Conjecturas

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Productive performance of cassava ethnovarieties in relation to planting position

Desempenho produtivo de etnovariedades de mandioca em função da posição de plantio

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ABSTRACT

The objective of this study was to evaluate the productivity of three cassava ethnovarieties, whose cuttings were planted in two positions: vertical and horizontal in the municipality of Alta Floresta, Mato Grosso state (MT), Brazil. The plants which originated from vertically planted cuttings gave rise to roots with a larger length and larger diameter when compared to those planted horizontally. Root yield was higher for the Cacau Roxa ethnovariety (13.79 t/ha), and produced 30.57% more than Cassava Amarela and 56.12% more when compared to Cassava for frying without being boiled first. This higher yield can also be observed for the weight of the aboveground part of the plant (10.60 t/ha). In both planting positions there was a positive correlation between root diameter and harvest index, as well as root yield and the weight of the aboveground part of the plant. The results show that the cultivation of the plant by placing the cuttings in the vertical position had superior performance in relation to planting them in the horizontal position in regards to the root length and diameter, but there was no difference in the root productivity when considering the planting positions of the roots.

Palavras-chave: *Manihot esculenta*; Agronomic characteristics; Productivity;

RESUMO

Objetivou-se neste estudo avaliar a produtividade de três etnovariedades de mandioca, cuja manivas foram plantadas em duas posições: vertical e horizontal no município de Alta Floresta, MT. As plantas originadas de manivas plantadas na posição vertical deram origem a raízes com maior comprimento e maior diâmetro, quando comparadas com as plantadas horizontalmente. A produtividade da raiz foi maior para etnovariedade Cacau Roxa (13,79 t/ha), produzindo 30,57% a mais que a mandioca Amarela e 56,12% em relação a Mandioca de Fritar Sem Cozinhar. Essa maior produtividade também pode ser observada para o peso da parte aérea (10,60 t/ha). Em ambas as posições de plantio houve uma correlação positiva do diâmetro da raiz e o índice de colheita, assim como para a produtividade das raízes e o peso da parte aérea. Os resultados obtidos, revelam que o cultivo com as manivas em posição vertical teve desempenho superior em relação a posição horizontal para as características comprimento e diâmetro da raiz, porém não há diferença na produtividade das raízes entre as posições de plantio das manivas.

Keywords: *Manihot esculenta*; Caracteres agronômicos; Produtividade;

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INTRODUCTION

The use of cassava (*Manihot esculenta* Crantz) in various parts of the world is due to its rusticity and adaptability to various edaphoclimatic conditions, as well as the advantage of easy propagation, satisfactory yield and resistance to pests and diseases (TONTINI, 2009). All these attributes lead cassava to be cultivated by small-scale farmers, and gives it great social and economic importance, since it is a source of income and energy for millions of people (GUSMÃO *et al*., 2006; ALVES, 2002).

Cassava, known as table cassava, macaxeira or aipim, is considered a vegetable product because of its peculiarities of cultivation and for being marketed together with vegetables (ELIAS *et al*., 2017). Its commercialization is occurs in supermarkets, markets and roadside stalls. In recent years, there has been a growth in the cassava market, due to the emergence of industries which provide frozen and pre-cooked frozen products, which guarantees quality products throughout the year. Since these products are more convenient for consumers, a greater consumption of the product has occurred (AGUIAR, 2003).

Brazil is the fourth largest cassava producer in the world, and its cultivation occurs mainly in the country's north, northeast, southeast, south and midwest (EMBRAPA, 2017; SEAB, 2017). It is among the main food sources of carbohydrates, second only to rice, sugar cane and corn (ANDRÉ and SANTOS, 2012). Its roots accumulate starch, which are the main parts of interest for human food and animal feed (BORGES *et al*., 2002), in addition to the aboveground protein-providing part, where the protein is mainly concentrated in the leaves (FERNANDES *et al*., 2006).

The main form of cassava propagation is vegetative, through the branches, cuttings or cuttings (RODRIGUES *et al*., 2008; FERREIRA *et al*., 2008). The most common planting position of the cutting is horizontal, because of the ease of planting and harvesting, but the cuttings can also be planted in vertical and inclined positions (TONTINI, 2009; EMBRAPA, 2003), as the studies described by Godo (1984), Viana *et al*. (2000), Tontini (2009), Cerqueira *et al*. (2016) have proven in terms of efficiency,

Considering that agriculture is one of the main activities developed in several municipalities of the state of MT, and that cassava is among the main crops, with more than one ethnovariety per farmer, this study aimed to evaluate the productivity of three ethnovarieties of cassava, whose cuttings were planted in two positions: vertical and horizontal in the municipality of Alta Floresta, MT.

MATERIAL AND METHODS

Study area

The experiment was carried out at the São Paulo smallholding, located in the Segunda Oeste Nova Esperança community in the municipality of Alta Floresta, MT (9°56’28.73 S and 56°9’12.78 W).

The climate of the region according to the Köppen classification is of type Am, with two well-defined seasons, with a rainy summer (October to April) and a dry winter (May to September), characterized by annual temperature averages above 24ºC and rainfall above 2,500 mm (ALVARES *et al.*, 2013).

The soils range from Yellow and Red-Yellow Argisols and, to a lesser extent, Oxisols and Hydromorphic soils, with low to medium fertility, medium nutrient percentage and mainly low levels of phosphorus and medium potassium, calcium, magnesium and organic matter (FERREIRA, 2001).

Soil analysis for chemical characterization of the area was performed at the Soil, Fertilizer and Leaf Analysis Laboratory (LASAF) and can be found in Table 1. For fertilization of ethnovarieties at three months of age, NPK with the formula 4-14-8 was used following the criteria described by Sousa and Lobato (2004).

