CROP BREEDING AND APPLIED BIOTECHNOLOGY

CULTIVAR RELEASE

BRS 400 and BRS 401, sweet cassava cultivars with pink roots developed by participatory breeding

Crop Breeding and Applied Biotechnology
19(4), 501-504, 2019
Brazilian Society of Plant Breeding.
Printed in Brazil
http://dx.doi.org/10.1590/1984-70332019v19n4c73

Eduardo Alano Vieira[1*], Josefino de Freitas Fialho[1], Laercio de Julio[1], Luiz Joaquim Castelo Branco Carvalho[2], João Luis Dalla Corte[1], Maria Madalena Rinaldi[1], Charles Martins de Oliveira[1], Francisco Duarte Fernandes[1] and José de Ribamar Nazareno dos Anjos[1]

Abstract: *Two sweet cassava cultivars with pink pulp, BRS 400 and BRS 401, are validated through participatory tests conducted at Distrito Federal, Brazil. Their high root yield stability and their high level of acceptance among producers certainly qualify them as a new crop option for cultivation in the region.*

Key words*: Manihot esculenta Crantz, participatory plant breeding, lycopene.*

INTRODUCTION

Consumers of sweet cassava at the Distrito Federal region of Brazil prefer the cream or yellow root pulps. This is a healthy habit, since the yellow color is associated with the presence of beta-carotene, which is the precursor of vitamin A.

Recent research has revealed that, besides being an excellent source of starch and a source of betacarotene, roots with pink pulk are also a source of lycopene (Carvalho et al. 2011). Lycopene is an antioxidant that is believed to slow down the aging process and help to prevent prostate cancer (Shami and Moreira 2004). In this context, the possibility of comercializing cassava roots that contain lycopene is a good way to improve the nutrition of the general population and to add value to the cultivars destined for human consumption.

Thus, Embrapa's sweet cassava breeding program is focused on the development of specific cultivars for the production of tuberous pink roots for human consumption (cooked, fried, chips, precooked, pasta etc). The following properties are desirable in these crops: level of *hydrocyanic acid* (HCN) in fresh roots less than 100 mg kg^{-1}; high yields; pleasant sensory qualities (softness and plasticity after cooking, non-sticky mass, aroma and pleasant appearance); good culinary properties (low fiber content, short cooking time and homogeneous mass after cooking); resistance to pests and diseases; pink coloration of the root pulp; among other characteristics (Carvalho et al. 2011, Vieira et al. 2011a, Vieira et al. 2011b, Vieira et al. 2018). Besides all these desirable qualities, the crop needs to be be well accepted by both producers and consumers of cassava in the Federal District region.

***Corresponding author:**
E-mail: eduardo.alano@embrapa.br
ORCID: 0000-0003-4931-3895

Received: 22 May 2018
Accepted: 08 November 2018

[1] Embrapa Cerrados, BR 020, km 18, 73.310-970, Planaltina, DF, Brazil
[2] Embrapa Recursos Genéticos e Biotecnologia, Parque Estação Biológica, PqEB, Av. W5 Norte, 70.770-917, Brasília, DF, Brazil

To meet the demand for sweet cassava with pink root pulp, Embrapa offers to local producers the cultivars BRS 400 and BRS 401, which are well adapted to the conditions of the Federal District. As has been done for other annual crops (Chiorato et al. 2018, Franco et al. 2018).

BREEDING METHOD APPLIED

The sweet cultivars BRS 400 and BRS 401 were selected from an open pollinated population of access BGMC 1228, preserved at the Cerrados Germplasm Regional Bank, of which the male parent is not known. The crops were planted and harvested in November of consecutive years following the recommendations for cassava cultivation in the Brazilian Cerrado (Fialho et al. 2013, Fialho and Vieira 2013). Since the cassava plants obtained from seeds have a pivotal type root system, the main selection criteria were adopted in the first selection cycle (2007/2008): i) pink root pulp; and ii) cassava bacterial blight resistance. The clones selected in this harvest were planted in the field in rows with 5 plants each, a space of 1.20 m between plants and 0.80 m between rows and were subjected to the second selection cycle.

