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CULTIVAR RELEASE

BRS 420: Early maturity cassava cultivar for production of flour and starch, adapted to no-till planting and mechanization

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Abstract: *The cultivar BRS 420 has superior starch yields in early and late harvest, moderate resistance to the main diseases of the crop, adaptation to mechanized planting and to the no-till system, as well as rapid formation of soil cover (which assists in weed control). It represents an alternative for cassava growers in Paraná and Mato Grosso do Sul.*

Keywords: Manihot esculenta *Crantz, plant breeding, dry matter yield, root yield*.

INTRODUCTION

The Central and southern regions of Brazil are recognized for the use of modern technologies to obtain high yields of cassava roots. (Valle and Lorenzi 2014). However, the decline in production of the cultivars currently used and the lack of technologies that ensure the stability of production, mainly as a result of climate change, are seen as threats to the competitiveness of cassava growing in the central and southern regions of Brazil.

Responsibility for providing responses to most demands from farmers is placed on conventional plant breeding, with its various selection cycles (Carvalho et al. 2011, Valle and Lorenzi 2014, Vieira et al. 2018, Vieira et al. 2019). In this respect, actions directed to the generation and selection of superior genotypes for the central and southern regions of Brazil have been developed since 2008.

According to Valle and Lorenzi (2014), Vieira et al. (2020) new cassava cultivars should have the following traits: high root and dry matter yield, resistance to pests, upright plant growth habit, vigorous growth with rapid formation of soil cover, adaptation to conservationist growing systems, early maturity, production stability, and good industrial performance. In relation to sustainability, the adoption of good land use practices is seen as extremely necessary and urgent to minimize further erosion and expressive loss of yield capacity. Conservationist production systems, with emphasis on no-till planting (Rangel et al. 2018), have been considered an alternative for solving these problems.

Embrapa now makes the cultivar BRS 420 available to growers with the aim of meeting the demand for options of cassava cultivars required by production of flour and starch that have early maturity, moderate resistance to the main crop diseases in cassava, and adaptation to mechanized planting and the no-till

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system under the conditions of the Northwest and West regions of Paraná and the Center and South regions of Mato Grosso do Sul.

The BRS 420 cassava cultivar is the newest developed by Embrapa for the Center-South region of Brazil and the first to adapt to no-till. The purpose of this publication is to present it to the scientific community and to the production system.

BREEDING METHOD APPLIED

The BRS 420 cassava cultivar for flour and/or starch production was selected within a segregating population obtained in the 2008/2009 crop season through a cross between the cassava cultivars IAC 12-829 and IAC 576-70. The seeds that were generated were taken to the laboratory and soaked in water to check their viability. Those that floated were immediately discarded, and those that remained submerged were dried at ambient temperature. The botanical seeds were placed to germinate in a greenhouse and, 45 days after emergence, the seedlings were transplanted in the field.

The first three selection cycles were conducted in an experimental area of Embrapa in Brasilia, in the Distrito Federal. In these steps, planting was performed in November of the respective years and harvest occurred at 12 months after planting. Crop treatments followed the recommendations for cassava growing in the Brazilian Cerrado (Brazilian tropical savanna) (Fialho et al. 2017).

In the first selection cycle (2009/2010 crop season), as the cassava plants obtained from seeds have a taproot that goes down into the soil at a right angle, the following selection criteria were used i) white coloring of the tuberous root pulp; ii) plant architecture (high plant height and high first branch height); and iii) resistance to bacterial diseases. The plants (seedlings) selected were cloned by planting stem cuttings in the field in rows consisting of 5 plants at a spacing of 0.60 m between plants and 1.00 m between rows, continuing into the second selection cycle.

In the second selection cycle (2010/2011 crop season), when the cassava plants came to be vegetatively propagated through stem cuttings and had a tuberous root system typical of commercial plantings, the following selection criteria were used: i) plant architecture (high plant height and high first branch height); ii) resistance to bacterial diseases; iii) root yield; and iv) starch content in the tuberous roots. The clones selected in this crop season were then planted in the field in blocks of 5 rows with 5 plants, with a spacing of 0.60 m between plants and 1.00 m between rows, continuing on to the third selection cycle (2011/2012 crop season), in which the same criteria as in the second cycle were used. One hundred fifty (150) clones selected in the third selection cycle were introduced in the municipality of Marechal Cândido Rondon in Paraná in the 2012 crop season.