Table 1 - Result of chemical and physical analysis of soil from the experimental area in Alta Floresta, MT, in 2017.

pH		P	K	Ca^{+2}	Mg^{+2}	K^{+}	H^{+} Al^{+3}	Al^{+3}	CTC(T)	SB
H_2O	$CaCl_2$	..mg/dm^3..		....................................cmol$_c$/dm^3..................................						
5.4	4.6	0.7	36	1.14	0.25	0.09	3.0	0.2	4.5	1.5
V (%)	m (%)	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)						
33.33	9.7	574	91	335						

Fonte: Elaboraborado pelos autores.

Soil preparation and experimental design

The ethnovarieties used in the study come from the collection of works by Tiago (2016). The experiment was implemented in November, 2017 and harvesting was done in November, 2018. The ethnovarieties were chosen taking into consideration the use of roots in fresh form for human and animal food, and for being cultivated in the municipality of Alta Floresta, MT.

The soil was prepared using a harrow and grader to clean the field. To simulate the farmers' planting system, no soil correction was performed before planting.

The cuttings which were of a length of 15-20 cm, were removed from the middle third of the plants, and the ends were discarded (Figure 1). Before planting, the cuttings were immersed in a bucket containing insecticide (Forpins) to prevent attacks by termites and ants.

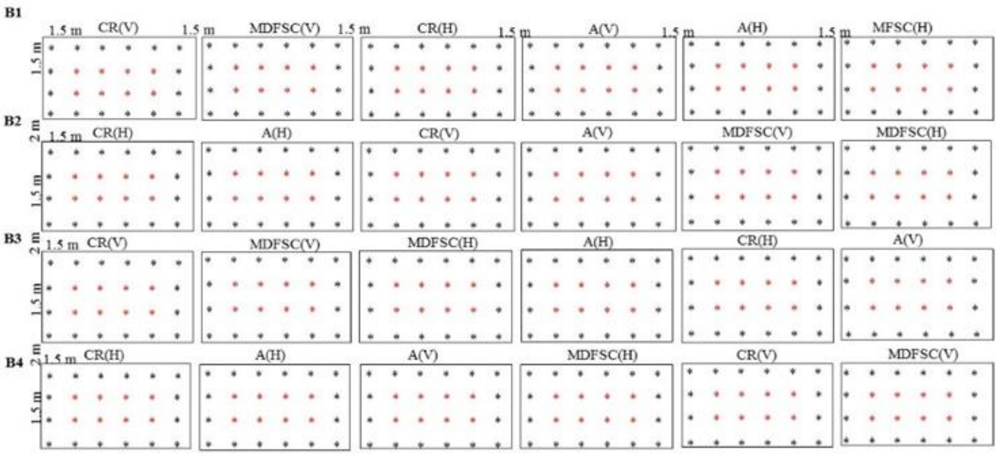
Figure 1 - Propagation material used in planting. A) *Mandioca de Fritar Sem Cozinhar*. B) *Cassava Amarela*. C) *Cassava Cacau Roxa*.

Fonte: Elaboraborado pelos autores.

The experiment consisted of two planting positions: T1: Vertical and T2: Horizontal and three cassava ethnovarieties. (Amarela; Cacau Roxa; Mandioca de Fritar Sem Cozinhar). The planting positions of each ethnovariety with the respective treatments in the plots were defined randomly. Thus, the same ethnovariety was present in the same block twice, i.e. in the vertical and horizontal position.

The total area of the experiment was 337.50 m2, with each plot measuring 33.75 m^2. The experimental design was a completely randomized block design (RBD), with 4 blocks, and six plots per block, each plot consisting of 24 plants, totaling 576 plants. Of the total, eight central plants of the useful area (192 plants) were evaluated, as highlighted in red, in Figure 2, and the others were used as border, standardizing the experiment installation environment. The planting was carried out with 1.5 m between rows; 1.5 m between plants and 2.0 m between blocks (Figure 2 and 3).

Figure 2 - Field experiment layout for the three ethnovarieties used in two planting positions. B: block; CR (*Cacau Roxa*); MFSC (*Mandioca de Fritar Sem Cozinhar*); A (*Amarela*); V (vertical); H (horizontal). The red dots indicate the plants evaluated and the black dots are the border plants.



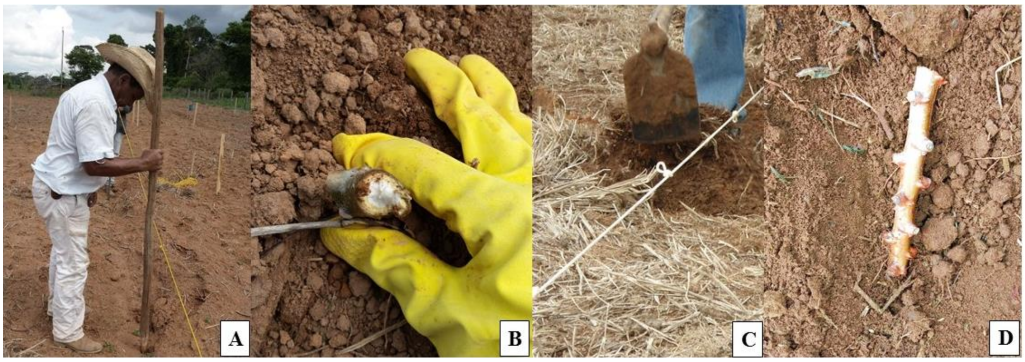
Fonte: Elaboraborado pelos autores.

Figure 3 - Development of cassava ethnovarieties in the experimental area (A), those planted in the vertical planting position (B) and those planted in the horizontal planting position (C).