During the second selection cycle (2008/2009), cassava plants began to be propagated by means of stem cuttings and to display a tuberosal root system, typical of commercial crops. The criteria for selecting them during this cycle were as follows: ii) resistance to cassava bacterial blight; ii) root productivity; iii) baking time of roots less than 30 minutes; iv) uniformity of the root (more than 80% of the roots between 20 and 45 cm in length and diameter greater than 50 mm); and (v) HCN content in the roots less than 100 mg kg^{-1}. The clones selected in this harvest were planted in blocks of 5 rows with 5 plants spaced 0.80 m between plants and 1.20 m between rows and were subjected to the third selection cycle.

The third selection cycle (2009/2010) was also conducted at Embrapa Cerrados and the same criteria used during the second cycle were used for selection.

The clones selected in the third selection cycle were subjected to the Differentiation, Homogeneity and Stability tests of the cassava cultivar (*Manihot esculenta* Crantz) of the Ministério da Agricultura, Pecuária e Abastecimento (MAPA) in 2010/2011 and 2011/2012. The experimental design was a randomized complete block design with three replications. Each plot was composed of 4 rows of 10 plants with spacing of 0.80 m between plants and 1.20 m between rows. Sixteen central plants per plot were evaluated. In this step, in addition to the parameters evaluated in the last two selection cycles, in each plot of the experiments, the *hydrocyanic acid* content of the roots (HCN) was also estimated in mg kg^{-1} using the qualitative method described by Willams and Edwards (1980), from five roots chosen at random from each plot.

PARTICIPATIVE EVALUATION

The method of participatory selection of cassava varieties was used to evaluate the cultivars. This process involves effective participation of the farmers, researchers and extension personnel in the clonal validation process (Fialho and Vieira 2011). In the end of the process, the degree to which the producers accepted the clones (which is an indication of the probability that they will plant them in the future) and other agronomic data were obtained. In this scenario the clones that were more often rated on the top positions by the producers are the ones that are most likely to be used by them in the future. Parallel the method proposed by Lin and Binns (1988) were used for ranking the root yield stability of the genotypes.

The cultivars BRS 400 and BRS 401 were selected after 19 participatory tests (Figure 1), which involved the evaluation of eight sweet cassava clones with pink pulp, generated and selected by the Embrapa Cerrados cassava breeding program (Clone 345/08, Clone 387/08, Clone 378/08, Clone 406/08, Clone 413/08, Clone 395/08, Clone 341/08 (BRS 400) and

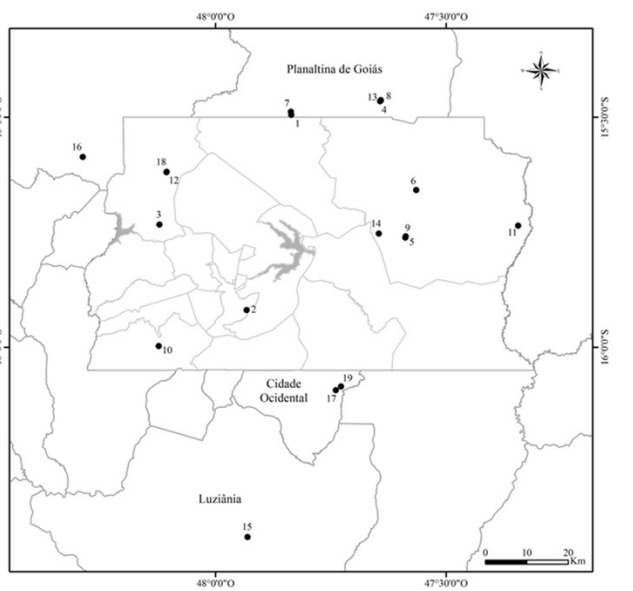

Figure 1. Location of the areas where the 19 participatory tests were placed at the agricultural regions of the Federal District.

Clone 390/08 (BRS 401). The participative tests lasted for three harvest seasons, 2011/2012, 2012/2013 and 2013/2014.

The farmers participating in the research were selected from different agricultural regions of the DF based on their experience with cassava cultivation. The plots consisted of 5 lines with 10 plants, 1.20 m between rows and 0.80 m between plants, and the plot area consisted of 24 central plants. The plants were cultivated following methods commonly applied by the producers selected for the participatory research; in this manner, the only difference in the producers' production process was the cultivar.

