Agrotrópica 34(1): 41 - 48. 2022.
Centro de Pesquisas do Cacau, Ilhéus, Bahia, Brasil

PARTICIPATORY SELECTION OF SWEET CASSAVA GENOTYPES WITH FARMERS IN THE NORTHERN AMAZONIA

Everton Diel Souza[1], Hyanameyka Evangelista de Lima-Primo[1], Dalton Roberto Schwengber[2], Admar Bezerra Alves[1] e José Alberto Martell Mattioni[1]

[1]Brazilian Agricultural Research Corporation, Embrapa Roraima, Highway BR-174, km 08, PO Box 151, 69301-970, Boa Vista, Roraima, Brazil. everton.souza@embrapa.br, hyananeyka.lima@embrapa.br, admar.alves@embrapa.br, jose.mattioni@embrapa.br. [2]Retired researcher from Embrapa Roraima. dalton.schwengber@embrapa.br

The participatory research methodology has been fundamental to the efficiency of using and propagating genotypes because it focuses on its main customers farmers who actively participate in the evaluation using their selection criteria. The objective of this study was to analyze the probability of using new sweet cassava genotypes by farmers in the municipalities of São João da Baliza, São Luiz, and Caroebe in Southern Territory of the Roraima State in the Northern Brazilian Amazon. From 2019 to 2020, 54 participatory evaluations were conducted in the three municipalities. The genotypes evaluated were Aipim Brasil, BRS Dourada, BRS Gema de Ovo, BRS Japonesa, BRS Moura, Clone RRM 7, Clone RRM 9, Clone RRM 10 and Saracura. During the participatory genotypes selection, 23 farmers of the female gender and 31 farmers of the male gender chose selection criteria like yield, root length and diameter, cooked pasta quality and starch content. Overall, on average, Clone RRM 7, BRS Japonesa, Clone RRM 9 and Clone RRM 10 were farmers' favorite genotypes with a high probability of adoption.

Key words: *Manihot esculenta*, participatory research, improved cultivars.

Seleção participativa de cultivares de mandioca para mesa com agricultores do norte da Amazônia. A metodologia de pesquisa participativa tem sido fundamental na eficiência da adoção e difusão de cultivares pois tem como foco o seu principal cliente, o agricultor, que participa ativamente da condução dos trabalhos de avaliação utilizando seus próprios critérios de seleção. Este trabalho teve por objetivo analisar a probabilidade de adoção de novas cultivares de mandioca para mesa, por agricultores dos municípios de São João da Baliza, São Luiz e Caroebe do Território Sul do estado de Roraima no Norte da Amazônia Brasileira. No período de 2019 a 2020 foram conduzidas 54 avaliações participativas nos três municípios. As cultivares avaliadas foram: Aipim Brasil, BRS Dourada, BRS Gema de Ovo, BRS Japonesa, BRS Moura, Clone RRM 7, Clone RRM 9, Clone RRM 10 e Saracura. Durante a seleção de genótipos participativa, 23 agricultoras e 31 agricultores escolheram como critérios de seleção a produtividade, o comprimento e diâmetro das raízes, a qualidade da massa cozida e o teor de amido na raiz. Na média geral, as cultivares Clone RRM 7, BRS Japonesa, Clone RRM 9 e Clone RRM 10 destacaram-se na preferência dos agricultores com alta probabilidade de adoção.

Palavras-chave: *Manihot esculenta*, pesquisa participativa, cultivares melhoradas.

Received for publication on March 06, 2022. Accepted on April 04, 2022.
DOI:10.21757/0103-3816.2022v34n1p41-48

Introduction

Cassava (*Manihot esculenta* L. Crantz) is a staple food for millions of tropical inhabitants around the world. In Brazil, it is cultivated in almost all regions, being used mainly in the form of flour and other industrialized products (Oliveira e Moraes, 2009). In Roraima, cassava has an expressive economic and social importance, constituting one of the basic food products of the population, mainly in the form of flour. In 2020, 6595 ha were harvested in Roraima with the cultivation of cassava resulting in the production of 85520 tons of roots, causing the average yield to reach 12.9 t ha^{-1}, much lower than the Brazilian average which was 14.9 t ha^{-1}. The production value corresponded to R$ 67.049.000 million only behind to crops such as soybeans, rice, corn and bananas (IBGE, 2021).