Fonte: Elaboraborado pelos autores.

During planting, the cuttings were placed in their respective holes manually, at a depth of 15 cm, in moist soil with subsequent compaction of the soil around the cuttings in order to fix the material to the soil. The holes for planting the cuttings in the upright position were opened with the aid of a 170 cm-long, 10 cm diameter wooden stick and by exerting up and down movements in order to open the hole. For the planting of the cuttings in the horizontal position, the opening of the holes was performed with the help of a hoe (Figure 4).

Figure 4 - A and B show the planting position of the cuttings. Holes and planting of the cuttings in a vertical position. C and D show holes and planting of the cuttings in a vertical position.



Fonte: Elaboraborado pelos autores.

Experiment Evaluation

The experiment was evaluated twelve (12) months after planting (Figure 4), following the descriptors for *Manihot esculenta* Crantz according to Fukuda and Guevara (1998).

Six quantitative agronomic characteristics were evaluated for the three ethnovarieties (Figure 5): root length (CR), expressed in cm; root diameter (DR) in cm; root yield (PR) t/ha; weight of the aboveground section (PPA) t/ha; number of roots per plant (NRP), and harvest index (IC) t/ha, which was obtained using the formula:

$$IC=\frac{\text{root weight}}{\text{root weight}+\text{weight of the aboveground section}}*100 \quad (1)$$

For the qualitative variables we evaluated: root position; root format; root epidermis texture; root constrictions; external color of the root; root cortex color and root pulp color.

Figure 5 - A and B show the evaluation of the experiment. Manual removal of ethnovarieties from the soil; C shows the separation of the roots of the stem; D shows weighing of roots, and E, separation of the roots according to respective ethnovariety and recording of the data.

Fonte: Elaboraborado pelos autores.

Statistical analysis

The data were submitted to stand correction, which aimed at reducing the experimental error and adjustment of the mean of the plot. The correction was performed according to Cruz (2006). The correction method applied was the rule of three. In this method, it is assumed that the presence of one or more faults does not affect the yield of neighboring plants, through the formula:

(2)

$$Z_{ij} = Y_{ij} * (H/X_{ij})$$

in which Z_{ij} represents corrected productivity and Y_{ij} the yield observed in the plots, whose stand is X_{ij} plants and H represents the ideal stand.

The transformed data were subjected to analysis of variance and the Shapiro-Wilk normality test at 5% of significance, with distribution considered normal. When the F value was significant at the 1% and 5% probability level, the Tukey test was applied to compare the means. Data were analyzed with the aid of the GENES program, version 2019.3, with integration with the R environment (CRUZ, 2016).

The analysis of the correlation coefficients between the six quantitative variables for the vertical and horizontal planting positions was performed using the R environment program, version 3.2.4 (R CORE TEAM, 2016).

RESULTS

The analysis of variance revealed a significance level of 1% ($p \leq 0.01$) for the variables root yield (PR) and weight of aboveground section (PPA) between the ethnovarieties, and a significance of 5% ($p \leq 0, 05$) for root length (CR) and root diameter (DR) according to planting position (Table 2). The largest CVs were found in the variables PR, PPA and NRP.

Table 2 - Analysis of variance for six quantitative variables among three cassava ethnovarieties in two planting positions in 2018.

Source of Variation	GL	Median of Squares					
		CR	DR	PR	PPA	IC%	NRP
Blocks	3	78.87	17.77	7.13	5.63	61.34	6.78
Position	1	262.55*	70.59*	19.80ns	4.28ns	45.95ns	4.83ns
Ethnovarieties	2	147.23ns	31.58ns	123.13**	97.51**	141.47ns	14.97ns
Position x EV	2	36.35ns	10.43ns	2.70ns	2.72ns	7.85ns	17.88ns
Residuals	15	51.65	13.55	10.30	5.94	104.78	12.67
Median		33.14	16.61	9.95	8.24	54.27	12.00
C.V (%)		21.69	22.16	32.26	29.56	18.86	29.67

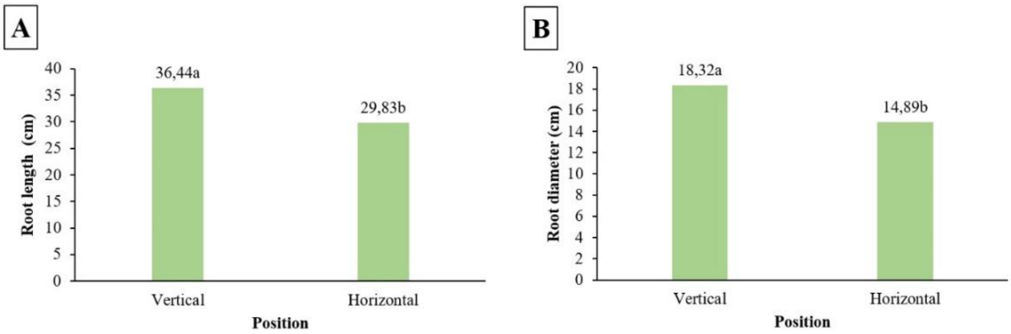
EV – Ethnovarieties; CR – Root length (cm); DR – Root diameter (cm); PR – Root yield (t/ha); PPA – weight of aboveground section (t/ha); IC – harvest index; NRP – Number of roots per plant; ** and * Significant at 1% and 5% probability by F test, ns – not significant.

Fonte: Elaboraborado pelos autores.