Cassava roots were planted between October and December and harvested between 11 and 12 months after planting. At the time of harvest, the farmers classified the clones according to their preference for planting, considering the entire crop cycle and not only the yield. Thus, in each of the 19 participatory evaluations, the clones were classified in a decreasing order of preference: the best clone (according to the producers) was placed in the first position and the worst in position eight (Table 1). At that moment, the main criteria used by the producers for the selection of cassava clones were also noted. Since it is a completely new product, the growers paid especial attention to root productivity, root cooking time (CT), which is closely associated with culinary quality, resistance to pests and diseases, initial vigor, which are associated with rapid soil cover and control of invasive plants, and uniformity of the root.

At harvest, the following characteristics were also ascertained: i) height of the first branching in m (HFB); ii) plant height in m (PH); iii) shoot weight without the original stem cutting in kg ha^{-1} (ShW); iv) root yield in kg ha^{-1} (RY); and v) time for cooking the roots, in minutes (CT).

Based on the absolute probability of acceptance of the clones, cultivars BRS 400 and BRS 401 (Table 1) had a 36.84% probability of being preferred, 68.42% (BRS 400) and 89.47% (BRS 401) of probability of being classified until second place, and 94.74% probability of being among the first three clones (Table 2).

The high acceptance of the cultivars by the producers together with the high root yield stability, certainly qualify the cultivars BRS 400 and BRS 401 as suitable for cultivation in the region of the Federal District, since both cooked in less than 30 min and had HCN levels in roots below 100 mg kg^{-1} (Table 3).

Table 1. Farmers' order of preference with respect to eight clones of sweet cassava with pink root pulp evaluated in 19 participatory tests at the Federal District agricultural regions

Clones	Preference order										
	1°	2°	3°	4°	5°	6°	7°	8°	9º	10º	11º
BRS 400	7	6	5	1	0	0	0	0	7	6	5
BRS 401	7	10	1	1	0	0	0	0	7	10	1
345/08	0	0	4	4	3	4	2	2	0	0	4
387/08	3	1	2	5	5	1	1	1	3	1	2
378/08	2	0	2	0	6	1	3	5	2	0	2
406/08	0	0	0	3	2	3	3	8	0	0	0
413/08	0	2	3	3	3	3	4	1	0	2	3
395/08	0	0	2	2	0	7	6	2	0	0	2

Table 2. Accumulated probability of acceptance calculated for eight sweet cassava clones evaluated in 19 participatory tests in the Federal District agricultural regions

Clones	Preference order										
	1°	2°	3°	4°	5°	6°	7°	8°	9º	10º	11º
BRS 400	36.84	68.42	94.74	100.00	100.00	100.00	100.00	100.00	36.84	68.42	94.74
BRS 401	36.84	89.47	94.74	100.00	100.00	100.00	100.00	100.00	36.84	89.47	94.74
345/08	0.00	0.00	21.05	42.11	57.89	78.95	89.47	100.00	0.00	0.00	21.05
387/08	15.79	21.05	31.58	57.89	84.21	89.47	94.74	100.00	15.79	21.05	31.58
378/08	10.53	10.53	21.05	21.05	52.63	57.89	73.68	100.00	10.53	10.53	21.05
406/08	0.00	0.00	0.00	15.79	26.32	42.11	57.89	100.00	0.00	0.00	0.00
413/08	0.00	10.53	26.32	42.11	57.89	73.68	94.74	100.00	0.00	10.53	26.32
395/08	0.00	0.00	10.53	21.05	21.05	57.89	89.47	100.00	0.00	0.00	10.53

Table 3. Means of the traits plant height in m (PH), height of first branching in m (HFB), shoot weight without original stem cutting in kg ha^{-1} (ShW), root yield in kg ha^{-1} (RY), cooking time in minutes (CT), HCN content in mg kg^{-1} in roots (HCN), the root yield stability parameter (RYSP) by Lin and Binns (1988) and order according to RYSP (SO) estimated in eight sweet cassava clones evaluated in 19 participatory tests in the Federal District agricultural regions

Clones	HFB	PH	ShW	RY	CT	HCN	RYSP	SO
BRS 400	0.34 L[1]	2.32	40895 H	25040	21.39	25-40	45466076[2]	1
BRS 401	0.60 H	2.29	34591	24931	23.16	40-60	49691954	2
345/08	0.43	2.10	24674	19061	21.39	40-60	114148261	5
387/08	0.47	2.20	27687	21158	23.56	40-60	100896800	4
378/08	0.38	1.99	30306	18241	21.59	40-60	134377533	6
406/08	0.51	2.10	30212	16629	23.18	25-40	140976753	7
413/08	0.59 H	1.98	29442	23443	22.89	40-60	52490184	3
395/08	0.45	2.19	31262	17384	24.24	25-40	142039344	8
Overall mean	0.47	2.15	31134	20736	22.68	-	-	-

[1] Means followed by H or L are, respectively, higher or lower than the overall mean according to the t test at 5% error probability; [2] The less the RYSP value the greater the stability of the genotype.