Sweet cassava, also known as “manioc” or table cassava, included cultivars that are distinguished from bitter cultivars by their low levels of hydrocyanic acid, a toxic principle of cassava (less than 100 ppm in the raw pulp of the roots). Cassava is harvested early between seven and 14 months for better cooking quality (Lorenzi, 2012). Embrapa’s sweet cassava breeding program is focused on the development of specific cultivars for the production of roots for human consumption (cooked, fried, chips, precooked, pasta etc.) (Rinaldi et al., 2017, Rinaldi, Vieira e Fialho, 2019, Vieira et al., 2018, Fuhrmann et al., 2019, Mendonça et al., 2020).

The objective of research experimentation with farmers is to implement a partnership involving farmers, researchers, and other members of the crop production chain in the technology development process and to simultaneously evaluate the performance of this technology in a broad range of edaphoclimatic conditions unavailable in the experimental bases (Fukuda e Saad, 2001). In this context, Hernandez-Romero (2000) highlights participatory breeding, in which farmers participate in some phases of genotype selection on their farms using their traditional production systems.

The use of participatory methodologies in cassava breeding as a complement to conventional breeding methods is an alternative to identifying the selection criteria used by farmers for adopting new varieties and feedback breeding programs, being also an efficient tool to adopt and disseminate cultivars (Fukuda et al., 2006, Vieira et al., 2018). To analyze this information, Hernandez-Romero (2000) developed a logistic regression program to evaluate cassava cultivar preference and the probability of acceptance in participatory evaluations with farmers. The objective of this study was to analyze the probability of adopting new cultivars of sweet cassava by farmers in Southern Territory in the state of Roraima.

Materials and Methods

The Component 2 Project (PC2) of the Mandiotec Project is an Integrated Amazon Project with the general objective of introducing and transferring new technologies to increase cassava production and productivity to provide an alternative to the traditional agriculture system used in the Amazon. Specifically, the project targets the states of Acre, Amazonas, Amapá, Pará, Rondônia, and Roraima, and the transition mesoregions in the states of Mato Grosso and Maranhão.

In Roraima, the municipalities chosen for the study were Caroebe, São João da Baliza, São Luiz, and Rorainópolis, and the district of Novo Paraiso in Caracaraí all in Southern Territory of Roraima, which was created on April 13, 2004, with the special purpose of promoting sustainable socioeconomic and environmental development to improve the quality of life of men and women from Roraima from generation to generation (MDA, 2010).

In 2019 and 2020, 54 participatory evaluations with sweet cassava cultivars were conducted in three municipalities in the state of Roraima. The evaluations were part of a Component 2 activity of the Mandiotec Network Integrated Amazon Project implemented by Embrapa in partnership with the Eliseu Alves Foundation (FEA) and funded by National Bank for Economic and Social Development (BNDES).

The study evaluated nine cultivars pre-established by Embrapa Roraima in Boa Vista, RR. The general criteria established for the cultivars were productivity, sprouting and establishment in the field, flour and starch content, and tolerance for the main pests and diseases found in each community.

The cultivars evaluated were Aipim Brasil, BRS Dourada, BRS Gema de Ovo, BRS Japonesa, BRS Moura, Clone RRM 7, Clone RRM 9, Clone RRM 10 and Saracura. Participatory evaluations were planted in the farms using plots of 9 lines of 50 plants per cultivar, spaced 1.0 m between rows and 0.60 m between plants, without repetition, following the traditional management used by each farmer. Cassava stakes were planted between May and June and harvested at six and nine months after planting. The selection of genotypes for propagation and the cultural practices were according to the recommendations of the cassava production system for the Roraima State proposed by Souza et al. (2014).

During the crop cycle, the researchers and farmers jointly evaluated the cultivars using open-ended questions to encouraged farmers to express their opinions. A field spreadsheet was used to register and analyze the two types of information obtained (quantitative and qualitative), systematizing the necessary descriptors for feedback. Of the 54 participatory tests, 23 were carried out by women and 31 by men, corresponding to 42.59% of the female gender and 57.41% of the male gender, respectively.