The mean length (CR) and root diameter (DR) for ethnovarieties, regardless of planting position, were 33.14 cm and 16.61 cm, respectively. (Table 2). The ethnovariety that stood out for having longer root length (CR) and root diameter (DR) was the *Cacau Roxa* variety (CR= 38.04 cm and DR= 17.94 cm), followed by *Mandioca de Fritar Sem Cozinhar* (CR= 31.29 cm and DR= 17.55 cm) and *Amarela* (CR= 30.08 cm and DR= 14.33 cm).

The planting position of the cutting in the soil showed a statistically significant difference, influencing the root length and diameter (Figure 6). Cuttings planted in an upright position gave rise to plants with larger root length (CR) and larger diameter (DR) when compared to those planted horizontally (Figure 6).

Figure 6 - Difference between planting position regardless of the evaluated ethnovarieties in relation to root length (CR) (A) and root diameter (DR) (B). Means followed by the same lowercase letter between positions do not differ statistically from each other by the Tukey test at 5% probability.

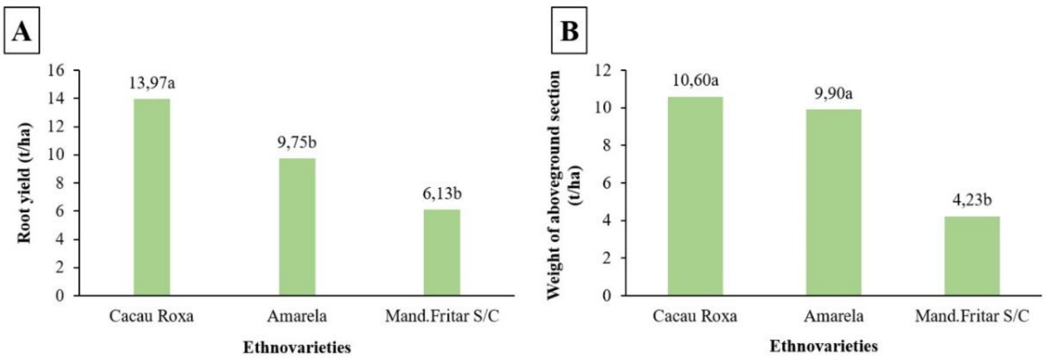


Fonte: Elaboraborado pelos autores.

The root yield (PR) and weight of aboveground section (PPA) showed no statistical differences between planting positions, but it was observed that the *Cacau Roxa* ethnovariety was the most productive (13.79 t/ha), since it produced 30.57% more than the ethnovariety *Amarela* and 56.12% in relation to *Mandioca de Fritar Sem Cozinhar* (Figure 6). This higher productivity can also be observed for the weight of aboveground section, where the ethnovarieties *Cacau Roxa* (10.60 t/ha) and *Amarela* (9.90 t/ha) presented a higher average in relation to *Mandioca de Fritar Sem Cozinhar* (4.23 t/ha) (Figure 7).

Although there was no statistical difference between the planting positions of cuttings for the root productivity variable, it was observed that the highest value was obtained by planting vertically (10.86 t/ha) in relation to the horizontal position (9.04 t/ha). The same was observed for PPA (8.66 and 7.82 t/ha, respectively). The number of roots per plant (NRP) was 12.44 for the vertical position and 11.56 for the horizontal position, with an average of 12 roots per plant.

Figure 7 - Root yield (t/ha) and weight of aboveground section (t/ha) of the cassava ethnovarieties evaluated irrespectively of the planting position in the municipality of Alta Floresta, MT. Means followed by the same lowercase letter between ethnovarieties do not differ statistically from each other by Tukey test at 1% probability.



Fonte: Elaboraborado pelos autores.

For the harvest index (IC%), the total average, regardless of the planting position was 54.27% (Table 2), with no statistically significant difference between the positions. However, planting with the vertical cuttings presented 2.77% more in the IC (IC = 55.65%) in relation to the horizontal position (IC = 52.88%). The ethnovarieties with the highest IC% were *Cacau Roxa* and *Mandioca de Fritar Sem Cozinhar* (56.79% and 56.61%, respectively), the lowest IC% was recorded for cassava *Amarela* (49.41%).

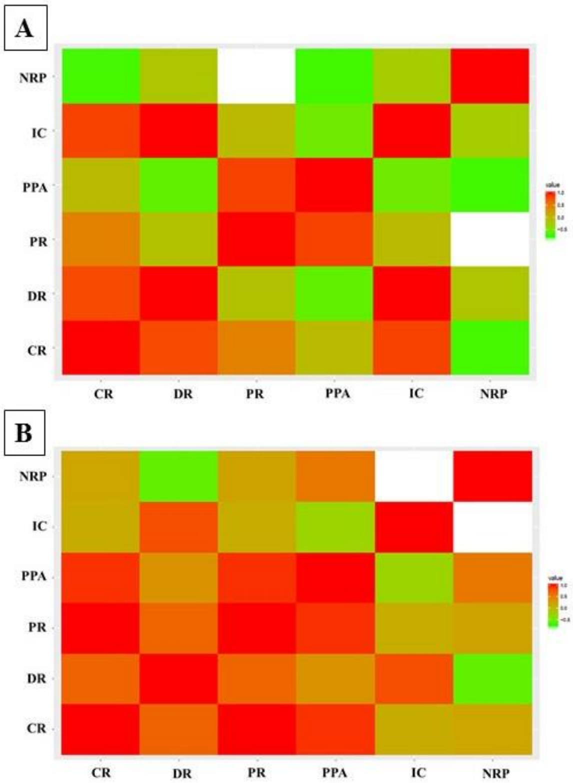
The correlation coefficient, between the means of the variables evaluated for the vertical planting position of the cutting, presented a scale that ranged from 1 to -0.5, with 1 being highly correlated and -0.5 being a negative correlation, therefore the closer to the red scale, the higher the correlation, the closer to green, the lower the correlation between the variables. The variables that showed negative correlation were CR with PPA (-0.04) and NRP (-0.69); DR with PR (-0.11), PPA (-0.61) and NRP (-0.15); PR with IC (-0.04) and NRP (-0.97); PPA with IC (-0.55) and NRP (-0.70); IC and NRP (-0.22). All other correlations were positive, and the variables CR with DR (0.82) and IC (0.86); DR and

IC (1.00); PR and PPA (0.86) presented correlation values close to 1 (Figure 8A). Only the CR and PR variables had a correlation below 0.50 (0.48).