The trials of distinctiveness, homogeneity, and stability of cassava (*Manihot esculenta* Crantz) cultivars of the Brazilian Ministry of Agriculture (MAPA - Ministério da Agricultura, Pecuária e Abastecimento) were conducted for two crop seasons (2014/2016 and 2015/2017) at the experimental station of the Universidade Estadual do Oeste do Paraná in Entre Rios do Oeste, PR.

SERIES OF EVALUATION

The BRS 420 cassava cultivar for production of flour and/or starch was evaluated in experiments conducted in areas of the Northwest and West of Paraná from 2012 to 2016 and of the Center and South of Mato Grosso do Sul from 2014 to 2017. The following traits were evaluated in the experiments: root yield in t ha^{-1} (RY), starch percentage in the roots/tubers through the hydrostatic equilibrium method using 5 kg of roots (S%), and starch yield in t ha^{-1} (SY). Crop treatments followed the recommendations for cassava growing in the central and southern regions of Brazil under the conventional tillage (Otsubo and Lorenzi 2004) and no-till (Rangel et al. 2018) systems.

In the 2012/2013 crop season, BRS 420 (clone 864/10) and 149 clones were introduced in the municipality of Marechal Cândido Rondon (PR) at lat 24º 30’ 40” S, long 54º 18’ 08” W, alt 238 m asl. The experiment was conducted for 11 months, with the planting in August, in a no-till system on wheat straw in a randomized block design with two replications at a spacing of 0.90 m between rows and 0.75 m between plants. The cassava cultivars Santa Helena and Baianinha were used as check cultivars for flour and starch production since they are most planted in the region (Table 1).

In Marechal Cândido Rondon (PR) in the 2012/2013 crop season in harvested 11 months after planting in a no-till

system, the mean values of the cultivar BRS 420 exceeded those of the check cultivars regarding the root yield and starch yield traits by around 80% (Table 1). The starch yield of BRS 420 of 17 t ha^{-1} also exceeded the highest starch yields reported by Vidigal Filho et al. (2000) in their evaluation of industry-directed cassava cultivars over three crop seasons in a conventional tillage system in the Northwest region of Paraná with harvest at 10 months after planting.

The experiment of the 2013/2015 crop season was conducted for 18 months, with the planting in July, in a no-till system over *Brachiaria brizantha* straw in the municipality of Paranavaí, PR, at lat 23º 07' 15" S, long 52º 28' 10" W, alt 425 masl. The experimental design used was randomized blocks with two replications at a spacing of 0.90 m between rows and 0.75 m between plants. In the experiment, the cassava cultivars for flour and starch production, Santa Helena, IAC 90, and Cascuda, were used as check cultivars (Table 1).

The cultivar BRS 420 exceeded the mean values of the check cultivars regarding the root yield and starch yield traits by more than 120% (Table 1). The mean starch yield of BRS 420 of 18.5 t ha^{-1} exceeded the highest mean values of starch yield reported by Otsubo et al. (2004) in evaluation of nine cassava cultivars in Mato Grosso do Sul.

In 2014, experiments were set up in the municipalities of i) Tamboara, PR, at lat 23º 08' 37" S, long 52º 25'48" W, alt 415 m asl, with the planting in July; ii) Entre Rios do Oeste, PR, at lat 24º 40' 32" S, long 54º 16' 59" W, alt 254 m asl, with the planting in August; and iii) Naviraí, MS, at lat 22º 59' 55" S, long 54º 22'12" W, alt 362 m asl, with the planting in September. In the three locations, the experiments were set up in a randomized block design with three replications, with spacing of 0.9 m between rows and 0.75 m between plants.

In Tamboara, PR, the experiment was set up in a no-till system on *Brachiaria brizantha*, evaluated at eight months after planting and with use of Santa Helena, Baianinha, and IAC 90 as check cultivars. In the municipality of Entre Rios do Oeste, PR, the experiments were set up in a no-till system on maize straw, evaluated at 10 and 23 months after planting, with use of Santa Helena, Baianinha, IAC 90, and Cascuda as check cultivars. In Naviraí, MS, the experiment was conducted under conventional tillage, evaluated at 18 months after planting, with use of Baianinha and IAC 90 as check cultivars (Tables 1 and 2).