The main selection criteria used by farmers for adopting new cassava cultivars were identified and ranked according to their preferences. According to the selection criteria and the preferences determined by the farmers, the cultivars evaluated were first divided into three categories in the field: good, regular, and bad. Thereafter, the cultivars were ranked according to the farmers' preferences from 1 to 9, with the best cultivar being scored 1 and the worst being scored 9. In this case, the evaluation was divided into two stages: one in the field at harvest based on yield, root, stem, and shoot size and shape; and the other based on the quality of the cooked root, including starch content, taste, presence of fiber, and cooking time. The latter was carried out only nine months after planting.

Using the participatory research methodology developed by Hernandez-Romero (2000) at the CIAT and established by Fukuda e Saad (2001) in northeast Brazil, the matrices were designed according to the order and frequency of preference for each cultivar. The absolute and cumulative probabilities of adoption were calculated for each cultivar evaluated. The absolute preference probability for each cultivar was obtained by dividing the number of times a cultivar was preferred by farmers within each preference order by the total number of evaluations. The cumulative preference probability was obtained by adding the absolute probabilities.

The probability of adopting each cultivar was determined by logistic regression curves estimated from the cumulative preference probability and order of preference of each cultivar using the following mathematical model:

$$\text{Logic}(p) = \log [p/(1-p)] = A_j + B_k,$$

where A_j and B_k are the coefficient estimates for $1 < j < k$ and $k = 9$ cultivars (6 improved + 3 experimental).

Results and Discussion

Table 1 shows the preference order and frequency of each cultivar, represented by the number of times the cultivar was ranked in a specific position. It should be noted that when ranking the cultivars by preference, the farmers justify the reason for their choice in a simple and clear manner. At this point, the farmers clearly show their actual criteria for adopting or discarding a cultivar (Fukuda et al., 2008a).

The Clone RRM 7 was in the first place in 16 of the 54 participatory evaluations with farmers, followed by Clone RRM 9 (second) and BRS Japonesa (third), which were chosen eight times each, and Clone RRM 10 (fourth) and BRS Gema de Ovo (fifth), which was chosen seven times, as the first option. Therefore, the Clone RRM 7 had a 29.63% probability of being chosen by farmers, Clone RRM 9 had 15.69%, BRS Japonesa had 14.81% and Clone RRM 10 and BRS Gema de Ovo had a 12.96% probability each (Table 2). In

Table 1. Frequency distribution of the acceptance of sweet cassava cultivars in the municipalities of São João da Baliza, São Luiz, and Caroebe, Roraima, Brazil

Cultivars	Preference order									Total
	1	2	3	4	5	6	7	8	9	
Clone RRM 7	16	5	8	9	9	3	3	1	0	54
Clone RRM 10	7	4	8	18	7	2	5	1	2	54
Saracura	0	5	10	7	8	6	11	4	3	54
BRS Dourada	0	5	1	3	3	10	3	18	8	51
BRS Gema de ovo	7	6	2	6	10	8	3	9	3	54
Aipim Brasil	5	6	4	4	3	2	4	4	22	54
BRS Japonesa	8	8	6	0	5	6	13	3	5	54
BRS Moura	3	3	7	4	7	12	8	7	3	54
Clone RRM 9	8	12	8	3	2	5	4	4	5	51
Total	54	54	54	54	54	54	54	51	51	480

Table 2. Absolute acceptance probability of new sweet cassava cultivars in the municipalities of São João da Baliza, São Luiz, and Caroebe, Roraima, Brazil

Cultivars	Absolute probability (%)									Total
	1	2	3	4	5	6	7	8	9	
Clone RRM 7	29.63	9.26	14.81	16.67	16.67	5.56	5.56	1.85	0.00	100.0
Clone RRM 10	12.96	7.41	14.81	33.33	12.96	3.70	9.26	1.85	3.70	100.0
Saracura	0.00	9.26	18.52	12.96	14.81	11.11	20.37	7.41	5.56	100.0
BRS Dourada	0.00	9.80	1.96	5.88	5.88	19.61	5.88	35.29	15.69	100.0
BRS Gema de ovo	12.96	11.11	3.70	11.11	18.52	14.81	5.56	16.67	5.56	100.0
Aipim Brasil	9.26	11.11	7.41	7.41	5.56	3.70	7.41	7.41	40.74	100.0
BRS Japonesa	14.81	14.81	11.11	0.00	9.26	11.11	24.07	5.56	9.26	100.0
BRS Moura	5.56	5.56	12.96	7.41	12.96	22.22	14.81	12.96	5.56	100.0
Clone RRM 9	15.69	23.53	15.69	5.88	3.92	9.80	7.84	7.84	9.80	100.0