For the horizontal planting position of the cutting, negative correlations were presented between the variables: DR and NRP (-0.59); PPA and IC (-0.29); IC and NRP (-0.96). The other variables presented positive correlations. The highest correlations were observed for the variables: CR with PR (1.00) and PPA (0.92); DR and IC (0.80); PR and PPA (0.92), (Figure 8B). Mean correlations were obtained between CR and DR (0.69); DR and PR (0.67); PPA and NRP (0.56). The lowest correlations were for CR and IC (0.12); CR and NRP (0.17); DR and PPA (0.34); PR and IC (0.10); PR and NRP (0.19).

In both planting positions there was a positive correlation between root diameter and harvest index, as well as root yield (PR) and weight of aboveground section (PPA) (Figure 8A and 8B).

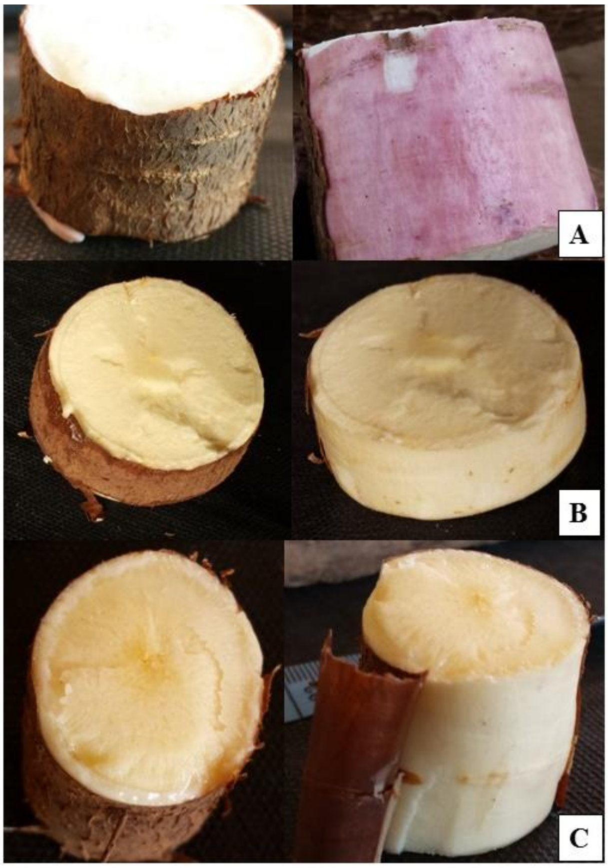
Figure 8 - Matrix correlation between six agronomic variables evaluated at 12 months after planting for three cassava ethnovarieties. A) Planting the cutting in the vertical position and B) Planting the cutting in the horizontal position. The darker the red, the greater the correlation between the variables, i.e. positive correlation close to 1; the darker the green, the lower and more negative the correlation; white indicates a negative correlation close to -1.



Fonte: Elaboraborado pelos autores.

The three cassava ethnovarieties showed horizontally-positioned root traits, cylindrical root shape, root epidermis texture as being rough, few or no constrictions (Figure 9). The ethnovarieties differed in external root color, root cortex color and root pulp color. The ethnovariety *Cacau Roxa* had dark brown external root color, rose-colored root cortex and white root pulp color. On the other hand, the *Cassava Amarela* and *Mandioca de Fritar Sem Cozinhar* ethnovarieties both stood out for having light brown outer root color, cream cortex color and a yellow pulp.

Figure 9 - Characteristics of the ethnovarieties. A) *Cacau Roxa*; B) *Mandioca de Fritar Sem Cozinhar* and C) *Amarela*.



Fonte: Elaboraborado pelos autores.

DISCUSSION

During the growth period of the three ethnovarieties in the field, no differences were observed between the planting positions, i.e., in both planting positions (vertical and horizontal) the plants' performance was excellent. This is different to what was reported by Viana *et al*. (2000) and Conceição (1983), who state that cassava cuttings, when planted horizontally and in a sloping position, may have slower emergence of sprouts. In the study by Santos *et al*. (2007) cited by Tonini (2009), upright planting of cuttings provided better plant growth and higher root yields compared to horizontal planting of cuttings. Godo (1984) also indicates that the planting of the cutting in the upright position is more advantageous than the horizontal one in terms of productivity and may be suitable for farmers growing cassava.

In our study, the planting position influenced the root length and diameter, with the highest average obtained in the vertical planting position, but did not interfere with the average root weight. Therefore, the two planting positions of the cuttings are recommended for use by farmers in the municipality of Alta Floresta, MT.

Although the planting position did not influence the average root weight, when we observed the individual variables for the means of the average root weight (PMRP), shoot weight (PPA), harvest index (IC%) and number of roots per plant (NRP), the highest values were acquired for the vertical position. Thus, if the farmer requires roots of greater length and diameter, the ideal planting position is a vertical one, otherwise, horizontal planting is indicated, since there is no influence on the final production. The position in which the cutting is planted will depend on the needs of the farmer and the market requirements or consumer preferences for sales of these roots.

