Scientia Agraria Paranaensis – Sci. Agrar. Parana.
ISSN: 1983-1471 – Online
DOI: https://doi.org/10.18188/sap.v20i4.28330

AGRICULTURE PERFORMANCE OF TABLE CASSAVA CULTIVARS IN WEST REGION OF PARÁ

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SAP 28330 Received: 23/12/2021 Accepted: 20/03/2022
Sci. Agrar. Parana., Marechal Cândido Rondon, v. 20, n. 4, oct./dec., p. 346-351, 2021

ABSTRACT - The cassava crops have a great diversity of cultivars, mostly creole, being necessary studies that aim the selection of materials able to express its productive potencial in distinctive areas of Brazil. Thus, this work aimed to assess the agronomic characteristics and the productive of seven cultivars of table cassava, in the West region of Pará. The experiment was carried out in a rural property, in the municipality of Mojuí dos Campos (Pará). The experimental design was randomized blocks, with three repetitions. The treatments were constituted of local cassava cultivars (Água Morna, Roxa do Curudi, Amarelona, Olhinho, Máximo, Tabocal II e Paço Branco). The evaluated characteristics were: height of plants – HP (m), height of the first ramification – HR (m), diameter of the plant stem – DPS (cm), number of sprouts - NS, number of harvested roots - NHR, root fresh biomass – RFB (g), root dry biomass – RDB (g), diameter of roots –DR (cm), length of roots – LR (cm) and productivity (PR). For the characters in the aerial part, the 'Roxa do Curundi' cultivar showed the highest HP and HR 'Máximo e Paço Branco' expressed the highest DPS and NS, respectively. The cassava cultivars studied distinguished as to the characteristics of agronomic interest for inclusion in plant breeding programs of the species in the western region of the state of Pará. Among the evaluated cultivars, 'Paço Branco' is recommended for agricultural improvement, as it presents desirable characteristics, such as higher productivity and smaller size.
Keywords: *Manihot esculenta* Crantz, agronomic characteristics, productivity.

DESEMPENHO AGRONÔMICO DE CULTIVARES DE MANDIOCA DE MESA NA REGIÃO OESTE DO PARÁ

RESUMO - As lavouras de mandioca contam com grande diversidade de cultivares, em sua maioria crioulas, sendo necessários estudos que visem a seleção de materiais capazes de expressar seu potencial produtivo em distintas regiões do Brasil. Assim, com este trabalho objetivou-se avaliar as características agronômicas e a produtividade de sete cultivares de mandioca de mesa, na região oeste do Pará. O experimento foi realizado em uma propriedade rural, no município de Mojuí dos Campos (PA). O delineamento experimental foi blocos casualizados, contendo sete tratamentos e três repetições. Os tratamentos foram constituídos por cultivares de mandioca locais (Água Morna, Roxa do Curudi, Amarelona, Olhinho, Máximo, Tabocal II e Paço Branco). As características avaliadas foram: altura de plantas - HP (m), altura da primeira ramificação – HR (m), diâmetro do caule da planta – DC (cm), número de brotações – NB, número de raízes colhidas – NRC, biomassa fresca das raízes –BFR (g), biomassa seca das raízes – BSR (g), diâmetro de raízes – DR (cm), comprimento de raízes – CR (cm) e produtividade – PR (t ha^{-1}). Para os caracteres de parte aérea, a cultivar Roxa do Curudi apresentou maior HP e HR, enquanto a Máximo e Paço Branco expressaram maior DC e NB, respectivamente. As cultivares de mandioca estudadas distinguiram quanto às características de interesse agronômico para inclusão em programas de melhoramento vegetal da espécie na região oeste do estado do Pará. Entre as cultivares avaliadas, a Paço Branco é recomendada para o melhoramento agrícola, por apresentar características desejáveis, tais como maior produtividade e menor porte.
Palavras-chave: *Manihot esculenta* Crantz, características agronômicas, produtividade.

INTRODUCTION

Brazil is the fourth biggest world cassava productor (*Manihot esculenta* Crantz), behind only from Nigeria, Democratic Republic of Congo and Thailand (FAO, 2019). In the harvest of 2019 were harvested 1.3 million hectares, totalizing a production of 20.4 million tons of roots and an average yield of 14.8 t ha^{-1}. The state of Pará is the biggest national productor with 3.7 million tons produced. However, its productivity reaches only 14.5 t ha^{-1}, lower value than that achieved in the state of Paraná, the second largest producer, with an average yield of 22.7 t ha^{-1} (IBGE, 2019).