contrast, the Aipim Brasil and BRS Dourada cultivars were discarded in 22 and eight of the 54 evaluations, respectively. These cultivars showed an inverse trend, presenting 40.74% and 15.69% probability of ranking last in the farmers' preference, respectively. According to Fukuda et al. (2008a), the absolute probability of accepting a cultivar in the first place increases as the probability of being ranked last decreases, and vice versa.

Table 3 shows the cumulative probability matrix of cultivar acceptance. The cumulative acceptance probability is the probability of a cultivar achieving a certain rank in the preference of farmers (Fukuda et al., 2008a). The Clone RRM 7 has a 29.63% probability of being accepted as the first by the farmers, 38.89% of being one of the two accepted cultivars, and 53.70% of being one of the top three in a ranking from 1 to 9. The Clone RRM 9 and BRS Japonesa cultivars have a 15.69% and 14.81% probability of being accepted in the first place, 39.22% and 29.63% of being one of the two accepted cultivars and 54.90% and 40.74% of being one of the top three cultivars, respectively. The Saracura and BRS Dourada cultivars had a 0% probability of being accepted in the first place by the farmers, with an increasing tendency to be classified in the last place, indicating the discard them.

Vieira et al. (2011) had related that based on the preference matrix, the cumulative probability of acceptance of accessions was estimated and the probability of preference of BRS Japonesa was 20% and the chance of being classified in the second, third and fourth position was 40%, 72% and 80% respectively, according to the farmers.

These matrices were used to generate regression curves to individually estimate the adoption probability of each cultivar. Based on these curves, there were several trends for the cultivars regarding the probability of being adopted by the farmers, improving the rapid identification of cultivars that showed adopting (Clone RRM 7) or discarding probabilities (Aipim Brasil) by farmers (Figure 1).

These curves confirm the information presented in Table 3, clearly showing the adoption probability of each cultivar. They indicate the higher preference for the Clone RRM 7 and BRS Japonesa cultivars and the low acceptance of the BRS Dourada, Aipim Brasil, and BRS Moura cultivars (Figure 2).

Table 4 provides the regression coefficient (^b) and intercept (â) estimates of the logistic model used to compose the linear regression curves established for each cultivar (Figure 1) and the coefficients of determination calculated for each cultivar. A positive coefficient (^b) indicates a higher probability of being the first in the farmers' preference, which is the case for the Clone RRM 7, Clone RRM 9, Clone RRM 10

Table 3. Accumulated acceptance probability of new sweet cassava cultivars in the municipalities of São João da Baliza, São Luiz, and Caroebe, Roraima, Brazil

Cultivars	Absolute probability (%)								
	1	2	3	4	5	6	7	8	9
Clone RRM 7	29.63	38.89	53.70	70.37	87.04	92.59	98.15	100.00	100.00
Clone RRM 10	12.96	20.37	35.19	68.52	81.48	85.19	94.44	96.30	100.00
Saracura	0.00	9.26	27.78	40.74	55.56	66.67	87.04	94.44	100.00
BRS Dourada	0.00	9.80	11.76	17.65	23.53	43.14	49.02	84.31	100.00
BRS Gema de ovo	12.96	24.07	27.78	38.89	57.41	72.22	77.78	94.44	100.00
Aipim Brasil	9.26	20.37	27.78	35.19	40.74	44.44	51.85	59.26	100.00
BRS Japonesa	14.81	29.63	40.74	40.74	50.00	61.11	85.19	90.74	100.00
BRS Moura	5.56	11.11	24.07	31.48	44.44	66.67	81.48	94.44	100.00
Clone RRM 9	15.69	39.22	54.90	60.78	64.71	74.51	82.35	90.20	100.00