Planting in a horizontal position also presents good results in root productivity, as observed in the study carried out by Viana *et al*. (2000), who studied the effects of cutting size and planting position in cassava harvests, and reported that the highest root yields were obtained with 20 cm horizontally-planted cuttings (20,292 kg / ha) and cuttings that were 30 cm planted in an inclined fashion (20.236 kg/ha).

The advantage of planting the cuttings in the horizontal position is to favor the superficial development of the roots, which facilitates the harvest. However, the inclined and vertical planting positions are less used, because the roots tend to go deeper into the soil and make harvesting more difficult, despite the higher obtained yield, as mentioned in previous works (MATTOS *et al*., 2006). This was also observed in our research, since all three ethnovarieties presented this same characteristic, i.e. the roots planted in the vertical position presented greater length and diameter of the roots.

The average yield for the aboveground section (PPA) was 8.24 t/ha (Table 2), and the planting position did not interfere with this variable. This is an important feature to be considered when selecting varieties, since this part of the plant serves as a source of protein in animal feed, in addition to it providing material for new cuttings and ground cover (FUKUDA *et al*., 2002; SOUZA *et al*., 2011). Thus, it is worth noting that, in terms of comparing root productivity against aboveground section yield, the ethnovariety *Amarela* showed higher performance in yield for the aboveground section (9.90 t/ha) when compared to root yield (9.75 t/ha). Thus, in studies aiming at higher yield in the aboveground section, this is an ethnovariety that can be used, due to its performance in this variable.

The root yield variable is the most interesting characteristic for economic and marketing reasons (GOMES *et al*., 2007). Root yield is considered a quantitative variable, and is influenced by planting time and environmental conditions, which often makes it difficult to compare our results with the results obtained with other studies (SILVA *et al*., 2002; KVITSCHAL *et al*., 2003; GOMES *et al*., 2007). In this study, it can be noted that the planting and harvesting time was favorable for all three of our ethnovarieties, since they presented excellent quality roots, good agronomic performance, and a low number of roots that could be considered non-commercially viable.

The highest root yield was presented by the ethnovariety *Cacau Roxa* (13.97 t/ha). Pedri (2018) studied four cassava ethnovarieties, which included *Cacau Roxa*, at different harvest times, also found higher yields for this ethnovariety at all the evaluated times, with an average of 20.80 t/ha. Tiago (2016) studied 17 cassava ethnovarieties, including *Cacau Roxa*, *Amarela* and *Mandioca de Fritar Sem Cozinhar*, observed that there was no difference in mean root weight per plant, but higher root yield was obtained for the ethnovariety *Cacau Roxa* (3.62 kg), followed by *Mandioca de Fritar sem Cozinhar* (3.57 kg) and *Amarela* (3.15 kg). Therefore, the ethnovariety *Cacau Roxa* is recommended for use on large or small scale plantations, either for commercialization of fresh roots or even for flour production, since it presents good agronomic performance in the relevant studies.

Root productivity is a character resulting from the expression and association of different components (CARVALHO *et al*., 2002), making it necessary to study the degree of association between the characteristics, via the estimates of the correlation coefficients. Gomes *et al*., (2007) in studies on morphoagronomic characterization of cassava showed a positive correlation between total aboveground weight and tuberous root yield per plant (0.549). Superior results were found in our study, where the values obtained between the average root weight and weight of the aboveground section were 0.86 for the vertical planting position and 0.92 for the horizontal planting position. Therefore, because it represents a relationship between the root weight and the weight of aboveground section, it is expected that an increase in root yield will lead to an increase in the harvest index.

In general, there are large variations in the harvest index among the various ethnovarieties cultivated (KAWANO, 1982). High crop yields are desirable because they show the ability of the roots to accumulate starchy carbohydrates produced by the aboveground section (ENYI, 1973; WILLIAMS, 1972). Besides being important in the selection of the variety to be cultivated and in the selection of table cassava genotypes, they permit high quality root production. Thus they can provide farmers with higher economic yields due to the quantity produced and the quality of production obtained (AGUIAR, 2003).

The harvest index (IC% - root weight and total plant weight ratio) is considered satisfactory when greater than 50% (PEIXOTO *et al.*, 2005). The values obtained for this index were reached for all ethnovarieties and all planting positions. According to Silva (2002), it is interesting to note that this index is related to high root yield. Therefore, ethnovarieties that presented higher productivity (PMRP, CR and DR) and lower weight for the aboveground section (PPA) stand out for having higher IC%. Thus, the highest IC% was obtained from *Cacau Roxa*, which presented a higher average than the other ethnovarieties - a root yield of 13.97 t/ha (Figure 7).

Cassava roots have different shapes and sizes that vary between and within individuals of the same ethnovariety. Combining all the desirable agronomic traits, such as good yield, high starch content, and resistance to pests and diseases, into a single cassava variety, is a challenge for breeders (SILVA, 2009). Thus, the ethnovarieties selected for this study have good agronomic performance for both quantitative and qualitative traits, and may be indicated for future studies in the region, as well as for cultivation by farmers.

CONCLUSIONS

The results show that planting cuttings in the upright position showed superior performance in relation to planting in the horizontal position in regards to the root length and diameter, but there was no difference in the root yield between the different planting positions. We recommend both types of planting of the manioc (vertical and horizontal) for future cassava cultivation of the ethnovarieties *Cacau Roxa, Amarela* and *Mandioca de Fritar Sem Cozinhar* in the municipality of Alta Floresta, MT.

The ethnovariety *Cacau Roxa* is recommended for future studies in genetic improvement, since it presents good agronomic performance and therefore great potential for the development of new cassava breeds for commercial use.

The variables for root length (CR), root diameter (DR), root mean weight (PMRP) and weight of aboveground section (PPA) were positively correlated with harvest index.