Table cassava, also known as manioc, vary from the industrial one, mainly due to the low levels of hydrocyanic acid (HCN) in their roots, that is, below 50 mg kg^{-1} of fresh roots (FUKUDA, 2006). The table cultivars should exhibit good agronomic performance, with productive plants and good architecture, coupled with

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acceptable sensory characteristics, such as: shorter cooking time, no bitterness, pleasant taste and low levels of hydrocyanic acid to avoid poisoning during consumption (VALLE et al., 2004; VALLE; LORENZI, 2014).

The table cassava is widely cultivated in the West region of Pará and it has good market acceptance because it is a basic source of carbohydrates and vitamins. In 2016, from the five municipalities that most contributed to the production of table cassava and industrial in the state, three belong to the western region, they are: Santarém (5.62 %), Alenquer (4.69 %) and Oriximiná (4.22 %) (FAPESPA, 2017). However, it is possible to observe that the crops are composed of creole cultivars or not adapted to the edaphoclimatic conditions of the region, in addition to the adoption of low technological level (AMORIM et al., 2020), mainly because it is a family activity.

In this sense, are needed studies that aim the increasing of the productivity of this crop by selecting cultivars capable of expressing their productive potential in the region. These studies may enable the indication of these cultivars for cultivation on a commercial scale and encourage an increase in domestic caloric intake as observed in Malawi (RUSIKE et al., 2010). Thus, this work aimed to evaluate the agronomic characteristics and productivity of seven cultivars of table cassava, in the western region of Pará.

MATERIALS AND METHODS

The experiment was carried out during the period from June 2014 to October 2015, in a rural property located in the community Mojuí dos Pereiras (under geographical coordinates of 2º 39' 11.7" S, 54º 43'06,7" W), municipality of Mojuí dos Campos (PA). The climate, according to the Köppen classification, is type Am, in other words, tropical humid and subhumid. In Figure 1, are shown climatic data collected at the Belterra meteorological station, located in the same geographical area of the experiment.

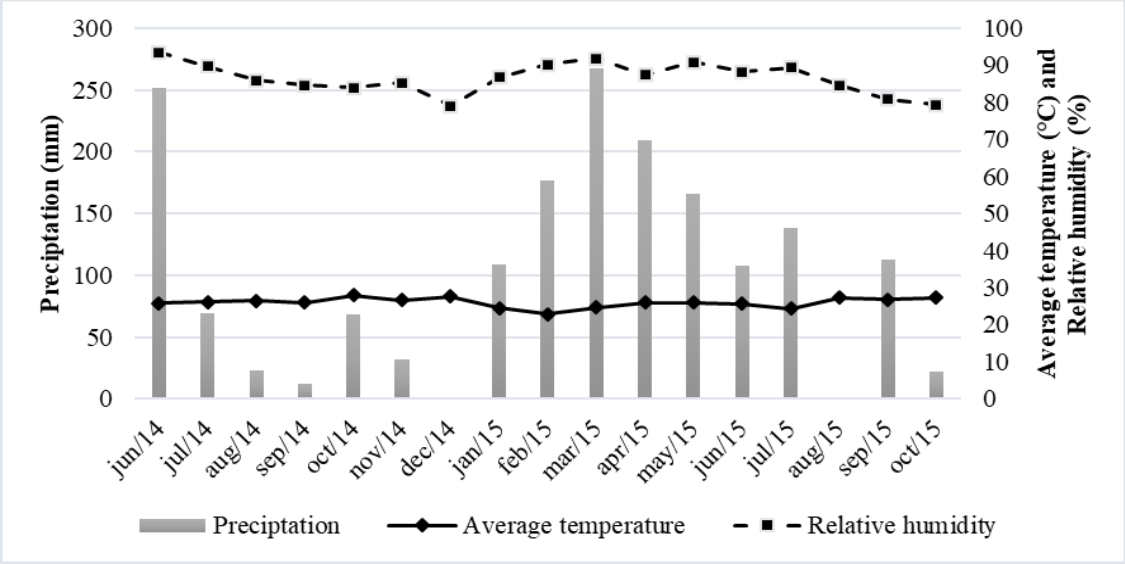

FIGURE 1 - Rainfall, relative air humidity and average monthly temperature in the period from June 2014 to October 2015, in the municipality of Belterra (PA). Meteorological Database for Teaching and Research.