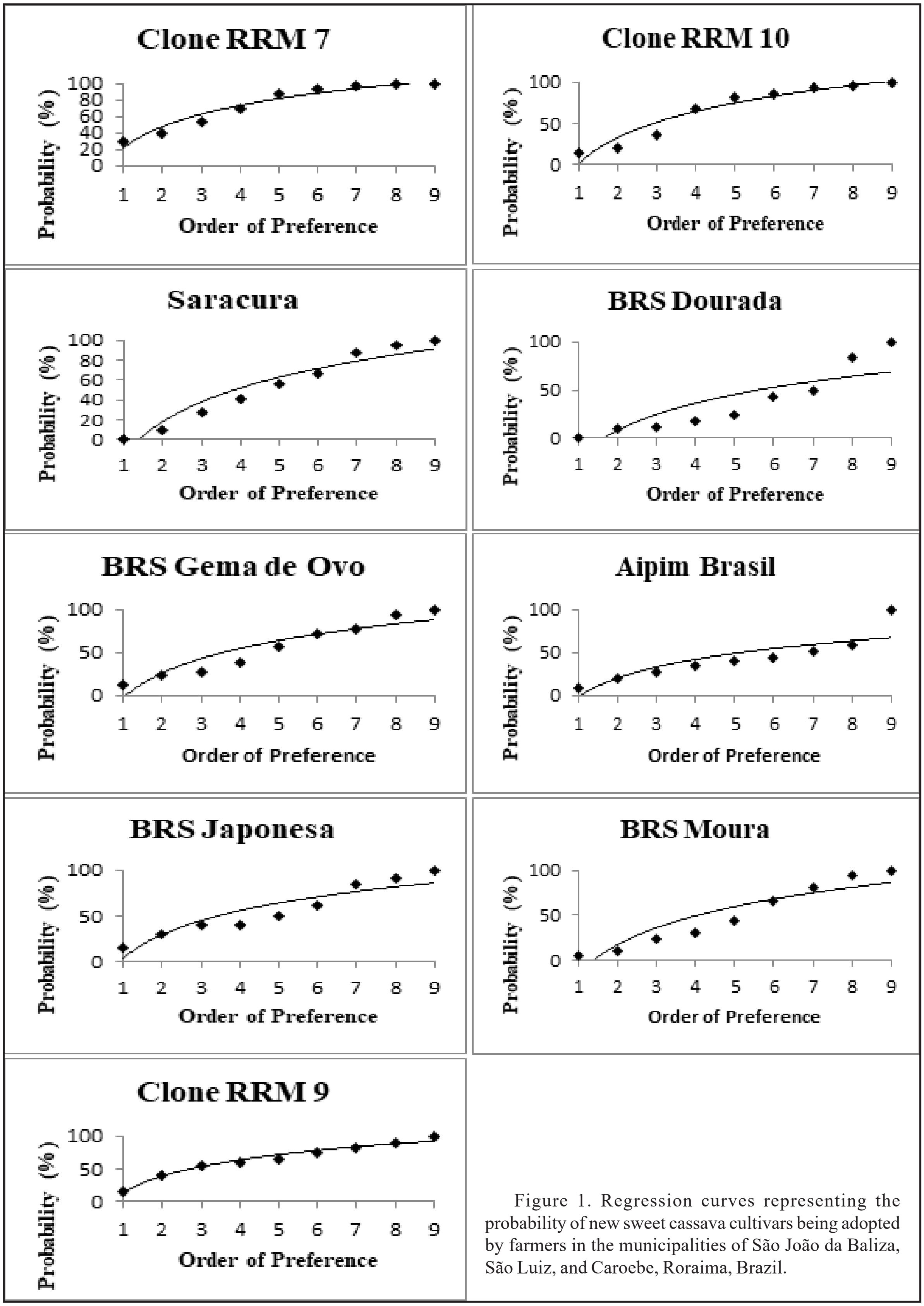

Figure 1. Regression curves representing the probability of new sweet cassava cultivars being adopted by farmers in the municipalities of São João da Baliza, São Luiz, and Caroebe, Roraima, Brazil.