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REFERÊNCIAS

AGUIAR, Eduardo Barreto. **Produção e qualidade de raízes de mandioca de mesa (*Manihot esculenta* Crantz) em diferentes densidades populacionais e épocas de colheita**. 2003. Dissertação (Mestrado em Agricultura Tropical e Subtropical) - Instituto Agronômico de Campinas, São Paulo, 2003.

ALVARES, C. A.; STAPE, J. L.; SENTELHAS, P. C.; GONÇALVES, J. L. M.; SPAROVEK, G. Koppen’s climate classification map for Brazil. **Meteorologische Zeitschrift**, v. 22, n. 6, p. 711–728, 2013.

ALVES, A. A. A. Cassava botany and physiology. In: HILLOCK, R. J.; THRESH, J. M.; BELLOTTI, A. C. **Cassava**: Biology, Production and Utilization. Cabi: International Oxford, 2002, p. 67-89.

ANDRÉ, T. B.; SANTOS, A. C. D. Uso de produtos da cultura da mandioca (*Manihot*) na produção animal. **Enciclopédia Biosfera**, v. 8, n. 15, p.1622-1647, 2012.

BORGES, F. M.; FUKUDA, W. M. G.; ROSSETTI, A. G. Avaliação de variedades de mandioca para consumo humano1. **Pesquisa Agropecuária Brasileira**, v. 37, n. 11, p. 1559-1565, 2002.

CARVALHO, C. G. P.; ARIAS, C. A. A.; TOLEDO, J. F.; OLIVEIRA, M. F.; VELLO NA. Correlações e análise de trilha em linhagens de soja semeadas em diferentes épocas. **Pesquisa Agropecuária Brasileira**, v. 37, n. 3, p. 311-320, 2002.

CERQUEIRA, F. B.; FARIA, A. J. G.; SANTOS, P. F.; CARNEIRO, J. S. S.; FREITAS, G. A.; RIBEIRO, F. C. Desenvolvimento inicial da mandioca 'cacau' sob diferentes posições da maniva. **Tecnologia & Ciência Agropecuária**, v. 10, n. 5, p. 16-21, 2016.

CONCEIÇÃO, A. J. **A mandioca**. 2ª ed. São Paulo: Nobel. 1983.

CRUZ C. D. **Programa Genes**: Estatística experimental e matrizes. 1ª. ed. Viçosa: UFV. 2006.

CRUZ, C. D. Genes Software: extended and integrated with the R, Matlab and Selegen. **Acta Scientiarum Agronomy**, v. 38, n. 4, p. 547-552, 2016.

ELIAS, H. T.; GUGEL, J.; JUNIOR GOULART, R. **Relatório de mercado agrícola na Ceasa/SC**. 2017. Disponível em: http://docweb.epagri.sc.gov.br/website_cepa/Relatorio_Ceasa/Relatorio_Mercado_Agricola_Ceasa_Abr_2017_n5.pdf. Acesso em: 17 jun. 2019.

EMBRAPA (EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA). **Cultivo da Mandioca para a Região dos Tabuleiros Costeiros**. 2003. Disponível em: https://sistemasdeproducao.cnptia.embrapa.br/FontesHTML/Mandioca/mandioca_tabcosteiros/plantio.htm. Acesso em: 03 jun. 2019.

EMBRAPA (EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA). **Mandioca em números**. 2017. Disponível em: https://www.embrapa.br/congresso-de-mandioca-2018/mandioca-em-numeros. Acesso em: 03 jun. 2019.

ENYI, B. A. C.; Growth rates of three cassava varieties (*Manihot esculenta* Crantz) under varying population densities. **Journal of Agricultural Science**, v. 81, n. 1, p. 15-28, 1973.

FERNANDES, F. D.; GUIMARÃES JÚNIOR, R.; VIEIRA, E. A.; FIALHO, J. D. F.; MALAQUIAS, J. V. Produtividade e valor nutricional da parte aérea e de raízes tuberosas de oito genótipos de mandioca de indústria. **Revista Brasileira Saúde Produção Animal**, v. 17, n. 1, p. 1-12, 2006.

FERREIRA, C. F.; ALVES, E.; PESTANA, K. N.; JUNGHANS, D. T.; KOBAYASHI, A. K.; SANTOS, V. J.; SILVA, R. P.; SILVA, P. H.; SOARES, E.; KUKUDA, W. Molecular characterization of cassava (*Manihot esculenta* Crantz) with yellow-orange roots for beta-carotene improvement. **Crop Breedingand Applied Genetics**, v. 8, n. 1, p. 23-29, 2008.

FERREIRA, J. C. V. **Mato Grosso e Seus Municípios**. Cuiabá, Secretaria de Estado de Educação. ed.especial. Cuiabá: Buriti, 2001.

FUKUDA, W. M. G.; GUEVARA, C. L. **Descritores morfológicos e agronômicos para a caracterização de mandioca (***Manihot esculenta* Crantz**)**. Cruz das Almas, EMBRAPA-CNPMF. 1998. Disponível em: https://www.embrapa.br/busca-de-publicacoes/-/publicacao/638631/descritores-morfologicos-e-agronomicos-para-a-caracterizacao-de-mandioca-manihot-esculenta-crantz. Acesso em: 20 jan. 2019.

FUKUDA, W. M. G.; SILVA, S. O.; IGLESIAS, C. Cassava Breeding. **Crop Breeding and Applied Biotechnology**, v. 2, n. 4, p. 617-638, 2002.