REGISTRATION, PROTECTION, BASIC PLANT AND LICENSING OF SEED MANUFACTURERS

Cultivars BRS 400 and BRS 401 are registered and protected by the Ministério de Agricultura, Pecuária e Abastecimento (MAPA) under the numbers 33075 and 20150163, 33077 and 20150161, respectively. The basic plant production and the licensing of seed producers are under the responsibility of Secretaria de Inovação e Negócios da Embrapa - Escritório de Brasília, Rodovia DF 001, km 69, Caixa Postal 999, Riacho Fundo I, CEP 71.805-970, Brasília/DF. Phone number (61) 3333-0417, E-mail: spm.ebsb@embrapa.br.

ACKNOWLEDGEMTS

We thank Empresa Brasileira de Pesquisa Agropecuária (Embrapa), à Fundação Banco do Brasil (FBB) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), for financial support and EMATER-DF for general help.

REFERENCES

Carvalho LJCB, Vieira EA, Fialho JF and Souza CRB (2011) A genomic assisted breeding program for cassava to improve nutritional quality and Industrial traits of storage root. **Crop Breeding and Applied Biotechnology 11**: 289-296.

Chiorato AF, Carbonell SAM, Gonçalves JGR, Silva DA, Benchimol-Reis LL, Carvalho CRL, Barros VLNP, Freitas RS, Ticellis M, Gallo PB and Santos NCB (2018) IAC Sintonia: new carioca common bean cultivar. **Crop Breeding and Applied Biotechnology 18**: 338-342.

Franco FA, Marchioro VS, Evangelista A, Polo M, Montecelli TDN, Souza LV, Schuster I, Lima FJA, Santos DA and Grave EL (2018) CD 1705 - healthy and high-yielding wheat cultivar for biscuit manufacturing**. Crop Breeding and Applied Biotechnology 18**: 334-337.

Fialho JF and Vieira EA (2011) **Seleção participativa de variedades de mandioca na agricultura familiar**. Embrapa Cerrados, Brasília, 76p.

Fialho JF, Sousa DMG and Vieira EA (2013) Manejo do solo no cultivo de mandioca. In Fialho JF and Vieira EA (eds) **Mandioca no Cerrado: orientações técnicas**. Embrapa Cerrados, Brasília, p. 39-60.

Fialho JF and Vieira EA (2013) Manejo e tratos culturais da mandioca. In Fialho JF and Vieira EA (eds) **Mandioca no Cerrado: orientações técnicas**. Embrapa Cerrados, Brasília, p. 61-88.

Lin CS and Binns MR (1988) A superiority measure of cultivar performance for cultivar x location data. **Canadian Journal of Plant Science 68**: 193-198.

Shami NJIE and Moreira EAM (2004) Licopeno como agente antioxidante. **Revista de Nutrição 17**: 227-236.

Vieira EA, Fialho JF, Faleiro FG, Bellon G, Fonseca KG, Carvalho LJCB, Silva MS, Paula-Moraes, SV, Oliveira CM and Denke ML (2011a) Characterization of sweet cassava accessions based on molecular, quantitative and qualitative data. **Crop Breeding and Applied Biotechnology 11**: 232-240.

Vieira EA, Fialho JF, Julio L, Carvalho LJCB, Dalla Corte JL, Rinaldi, MM, Oliveira CM, Fernandes FD and Anjos JRN (2018) Sweet cassava cultivars with yellow or cream root pulp developed by participatory breeding. **Crop Breeding and Applied Biotechnology 18**: 450-454.

Vieira EA, Fialho JF, Silva MS, Paula-Moraes SV, Oliveira CM, Anjos JRN, Rinaldi MM, Fernandes FD and Guimarães Junior R (2011b) BRS Japonesa: new sweet cassava cultivar for the Distrito Federal region. **Crop Breeding and Applied Biotechnology 11**: 93-196.

Williams HJ and Edwards TG (1980) Estimation of cyanide with alkaline picrate. **Journal of the Science of Food and Agriculture 31**: 15-22.