The soil preparation was carried out in a conventional way, through plowing and harrowing. The soil was corrected by the application of 1.0 t ha^{-1} of dolomitic limestone and the planting and covering fertilizers were: 40 kg ha^{-1} of N, 40 kg ha^{-1} of P_2O_5 and 20 kg ha^{-1} of K_2O, following the recommendation of Embrapa Pará (CRAVO et al., 2020) and taking into consideration the soil analysis of the site, described in Table 1.

TABLE 1 - Chemical and particle size characterization of the soil, before the installation of the experiment.

Chemical characterization													
Prof.[1]	pH	N	P	K	Na	Ca	Ca+Mg	Al	H+Al	SB[2]	T[3]	V[4]	MO[5]
(cm)	(H_2O)	(dag kg^{-1})	(mg dm^{-3})			---------- ($cmol_c$ dm^{-3}) ----------						(%)	(g kg^{-1})
0-20	4.6	0.41	7	67	34	2.0	2.6	0.8	6.77	6.00	9.69	30.13	6.39

Granulometric Characterization[6]				
Prof.[1]	Sand	Silt	Clay	Textural class
(cm)	---------- (g kg^{-1}) ----------			
0-20	50	250	700	Very clayey

[1]Depth, [2]base sum, total cation exchange capacity (CTC), [4]base saturation (V), [5]organic matter (OM), [6]pipette method.

The weeds control was carried out during the whole period of conducting the experiment, as necessary, by means of manual weeding, with the objetive of eliminating any interference on the genotypes evaluated. The cultivars used in the experiment, which constituted the treatments, were collected in the region because they were cultivated by different producers, having the following denominations: Água Morna, Roxa do Curudi, Amarelona, Olhinho, Máximo, Tabocal II e Paço Branco.

The planting was carried out manually, adopting 20 cm long grooves, which were arranged horizontally in grooves of 10 cm depth previously opened with a grower, and spaced 1 m between plants and 1 m between lines. The experimental design was random blocks, containing seven treatments (cultivars) and three repetitions. Each plot consisted of three lines of 5 m in length, totaling 15 plants per plot and 45 per treatment, in a total of 315 plants in 315 m² of area.

The following characteristics were evaluated: plant height (m) - determined with the aid of wooden strips from the ground level to the terminal bud; diameter of the plant stem (cm) - measured at the base of the plant, through digital caliper; number of sprouts - assessed by counting the number of sprouts of the "mother" maniva; height of first branch (m) - measured with wooden ruler, from ground level to first fork. For these variables, random data were collected from seven plants from each plot, at 13 months after planting.

The harvest was carried out at 15 months after planting. At this time, the plants from the central row of each plot were collected and the characteristics assessed: number of roots harvested - by counting the number of roots immediately after harvest and productivity (t ha^{-1}) - expressed by root biomass per hectare.

Four representative roots were selected from each plot after harvesting and taken to the laboratory for the following evaluations: fresh root biomass (g) - carried out by weighing the fresh root; dry root biomass (g) - determined by weighing the root, which has been sliced and placed in an oven for 144 h, at a temperature of 70°C until it reaches a constant weight; root length (cm) - determined from the measurement of the four roots, with the aid of a tape measure and a root diameter (cm) - determined from the measurement, with a digital caliper, of the four selected roots.

The results obtained were submitted to the Kolmogorv-Sminov and Bartlett tests for checking the assumptions of the variance analysis. This was followed by Anova and Pearson's correlation. The mean of the treatments, when significant, were compared by the Tukey test at 5 % probability of error. Software ASSISTAT 7.7 Beta (SILVA; AZEVEDO, 2016).

RESULTS AND DISCUSSION

The treatments showed significant differences for the variable height of plants (HP), whose cultivar Roxa do Curudi presented higher average height (2.41 m) and the cultivar Paço Branco the smaller (1.38 m) (Table 2). Rimoldi et al. (2006) similar results were found for cultivars: Caipira (2.60 m) and Forty Kilos (2.53 m). Also according to the authors, the variation in the height of plants occurs as a function of the environment and also of the genotype of each cultivar. In the state of Minas Gerais, the BGMC 768 and BGMC 982 accesses, evaluated in two crops, obtained an average height of 2.50 m (VIEIRA et al., 2015).

The height of plants is an important factor for the implantation of the crop, since from this can be made decisions as to the choice of species for consortium, as well as to define the best spacing between plants (RÓS et al., 2011). There was no difference between the treatments for the diameter of the stem of the plants (SD), being the variation of 2.50 to 2.92 cm for Tabocal II and Maximus, respectively, corroborating the results found by Foloni et al. (2010), for twelve industrial cassava cultivars, where they also did not observe any difference between treatments for this variable and whose variation was 2.04 to 2.56 cm.