GODO, G. H. **Yield Components as Influenced by Methods of Planting Cassava Cuttings**. 1984. Disponível em:

http://www.istrc.org/images/Documents/Symposiums/Sixth/6th_symposium_proceedings_0038_section_3_219.pdf. Acesso em: 20 jan. 2019.

GOMES, C. N.; CARVALHO, S. P.; JESUS, M. A. S.; CUSTÓDIO, T. N. Caracterização morfoagronômica e coeficientes de trilha de caracteres componentes da produção em mandioca. **Pesquisa agropecuária brasileira**, v. 42, n. 8, p. 1121-1130, 2007.

GUSMÃO, L. L.; NETO, J. A. M.; SILVA, M. N. Avaliação participativa de sete variedades de macaxeira em São Luís-MA. **Revista da FZVA**, v. 13, n. 2, p. 1-9, 2006.

KAWANO, K. Mejoramiento genetico de yuca para productividad. In: DOMÍNGUEZ C. E. **Yuca**: investigación, producción y utilización. Cali: PNUD & CIAT. 1982, p. 91-112.

KVITSCHAL, M. V.; VIDIGAL FILHO, P. S.; PEQUENO, M. G.; SAGRILO, E.; BRUMATI, C. C.; MANZOTI, M.; BEVILAQUA, G. Avaliação de clones de mandioca (*Manihot esculenta* Crantz) para indústria na região noroeste do estado do Paraná. **Acta Scientiarum**, v. 25, n. 2, p. 299-304, 2003.

MATTOS, P. L. P.; NUNES, A. R. F.; FERREIRA FILHO, J. R. **Mandioca**: O produtor pergunta, a Embrapa responde. 1 ª ed. Brasília: Embrapa Informação Tecnológica, 2006.

PEDRI, E. C. M. **Diversidade genética, caracterização morfoagronômica e culinária de etnovariedades de mandioca em épocas de colheita.** 2018. Dissertação (Mestrado em Biodiversidade e Agroecossistemas Amazônicos) - Universidade do Estado de Mato Grosso, Alta Floresta, 2018.

PEIXOTO, J. R.; BERNARDES, S. R.; SANTOS, C. M.; BONNAS, D. S.; FIALHO, J. F.; OLIVEIRA, J. A. Desempenho agronômico de variedades de mandioca mansa em Uberlândia. **Revista Brasileira de Mandioca**, v. 18, n. 1, p. 19-24, 2005.

R CORE TEAM. **R**: A language and environment for statistical computing. Vienna, R Foundation for Statistical Computing. 2016. Disponível em: https://www.R-project.org/. Acessado em: 10 out. 2019.

RODRIGUES, A. R.; ALVES, J. M. A.; UCHÔA, S. C. P.; ALBUQUERQUE, J. D. A. A.; RODRIGUES, G. S.; BARROS, M. M. Avaliação da capacidade de enraizamento, em água, de brotações, ponteiros e estacas herbáceas de clones de mandioca de mesa. **Agro@mbiente on-line**, v. 2, n. 1, p. 37-45, 2008.

SEAB (SECRETARIA DE ESTADO DA AGRICULTURA E DO ABASTECIMENTO). **Prognóstico mandioca 2017/18**. 2017. Disponível em: http://www.agricultura.pr.gov.br/arquivos/File/deral/Prognosticos/2018/Mandioca_2017_18.pdf. Acesso em: 04 jun. 2019.

SILVA, B. S. **Caracterização botânica e agronômica da coleção de trabalho de mandioca da Embrapa acre**. 2009. Dissertação (Mestrado em Agronomia) - Universidade Federal do Acre, Rio Branco, 2009.

SILVA, R. M.; FARALDO, M. I. F.; ANDO, A.; VEASEY, E. A. Variabilidade genética de etnovariedades de mandioca. In: CEREDA, M. P. **Cultura de Tuberosas Amiláceas latino americanas**. São Paulo: Fundação Cargil. 2002, p. 207-242.

SOUSA, D. M. G.; LOBATO, E. **Cerrado**: correção do solo e adubação. 2ª ed. Planaltina: Embrapa. 2004.

SOUZA, A. S.; ROCHA JÚNIOR, V. R.; MOTA, Á. D. S.; PALMA, M. N. N.; FRANCO, M. O.; DUTRA, E. S.; SANTOS, C. C. R.; AGUIAR, A. C. R.; OLIVEIRA, C. R.; ROCHA, W. J. B. Valor nutricional de frações da parte aérea de quatro variedades de mandioca. **Revista Brasileira de Saúde e Produção Animal**, v. 12, n. 2, p. 441-455, 2011.

TIAGO, A. V. **Diversidade genética e uso de etnovariedades de mandioca** (*Manihot esculenta* Crantz) **cultivadas em propriedades rurais no município de Alta Floresta, norte do estado de Mato Grosso**. 2016. Dissertação (Mestrado em Biodiversidade e Agroecossistemas Amazônicos) - Universidade do Estado de Mato Grosso, Alta Floresta, 2016.

TONTINI, F. **Avaliação da densidade populacional e posição da maniva no plantio na produtividade de mandioca no município de Altamira-Pará**. 2009. Trabalho de Conclusão de Curso (Graduação em Agronomia) - Universidade Federal do Pará, Altamira, 2009.

VIANA, A. E. S.; SEDIYAMA, T.; LOPES, S. C.; SEDIYAMA, C. S.; ROCHA, V. S. Effects of length in stem cutting and its planting position on cassava yield cassava yield. **Acta Scientiarum**, v. 22, n. 4, p. 1011-1015, 2000.

WILLIAMS, C. N. Growth and productivity of tapioca (*Manihot* utilissima): III. crop ratio, spacing and yelding. **Experimental Agriculture**, v. 8, n. 1, p. 15-23, 1972.

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