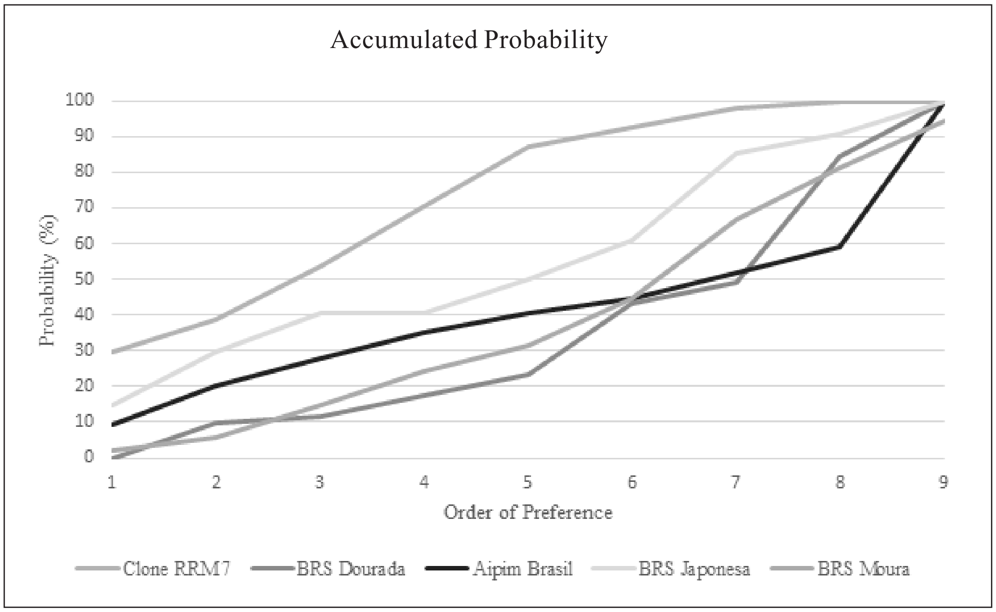

Figure 2. Comparison of the preference curves of the sweet cassava cultivars selected by farmers in participatory evaluations in the municipalities of São João da Baliza, São Luiz, and Caroebe, Roraima, Brazil.

Table 4. Regression parameters, intercept (â), regression coefficient (^b), standard deviation (SD), and coefficient of determination (r^2) estimated by the regression curves for each cultivar

Cultivars	â	^b	SD	r^2
Clone RRM 7	0.09599	0.26492	0.01141	0.90994
Clone RRM 10	0.11852	0.06790	0.01475	0.90220
Saracura	0.13333	-0.13169	0.00531	0.98903
BRS Dourada	0.12059	-0.22603	0.01513	0.90069
BRS Gema de Ovo	0.11543	-0.01543	0.00533	0.98532
Aipim Brasil	0.08951	-0.01543	0.01323	0.86737
BRS Japonesa	0.10556	0.04218	0.00724	0.96814
BRS Moura	0.12963	-0.13786	0.00665	0.98189
Clone RRM 9	0.09314	0.18137	0.00790	0.95200

and BRS Japonesa cultivar. A negative regression coefficient (^b), even with a higher intercept (â), rules out the probability of a cultivar being the first in the farmers' preference and increases the probability of being the last in the ranking, which is the case for the other cultivars, especially BRS Dourada, BRS Moura, Aipim Brasil and Saracura.

Similar results were found by Fukuda et al. (2008b) applying the methodology in several states, municipalities and communities in Northeast Brazil. The cultivars BRS Dourada, BRS Gema de Ovo and Amarelo II presented a positive regression coefficient (^b) and being first in the farmers' rank. Amarelo I, Rosa, Cacau Amarelo, and Aipim Cacau obtained a negative regression coefficient (^b) and were last in the ranking order. However, there were some differences among communities from different States. In Maranhão State, the cultivars Amarelo I and Amarelo II presented the highest probability of acceptance by farmers, whereas in Pernambuco and Piauí States the preference was for the cultivars BRS Dourada, BRS Gema de Ovo and Abóbora and in Ceará State for Cacau and BRS Gema de Ovo. The factors that determined the adoption of cultivars were the different ecosystems, which varied within the same state and municipalities, showing the vulnerability of recommending cassava cultivars without first testing them in several places with the participation of farmers. This demonstrates that in the genotype x environment interaction, in cassava, the farmer's environment is included.

Vieira et al. (2018) had conducted and selected through 27 participatory tests at Distrito Federal, Brazil, the sweet cassava cultivars BRS 396, BRS 397, BRS 398 and BRS 399 that by their agronomic performance and their high level of acceptance among producers qualified them as a new crop option for cultivation in the region.