TABLE 2 - Height of plants (m), stem diameter (cm), height of first branch (m) and number of sprouts of cassava cultivars.

Cultivars	Height of plants	Stem diameter	Height of first branch	Number of sprouts
Água Morna	2.00 ab*	2.79 a	0.39 ab	1.38 a
Paço Branco	1.38 b	2.70 a	0.23 b	2.17 a
Roxa do Curudi	2.41 a	2.71 a	0.71 a	1.95 a
Amarelona	1.86 ab	2.80 a	0.54 ab	1.58 a
Olhinho	1.98 ab	2.79 a	0.40 ab	1.92 a
Máximo	1.76 ab	2.96 a	0.53 ab	1.76 a
Tabocal II	1.71 b	2.50 a	0.34 ab	1.81 a
Overall Average	1.87	2.75	0.44	1.79
CV (%)	12.60	13.62	35.86	22.42

*Averages followed by the same letter in the column do not differ significantly, by the Tukey test, at 5% probability of error. CV(%) = coefficient of variation.

The stem diameter is an important indicator of the quality of the planting material, since stems with larger diameters show greater nutritional reserves that favor the initial development of the plants (DUQUE; SETTER, 2013). The treatments showed significant difference for height of the first branch (HB), with an average of 0.71 m for Curudi Purple and 0.23 m for Paço Branco (Table 2). Vieira et al. (2015) found the same behavior when

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evaluating eight approaches of cassava in two crops. However, the average HB found by the authors was higher, with variation from 0.63 to 1.11 m in the first harvest and 0.76 to 1.29 m in the second harvest. Manioc cultivars with higher branching heights are preferable, due to this characteristic is directly related to the ease of cultivation and use of manivas for future planting (VIEIRA et al., 2013).

For the number of sprouts (NS) there was no difference between the cultivars. However, it is observed that Paço Bran-co, among the others, was the one that developed the largest number of buds (2.17). One of the hypotheses that explains the non-occurrence of difference for this variable is the standardization in the length of the grapes used in planting, given that all of them were 20 cm. The length of manivas has a linear effect on the number of buds, because the larger the manivas, the more reserves and the larger number of buds they will present (VIANA et al., 2001).

Under the conditions in which the treatments were tested, there was no influence on length (RL), diameter (RD) and number of roots collected (NRC) (Table 3). In the Cerrado, a distinct behavior was observed, where the six cultivars evaluated showed effects on the length, diameter and number of roots per plant (PAZ et al., 2020). This difference in behavior between the studies may be related both to the cultivars used and to the environment (EMBRAPA, 2005).

TABLE 3 - Root length (RL), root diameter (RD), number of harvested roots (NHR), root fresh biomass (RFB), root dry biomass (RDB) and cassava cultivar productivity (PR).

Cultivars	RL (cm)	RD (cm)	NHR	RFB (g)	RDB (g)	PR (t ha^{-1})
Água Morna	25.83 a*	5.78 a	8.00 a	363.77 a	147.05 a	20.80 b
Paço Branco	25.08 a	7.49 a	9.66 a	519.71 a	171.86 a	45.00 a
Roxa do Curudi	28.25 a	5.57 a	13.33 a	361.35 a	142.05 a	19.06 b
Amarelona	26.50 a	5.44 a	7.66 a	219.01 a	82.05 a	24.63 b
Olhinho	24.83 a	6.08 a	7.66 a	400.31 a	136.76 a	20.26 b
Máximo	25.41 a	6.13 a	6.50 a	316.50 a	142.50 a	14.16 b
Tabocal II	26.78 a	4.90 a	9.50 a	222.29 a	80.88 a	25.00 b
Overall Average	26.10	5.91	8.90	343.28	129.02	24.13
CV(%)	13.01	16.52	34.72	43.82	40.06	18.14

*Averages followed by the same letter in the column do not differ significantly by the Tukey test at 5 % probability of error. CV(%) = coefficient of variation.

No differences were obtained for RFB and RDB, although the cultivar Paço Branco has presented values higher than the others, for both characteristics. RDB is an important predictor of starch content in cassava roots, which becomes a fundamental characteristic for industrial root yield (CARDOSO et al., 2014). The treatments showed effects on root PR. The Paço Branco cultivar expressed the highest productivity (45 t ha^{-1}), being higher than the average of the state of Pará (14.5 t ha^{-1}) (IBGE, 2019) and, also, the averages of studies carried out in the states of Paraná and Rio Grande do Sul (VIDIGAL FILHO et al., 2007; TIRONI et al., 2015). In turn, the cultivars Maximo, Roxa do Curudi and Olhinho had the lowest values of productivity, with averages of 14.16; 19.06; 20.26 t ha^{-1}, respectively. Of the treatments evaluated, only the Maximum cultivar showed a productivity value below the average in the state of Pará.