In the experiments conducted for one cycle in Tamboara, PR (8 months), and Entre Rios do Oeste, PR (10 months), in the 2014/2015 crop season, the mean values of the cultivar BRS 420 exceeded the mean values of the check cultivars

Table 1. Mean values of the traits of root yield in t ha^{-1} (RY), starch percentage in the roots (S%), and starch yield in t ha^{-1} (SY) evaluated at different ages of harvest in cassava cultivars grown in the no-till systems in the municipalities of Marechal Cândido Rondon (MCR), Paranavaí (PRV) and Tamboara (TMB) in the state of Paraná

Cultivar	Location	Crop Season	Tillage method	Months to harvest	RY	S%	SY
BRS 420	MCR	2012/2013	no-till	11	54.78 A	32.1 A	17.7 A
Santa Helena	MCR	2012/2013	no-till	11	31.59 B	32.0 A	10.1 B
Baianinha	MCR	2012/2013	no-till	11	29.58 B	30.3 B	9.1 B
Check cultivars	MCR	2012/2013	no-till	11	30.58	31.2	9.6
Superiority (%)	MCR	2012/2013	no-till	11	79.1	2.9	84.4
BRS 420	PRV	2013/2015	no-till	18	62.3 A	29.7 A	18.5 A
Cascuda	PRV	2013/2015	no-till	18	28.8 B	30.2 A	8.7 B
Santa Helena	PRV	2013/2015	no-till	18	21.2 C	30.3 A	6.4 B
IAC 90	PRV	2013/2015	no-till	18	31.9 B	22.3 B	7.1 B
Check cultivars	PRV	2013/2015	no-till	18	27.3	27.6	7.4
Superiority (%)	PRV	2013/2015	no-till	18	128.2	7.6	150.0
BRS 420	TMB	2014/2015	no-till	8	32.9 A	34.5 A	11.4 A
Baianinha	TMB	2014/2015	no-till	8	17.6 B	30.5 C	5.4 B
Santa Helena	TMB	2014/2015	no-till	8	13.7 B	33.2 B	4.6 B
IAC 90	TMB	2014/2015	no-till	8	13.7 B	32.7 B	4.5 B
Check cultivars	TMB	2014/2015	no-till	8	15.0	32.1	4.8
Superiority (%)	TMB	2014/2015	no-till	8	119.3	7.5	137.5

*Mean values followed by the same letter in the column in each location, crop season, and harvest do not differ from each other at 5% probability of error according to the Scott and Knott means clustering method.

in all the traits evaluated (Tables 1 and 2). It is noteworthy that in the harvest carried out at eight months after planting, the superiority of BRS 420 in relation to the check cultivars regarding starch yield was greater than 135%. It is also important to highlight that this superiority was obtained in a no-till system and that the mean values of starch yield and root yield obtained also considerably exceeded the mean values reported by Vidigal Filho et al. (2000) in evaluation of nine cassava cultivars in the Northwest region of Paraná.

In the two-cycle harvests of the 2014/2016 crop season, the mean values of the cultivar BRS 420 exceeded the mean values of the check cultivars both in the environment of the no-till system harvested at 23 months after planting in Entre Rios do Oeste, PR, and in the environment of conventional tillage harvested at 18 months after planting in Naviraí, MS (Table 2). Such performance indicates adaptation of the cultivar BRS 420 to both tillage systems.

In 2015, experiments were set up in the municipality of Entre Rios do Oeste, PR, at lat 24º 40' 32" S, long 54º 16' 59" W, alt 254 m asl, with the planting in September. The experimental design used was randomized blocks with four replications and spacing of 0.9 m between rows and 0.75 m between plants. The experiments were conducted in a no-till system on maize straw, with one experiment evaluated at 12 months and another at 18 months after planting. Baianinha, Santa Helena, Cascuda, and IAC 90 were used as check cultivars (Table 3).

In the one-cycle harvest (12 months after planting) in a no-till system in Entre Rios do Oeste, PR, in the 2015/2016 crop season, the mean values of root yield and starch yield of the cultivar BRS 420 were slightly lower than the mean values of the check cultivars, -5.3% and - 2.4%, whereas the mean of the starch percentage was slightly higher, 2.6% (Table 3). However, in the harvest at 18 months after planting (two-cycle harvest) in the same location and with the same no-till management, the mean values of the cultivar BRS 420 exceeded the mean values of the check cultivars by more than 10% in all the traits (Table 3). In the two-cycle harvest, BRS 420 had expressive mean starch yield of 16 t ha^{-1}, whereas in the one-cycle harvest, the mean starch yield was 50% lower (Table 3).

In 2016, in the municipality of Naviraí, MS, at lat 22º 59' 55" S, long 54º 22' 12" W, alt 362 m asl, two experiments were set up in conventional tillage in a randomized block design with four replications and spacing of 0.9 m between rows and 0.75 m between plants, with the planting in july. Evaluations occurred at 10 and 12 months after planting, and the cultivars Santa Helena and IAC 90 were used as check cultivars (Table 4).

