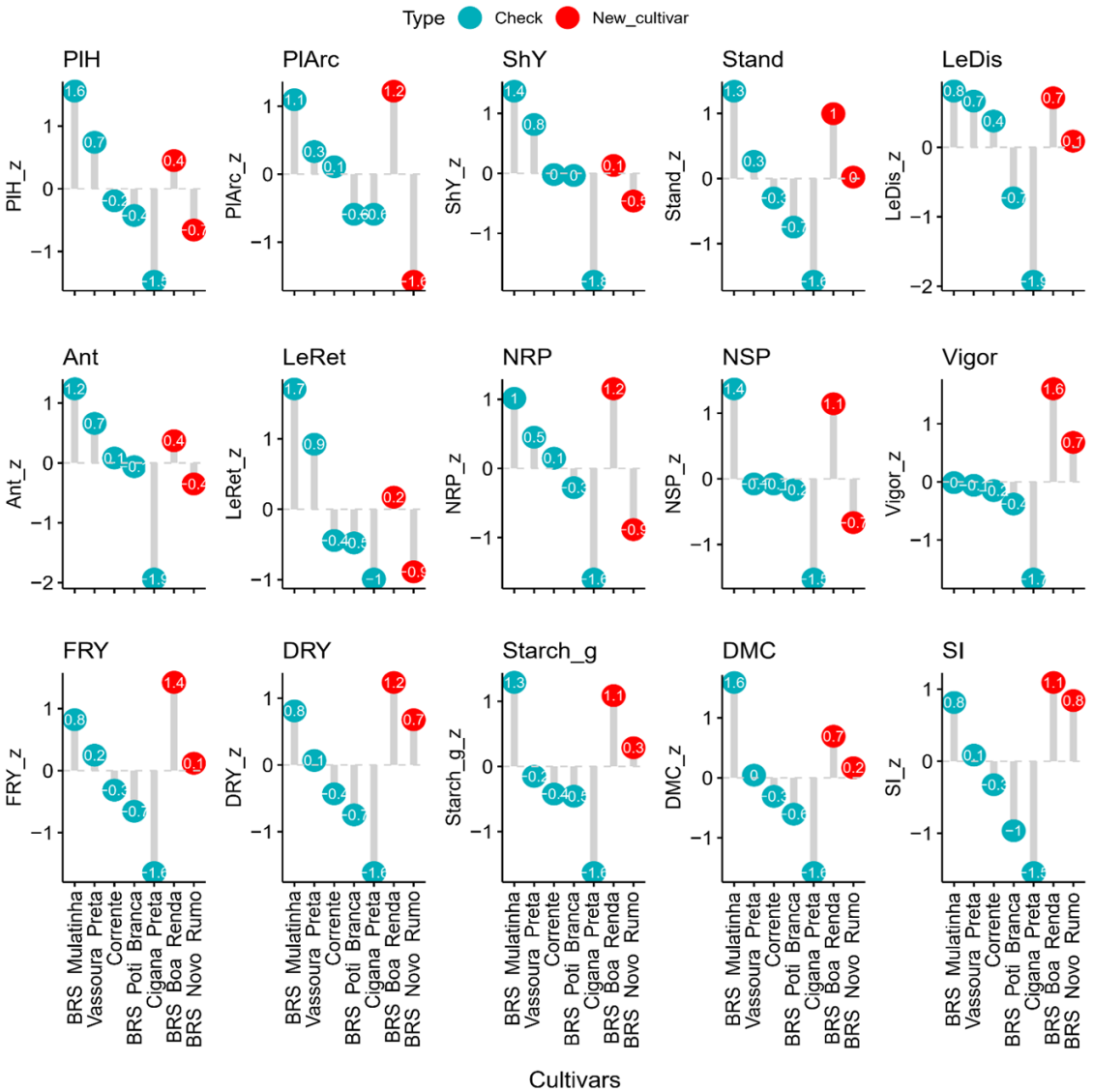

Figure 1. Lollipop plot of the z scores of several agronomic performance traits of the new cassava cultivars BRS Boa Renda and BRS Novo Rumo as well as the checks: BRS Poti Branca and BRS Mulatinha (improved varieties) and landraces (Vassoura Preta, Corrente and Cigana Preta) in multienvironment trials from 2018 to 2024. Starch content (Starch_g), plant height (PlH), dry matter content (DMC), shoot yield (ShY), plant architecture (PlArc), leaf disease resistance (LeDis), anthracnose resistance (Ant), leaf retention (LeRet), harvest stand percentage (Stand), number of roots per plant (NRP), number of stems per plant (NSP), plant vigor (Vigor), fresh root yield (FRY), and dry root yield (DRY).

was Cigana Preta, which showed slightly better resistance throughout the evaluations (Table 2). Leaf retention in both new cassava cultivars was comparable, falling within an intermediate range relative to Cigana Preta and Corrente.

Yield attributes

BRS Boa Renda stood out in terms of root production, averaging 5.7 roots per plant - 20% more than landraces and 11% more than the average of Embrapa cultivars. However, there was no significant difference compared to Cigana Preta. On the other hand, BRS Novo Rumo had the lowest root count among the tested cultivars, averaging 4.4 roots per plant (Figure 2). For total biomass production, the shoot yield of the new cultivars yielded less than previously released Embrapa cultivars (-15% for BRS Boa Renda and -25% for BRS Novo Rumo). However, their shoot yield was comparable to those of landraces (Vassoura Preta and Corrente) and higher than that of Cigana Preta.