Generally speaking, the Paço Branco cultivar presented the lowest PH, in relation to the other cultivars, thus expressing a higher productivity. This can be justified by the high diameter and production of fresh and dry root biomass. Thus, smaller cassava cultivars have greater efficiency in the use of nutrients for root production (EL-SHARKAWY; TAFUR, 2010).

Table 4 shows the correlation between the variables evaluated, i.e. the degree of influence that one variable has on the other. In this case, values closer to 1.0 represent a strong correlation between the variables. The RDB and RDB variables presented positive and non-significant correlations with productivity (Table 4), which indicates that there is no influence of these characteristics on the PR. These results are contrary to those observed in Sousa et al. (2021), which when evaluating cassava clos in second cycle noted a high positive correlation between the fresh biomass of commercial roots and PR, RD and NHR are positively correlated with productivity, as observed by Gomes et al. (2007), when evaluating one hundred clones of cassava, in which they noted the direct effect of the diameter and number of roots on productivity. The same authors also noted a positive correlation between RL and root production, differing from the result found in this work. The RL is a component that does not have a direct influence on cassava productivity, as it can be compensated for by the increase in RD (FIGUEIREDO et al., 2014).

The PH, PSD and HB variables showed negative correlations with productivity (Table 4), however, only PH was significant. Such results corroborate Somavilla et al. (2022), in which they state that the high growth of the aerial part of cassava occurs to the detriment of the development of roots and also confirm the data present in Table 2 (lower height of plants) and Table 3 (higher productivity of roots). Divergent results were presented by Campos et al. (2004), Gomes et al. (2007) and Vieira et al. (2014). In general, it is possible to observe that RD, NS and MRB, were the agronomic characters that presented positive correlations of greater magnitudes with productivity. The RD presents high flow-rate with FRB

and DRB, considered decisive components in the high productivity of cassava (FIGUEIREDO et al., 2014).

For the above, the results of this research point to important primary information for the introduction of better cultivars adapted to the conditions of western Pará. In addition, it provides useful data for the advancement of genetic improvement research in the region, aiming at increasing productivity in cassava, which may result in agro-industrial and socioeconomic development in the Amazon region.

TABLE 4 - Pearson simple correlation coefficients and probability between the characteristics of root fresh biomass (RFB), root dry biomass (RDB), productivity (PR), root length (RL), root diameter (RD.), number of harvested roots (NHR), plant height (PH) plant stem diameter (PSD), height of first branch (HB) and number of sprouts (NS) of manioc cultivars.

	RFB	RDB	PR	RL	RD	NHR	PH	PSD	HB	NS
RFB	1.000	0.943	0.358	0.297	0.766	0.450	-0.066	0.177	-0.124	0.086
		0.000**	0.111	0.191	0.000**	0.041*	0.777	0.443	0.594	0.711
RDB		1.000	0.208	0.351	0.786	0.316	0.023	0.154	0.020	0.179
			0.366	0.119	0.000**	0.163	0.921	0.504	0.930	0.436
PR			1.000	-0.053	0.516	0.135	-0.509	-0.131	-0.411	0.417
				0.818	0.017*	0.559	0.018*	0.570	0.064	0.060
RL				1.000	0.213	0.326	0.393	0.106	0.338	0.231
					0.353	0.149	0.078	0.647	0.134	0.313
RD					1.000	0.046	-0.213	0.313	-0.123	0.491
						0.843	0.354	0.167	0.595	0.024*
NHR						1.000	0.247	0.166	0.126	-0.158
							0.281	0.473	0.588	0.495
PH							1.000	0.320	0.590	-0.006
								0.157	0.005**	0.978
PSD								1.000	0.088	-0.098
									0.704	0.672
HB									1.000	-0.006
										0.978
NS										1.000

** and *: by F-test, respectively, at the level of 1% and 5% probability of error.

CONCLUSIONS

The cassava cultivars studied distinguished in terms of characteristics of agronomic interest for inclusion in plant breeding programs of the species in the western region of the state of Pará.

Among the cultivars evaluated, Paço Branco is recommended for agricultural improvement, as it has desirable characteristics, such as higher productivity and smaller size.

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