Table 2. Mean values of the traits of root yield in t ha^{-1} (RY), starch percentage in the roots (S%), and starch yield in t ha^{-1} (SY) evaluated at different ages of harvest in cassava cultivars grown in the no-till and conventional tillage systems in the municipality of Entre Rios do Oeste (ERO) in the state of Paraná and in the municipality of Naviraí (NVI) in the state of Mato Grosso do Sul

Cultivar	Location	Crop Season	Tillage method	Months to harvest	RY	S%	SY
BRS 420	ERO	2014/2015	no-till	10	33.5 A	32.2 A	10.8 A
Cascuda	ERO	2014/2015	no-till	10	26.3 B	31.6 B	8.3 B
Santa Helena	ERO	2014/2015	no-till	10	28.6 B	32.1 A	9.2 B
Baianinha	ERO	2014/2015	no-till	10	27.5 B	31.6 B	8.7 B
Check cultivars	ERO	2014/2015	no-till	10	27.5	31.79	8.7
Superiority (%)	ERO	2014/2015	no-till	10	22.0	1.4	24
BRS 420	ERO	2014/2016	no-till	23	47.7 B	28.9 A	13.8 B
Cascuda	ERO	2014/2016	no-till	23	59.8 A	27.9 A	16.7 A
Santa Helena	ERO	2014/2016	no-till	23	39.2 C	30.4 A	11.9 B
IAC 90	ERO	2014/2016	no-till	23	40.9 C	27.6 B	11.3 B
Baianinha	ERO	2014/2016	no-till	23	27.0 D	29.3 A	7.9 C
Check cultivars	ERO	2014/2016	no-till	23	41.7	28.8	12.0
Superiority (%)	ERO	2014/2016	no-till	23	14.3	0.5	15.5
BRS 420	NVI	2014/2016	conventional	18	44.5 A	31.9 B	14.3 A
Baianinha	NVI	2014/2016	conventional	18	17.0 C	31.5 B	5.3 B
IAC 90	NVI	2014/2016	conventional	18	37.5 B	33.2 A	12.5 A
Check cultivars	NVI	2014/2016	conventional	18	27.3	32.4	8.9
Superiority (%)	NVI	2014/2016	conventional	18	63.0	-1.5	60.7

* Mean values followed by the same letter in the column in each location, crop season, and harvest do not differ from each other at 5% probability of error according to the Scott and Knott means clustering method.

In Naviraí, MS, in the 2016/2017 crop season in one-cycle harvests (10 and 12 months after planting) in a conventional tillage system (soil tilled with two plowings and one disking), the cultivar BRS 420 had a better response than the checks for all the traits observed (Table 4). It is noteworthy that the values for BRS 420 exceeded the root and starch yields of the check cultivars in both harvests by more than 20% (Table 4). The mean values of starch yield of the cultivar BRS 420 of 14.5 and 15 t ha^{-1} can be considered high since they exceeded the mean of the best cultivar evaluated in Mato Grosso do Sul by Otsubo et al. (2004).

The data obtained confirm that BRS 420 has potential for growing both in a no-till system and under conventional tillage in the states of Paraná and Mato Grosso do Sul. The expression of yield capacity greater than that of the cultivars most used in the regions tested allows good results in early harvests (of 10 and 12 months after planting) or late harvests (around 18 months after planting), which gives the grower the option of harvesting when commercial conditions are more favorable.

In addition, it is important to emphasize that in all the environments evaluated, the crop had moderate resistance to the main diseases affecting cassava in the region: bacterial disease (*Xanthomonas axonopodis* pv. *manihotis*), superelongation disease (*Sphaceloma manhoticola*), and anthracnose (*Colletotrichum gloeosporioides*), which shows the

Table 3. Mean values of the traits of root yield in t ha^{-1} (RY), starch percentage in the roots (S%), and starch yield in t ha^{-1} (SY) evaluated at different ages of harvest in cassava cultivars grown in the no-till systems in the municipality Entre Rios do Oeste (ERO) in the state of Paraná