Figure 2. Overall appearance of the stems and roots of BRS Boa Renda and BRS Novo Rumo, harvested 11 months after planting.

On average, BRS Boa Renda and BRS Mulatinha were the most productive cultivars (Table 2). The fresh root yield of BRS Novo Rumo was 22.6 t ha^{-1}, while BRS Boa Renda averaged 25.7 t ha^{-1}, surpassing local cultivars by approximately 8 and 22%, respectively. Compared to Embrapa's previously released cultivars, BRS Novo Rumo had similar yields, while BRS Boa Renda outperformed them by 14% in fresh root yield. For dry root yield, BRS Boa Renda averaged 9.5 t ha^{-1}, exceeding local cultivars by 24% and Embrapa cultivars by 14%. BRS Novo Rumo produced 8.9 t ha^{-1}, 17% higher than local cultivars and 8% higher than Embrapa cultivars.

Starch content and root quality

The average dry matter content in the roots was 36.3% for BRS Boa Renda and 35.7% for BRS Novo Rumo, second only to BRS Mulatinha (37.2%). The extractable starch content of BRS Novo Rumo (21.7%) was similar to that of BRS Mulatinha (21.9%), while the starch content of BRS Boa Renda (21.0%) was close to the average for landraces (20.4%) and numerically higher than the average of BRS Poti Branca (19.3%).

In terms of root quality, BRS Boa Renda has cream-colored pulp, a dark brown peel, and a cream-colored cortex with easy peeling (Table 3). This variety is well-suited for producing yellowish cassava flour, potentially eliminating the need for artificial coloring agents. Additionally, it can be used for modified starch production that does not require high whiteness levels. Conversely, BRS Novo Rumo has white pulp, a cream-colored cortex, and a thin, light-colored peel - highly desirable traits for producing native starch with high whiteness, which is essential for specific high-value applications in the food industry.

Selection index and final evaluation

Figure 1 presents the z-scores for each trait, calculated using the formula $z = (x - \mu)/\sigma$, where x is the data point, μ is the mean, and σ is the standard deviation. The figure supports the findings discussed throughout this text, confirming the desirable attributes of the new cultivars. More importantly, it highlights their suitability for recommendation based on a comparative selection index. BRS Boa Renda had the highest selection index, while BRS Novo Rumo had a selection index similar to that of the best control variety in the trials (BRS Mulatinha), with the added advantage of superior starch quality for industrial use.

Table 3. Main morphological traits of the BRS Boa Renda and BRS Novo Rumo cultivars

	Trait	BRS Boa Renda	BRS Novo Rumo
Stem	Color of the outer layer of the epidermis	Light brown	Silver
	Color of the inner layer of the epidermis	Orange	Cream
	Cortex color	Light green	Light green
	Phyllotaxis length	Medium	Medium
	Predominant number of primary branches	One	Two
Leaf	Apical leaf color	Green	Purplish green
	Color of fully expanded leaf	Dark green	Dark green
	Central vein color	Green	Reddish green
	Shape of the central lobe	Lanceolate	Elliptic-lanceolate
	Sinuosity of lobes	Absent	Absent
Petiole	Petiole color	Dark red	Red
Plant	Pubescence of young leaves	Present	Present
Root	Cortex color	Cream	Cream
	Skin color	Dark brown	White
	Shape	Conic-cylindrical	Conic-cylindrical
	Presence of peduncle	Mixed	Mixed
	Epidermis texture	Rough	Smooth

OTHER TRAITS

The resistance to diseases affecting shoots (including bacterial blight, brown leaf spot, white leaf spot, and blight leaf spot) and root diseases (specifically root rot) was found to be similar between the improved cultivars and landraces. The primary morphological traits that serve to differentiate the BRS Boa Renda and BRS Novo Rumo cultivars from other cultivars cultivated within the designated regions are delineated in Table 3.

TECHNICAL RECOMMENDATION AND CUTTING-SEED PRODUCTION

The agronomic evaluation of the BRS Boa Renda and BRS Novo Rumo cultivars followed the technical guidelines for cassava cultivation management in the State of Bahia, which encompassed conventional tillage methods (plowing, harrowing, and furrowing) and the planting of cutting segments measuring 16 to 18 cm in length, with an inter-row spacing of 0.90 m and an intra-plant spacing of 0.80 m. Weed management was accomplished through the application of pre-emergent herbicides, supplemented by manual weeding conducted approximately 60 days post-planting. Fertilization protocols complied with the recommendations outlined in Souza et al. (2006). Harvesting was carried out 11 to 12 months subsequent to planting.

The BRS Boa Renda and BRS Novo Rumo cultivars received official registration from the Ministry of Agriculture, Livestock and Supply in September 2024 (N. 57841 and 57840, respectively). The Empresa Brasileira de Pesquisa Agropecuária (Embrapa) is responsible for basic seed production.

DATA AVAILABILITY

The datasets generated and/or analyzed during this research are available from the corresponding author upon request.

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