Fukuda et al. (2006, 2008a and 2008b) concluded in their work that the logistic analysis of cassava cultivars preference by farmers as calculated from the probability matrices was one of the most effective tools for selecting or discarding new research-generated cultivars.

Conclusion

Based on these preference matrices and the acceptance probability of the cultivars evaluated in Southern Territory, Roraima, Clone RRM 7, Clone RRM 9, BRS Japonesa cultivar and Clone RRM 10 were selected for their recommendation potential given their high probability of being adopted by farmers in that region.

Acknowledgments

First, the authors thank all of the farmers in the three municipalities and the collaborators who participated in all stages of the project. They also thank the Fundação Eliseu Alves (FEA) for the efficient release of resources and the Banco Nacional de Desenvolvimento Econômico e Social (BNDES) for financing the Integrated Amazon Project.

Literature Cited

FUHRMANN, E. et al. 2019. Agronomic performance and biochemical attributes of yellow-pulped elite sweet cassava clones. Científica 47:77-82.

FUKUDA, W. M. G.; SAAD, N. 2001. Participatory research in cassava breeding with farmers in Northeastern Brazil. Cruz das Almas, BA, Embrapa Mandioca e Fruticultura Tropical. (Documentos 99).

FUKUDA, W. M. G. et al. 2006. Seleção participativa de variedades de mandioca de mesa na Chapada do Araripe. Cruz das Almas, BA, Embrapa Mandioca e Fruticultura Tropical. (Documentos 160).

FUKUDA, W. M. G. et al. 2008a. Seleção de variedades de mandioca com a participação de agricultores do Sudoeste do estado da Bahia. Cruz das Almas, BA, Embrapa Mandioca e Fruticultura Tropical. (Documentos 164).

FUKUDA, W. M. G. et al. 2008b. Adoção de variedades de mandioca de polpa amarela para mesa no Nordeste Brasileiro. Cruz das Almas, BA, Embrapa Mandioca e Fruticultura. Boletim de Pesquisa e Desenvolvimento, 41.

HERNANDEZ-ROMERO, L. A. 2000. Logistic preference ranking analysis for evaluation technology options: a user manual and application for Microsoft Excel 7.0. Final version. Cali: CIAT. (Document 319).

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA - IBGE. 2021. Produção Agrícola Municipal. Mandioca. Brasília, DF, Ministério do Planejamento, Orçamento e Gestão. Disponível em: <https://cidades.ibge.gov.br/brasil/rr/pesquisa/14/10193> Accessed on 2 dec 2021.

LORENZI, J. O. 2012. Mandioca. Campinas, SP, CATI. Boletim Técnico 245.

MINISTÉRIO DO DESENVOLVIMENTO AGRÁRIO - MDA. 2010. Plano Territorial de Desenvolvimento Rural Sustentável: Propostas de Políticas Públicas para o Território Sul de Roraima. Rorainopolis/RR: P. 120. Disponível em: <http://sistemas. mda.gov.br/sdt/pdf>. Accessed on 16 nov 2020.

MENDONÇA, R. M. et al. 2020. Agronomic performance of sweet cassava cultivars. Horticultura Brasileira 38:434-438.

OLIVEIRA, M. A.; MORAES, P. S. B. 2009. Características físico-químicas, cozimento e produtividade de mandioca cultivar IAC 576-70 em diferentes épocas de colheita. Ciência e Agrotecnologia 33:837-843.

RINALDI, M. M. et al. 2017. Shelf life of minimally processed cassava roots submitted to different conservation methods. Científica 45:9-17.

RINALDI, M. M.; VIEIRA, E. A.; FIALHO, J. F. 2019. Postharvest conservation of minimally processed cassava roots subjected to different packaging systems. Científica 47:144-155.

SOUZA, E. D. et al. 2014. O Cultivo da Mandioca em Roraima. Boa Vista, Roraima, Embrapa Roraima. Sistema de Produção, 05. 90p.

VIEIRA, E. A. et al. 2011. BRS Japonesa: new sweet cassava cultivar for the Distrito Federal region. Crop Breeding and Applied Biotechnology 11:193-196.

VIEIRA, E. A. et al. 2018. Sweet cassava cultivars with yellow or cream root pulp developed by participatory breeding. Crop Breeding and Applied Biotechnology 18:450-454.