Cultivar	Location	Crop Season	Tillage method	Months to harvest	RY	S%	SY
BRS 420	ERO	2015/2016	no-till	12	25.1 B	31.7 A	8.0 B
Cascuda	ERO	2015/2016	no-till	12	30.5 A	31.4 A	9.5 A
Santa Helena	ERO	2015/2016	no-till	12	22.7 B	29.4 B	6.7 B
Baianinha	ERO	2015/2016	no-till	12	34.3 A	30.6 B	10.6 A
IAC 90	ERO	2015/2016	no-till	12	18.4 C	32.2 A	5.9 B
Check cultivars	ERO	2015/2016	no-till	12	26.5	30.9	8.2
Superiority (%)	ERO	2015/2016	no-till	12	-5.3	2.6	-2.4
BRS 420	ERO	2015/2016	no-till	18	50.9 A	31.6 A	16.0 A
Cascuda	ERO	2015/2016	no-till	18	41.2 B	27.0 B	10.9 C
Santa Helena	ERO	2015/2016	no-till	18	54.1 A	27.1 B	14.8 B
Baianinha	ERO	2015/2016	no-till	18	45.4 B	29.4 A	13.4 B
IAC 90	ERO	2015/2016	no-till	18	36.1 C	30.3 A	10.9 C
Check cultivars	ERO	2015/2016	no-till	18	44.2	28.5	12.5
Superiority (%)	ERO	2015/2016	no-till	18	15.2	10.9	28.0

* Mean values followed by the same letter in the column in each location, crop season, and harvest do not differ from each other at 5% probability of error according to the Scott and Knott means clustering method.

Table 4. Mean values of the traits of root yield in t ha^{-1} (RY), starch percentage in the roots (S%), and starch yield in t ha^{-1} (SY) evaluated at different ages of harvest in cassava cultivars grown in the conventional tillage systems in the in the municipality of Naviraí (NVI) in the state of Mato Grosso do Sul

Cultivar	Location	Crop Season	Tillage method	Months to harvest	RY	S%	SY
BRS 420	NVI	2016/2017	conventional	10	47.6 A	31.5 A	15.0 A
Santa Helena	NVI	2016/2017	conventional	10	39.2 B	28.2 A	11.1 B
IAC 90	NVI	2016/2017	conventional	10	38.7 B	29.6 A	11.5 B
Check cultivars	NVI	2016/2017	conventional	10	39.0	28.9	11.3
Superiority (%)	NVI	2016/2017	conventional	10	22.0	9.0	32.7
BRS 420	NVI	2016/2017	conventional	12	46.8 A	30.9 A	14.5 A
Santa Helena	NVI	2016/2017	conventional	12	33.0 B	28.2 B	9.3 B
IAC 90	NVI	2016/2017	conventional	12	41.9 A	30.9 A	12.9 A
Check cultivars	NVI	2016/2017	conventional	12	37.5	29.6	11.1
Superiority (%)	NVI	2016/2017	conventional	12	24.8	4.4	30.6

* Mean values followed by the same letter in the column in each location, crop season, and harvest do not differ from each other at 5% probability of error according to the Scott and Knott means clustering method.

potential of the cultivar BRS 420 in the region from the perspective of plant health. The main phenotypic traits of the BRS 420 are i) mean plant height (2.06 m); ii) mean number of roots per plant (9,6); iii) root skin color (light brown); iv) root pulp color (white); v) petiole color (reddish green); vi) external stem color (dark brown); vii) leaf color (light green) and viii) apical leaf color (reddish green).

In short, the cultivar BRS 420 constitutes an option for the cassava industrial production chain of Paraná and Mato Grosso do Sul because of the higher starch yield comparative the control cultivars in both the conventional tillage system and in the no-till system in one- and two-cycle harvests.

REGISTRATION, PROTECTION, BASE PLANT, AND LICENSING OF PRODUCERS OF STALK/STEM CUTTINGS FOR PLANTING

The cassava cultivar BRS 420 for production of flour and/or starch is registered and protected through the Brazilian Ministry of Agriculture (Ministério de Agricultura, Pecuária e Abastecimento - MAPA) under numbers RNC 39140 (25/09/2018) and SNPC 20190156 (31/01/2019), respectively.

Production of the base plant and licensing of stalk/stem cuttings for planting are under the responsibility of the Innovation and Business Division (Secretaria de Inovação e Negócios) of Embrapa - Escritório de Brasília, Rodovia DF 001, km 69, Caixa Postal 999, Riacho Fundo I, 71805-970, Brasília/DF. E-mail: spm.ebsb@embrapa.br. The result of the public offering of propagating material was released on 23/07/2019, when the companies that will commercialize the BRS 420 stalk/stem cuttings were announced. As cassava is a semi-perennial plant, licensees must have material for commercialization from August 2021.

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