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Selection of cassava (*Manihot esculenta* Crantz) genotypes based on agro-morphological traits in Angola

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The aim of the present study is to select superior cassava genotypes based on agro-morphological traits using three non-parametric indices and to correlate them in order to verify the degree of agreement between them. Traits such as number of branches, plant height, stem diameter, distance between internodes, height of the first branch, number of roots, root diameter, root length, shoot yield and root yield in experiments conducted in the Experimental Farm of Malanje Food Company were evaluated. Data collected were subjected to an analysis of variance and to Scott and Knott clustering test. Mean values were subjected to multiplicative indices of sum of classification and genotype-ideotype distance. The morpho-agronomic traits used to assess the 40 cassava genotypes pointed out the existence of promising materials that can be used to diversify cassava cultivation in Angola. The sum of classification and genotype-ideotype distance indices allowed a more realistic ranking of cassava genotypes. The genotype-ideotype distance index did not present any correlation with the multiplicative and sum of classification indices as well. Genotypes Tio Jojo, Ngana Yuculu, Kimbanda, Vermute, Jaca Vermelha and Jaca Branca have the potential to be incorporated into cassava cultivation in Angola

Key words: *Manihot esculenta*, multiplicative index, sum of classification index, genotype-ideotype distance index, variability.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a high rusticity and low soil-fertility demanding crop, a fact that allows it

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Figure 1. The roots and leaves of Northern and Western Angola.

to be grown in a wide range of areas (Nassar et al., 2008). Tubers are used in human and animal diets (Fukuda et al., 2005), besides being used as raw-material in countless industrial goods (cassava flour, tapioca flour, or starch, cassava gum and other). The world production of cassava in 2016 was 277.1 million tons (FAO, 2018), and Angola ranked 9th with approximately 10 million tons.

Northern and Western Angola are the regions hosting the highest cassava production areas and their populations use to consume the roots and leaves (Figure 1) as vegetables. Moreover, cassava can replace wheat in the bread and cereals in some regions, since it is a subsistence crop and its production technology is relatively simple and has a high ability to adapt to different soil and weather conditions.

It is important to highlight that some farmers in Angola insist on using the same planting material employed by their ancestors, which is experiencing genetic erosion or increased susceptibility to pests (Muondo, 2013). It is necessary performing studies to feature different genotypes in Angola, assess their agronomic potentials in order to diversify the cultivated genotypes. Although assessments of genotypes' performances are relevant, only few research in this field have been conducted in Angola. According to Garcia and Souza Junior (1999), the obtainment of genotypes, presenting acceptable values of the traits of interest is not an easy task. However, methods that help breeders to improve their decision-making processes are essential. Selection indices were developed in order to facilitate the selection of superior genotypes, which constitute an additional character set through the optimum combination of many traits. It was done in order to efficiently allow a simultaneous selection (Lessa et al., 2010; Rocha et al., 2012) to enhance the phenotypic value of the selected population. Smith (1936) developed the selection index theory, which is widely applied in the genetic enhancement of plants. Indices developed after the selection index for use under specific conditions (Garcia and Souza Júnior, 1999; Lin, 1978; Pesek and Baker, 1969) require genetic-parameter estimates known as parametric indices. These indices are often applied to populations or when genotypes form a random sample. Yet, one can count on the selection of non-parametric indices, which do not need estimates of genetic parameters. Moreover, these indices can be used either in random samples or in selected genotypes, that is fix samples (Lessa et al., 2010).

The multiplicative index was proposed by Elston (1963) who takes into account all traits presenting similar economic relevance. According to Garcia and Souza Júnior (1999), this index adapts to recurrent selection programs as the final stages of enhancement programs, although it does not require parameter estimates and does not assume the existence of the genotypic value of the population to be enhanced.

The index based on sums and ranks was proposed by Mulamba and Mock (1978) and it classifies genotypes based on each of the traits organized in favoring enhancement order. The order number presented in each trait is summed and, in this case, the lower the value of the sum, the better the genotypic development in the selection.

The index based on the genotype-ideotype distance (Schwarzbach, 1972; Wricke and Weber, 1986) allows defining the optimum values for each trait; therefore, it enables creating an ideal genotype or ideotype. The Euclidian or Mahalanobis distance can be used in this index to calculate dissimilarities; thus, genotypes presenting the lowest ideotype values in the matrix are selected. The adoption of selection indices to genetically enhance cassava cultures could help breeders to make the best decisions about the selection of genotypes that aggregate high production and other traits of interest in the same individual (Lessa et al., 2017).

In light of the foregoing, the aims of the present study

Table 1. Charcteristics of the 40 cassava cultivars studied.

Origin	Main growing provinces	Cultivars
Malanje	Nordern	Waticamana
Malanje	Nordern	Maria dia Pedro
Malanje	Nordern	Hoto
Malanje	Nordern and Western	Mata Capim
Malanje	Nordern and Western	Kambaxi
Malanje	Nordern and Western	Paco Vermelho
Cuanza Norte	Nordern	Tio Jojo
Malanje	Nordern	Verdinha
Malanje	Nordern	Mukoto ua Nguadi (Pé de perdiz)
Cuanza Norte	Nordern	Paco branco
Cuanza Norte	Nordern	Munenga
Cuanza Norte	Nordern	Kimbanda
Cuanza Norte	Nordern	Suzi
Cuanza Norte	Nordern	Jaca Branca
Cuanza Norte	Nordern	Jaca Vermelha
Cuanza Norte	Nordern	Kalazula
Uíge	Countrywide	Ngana Rico 1 (Uíge)
Uíge	Countrywide	TMS3
Uíge		Mandioca Banana
Uíge		Rio Dange
Uíge	Countrywide	Cassandi
	Countrywide	Vermute
Malanje	Nordern	Guita
Malanje	Nordern	Chico dia kombe
Malanje	Nordern	TMS 4025 (precoce de Angola)
Malanje	Nordern	Kalami
Malanje	Countrywide	Baco
Malanje	Nordern	Katenda
Malanje	Nordern	Malanje
Malanje	Countrywide	Ngana Rico 2 (Malanje)
Malanje	Nordern and Western	Kalawenda
Malanje	Nordern and Western	Gonçalo
Malanje	Nordern	Mundele Paco
Malanje	Nordern	Suingui
Malanje	Nordern	NganaYuculu
Malanje	Nordern	Muringa
Malanje	Nordern	Kinzela
Uíge	Nordern and Western	Mpelo
Malanje	Nordern	Gueti
Malanje	Nordern	Kapumba

were to select superior cassava genotypes based on agro-morphological traits by using three non-parametric indices, as well as to correlate them in order to check the degree of agreement between them.

MATERIALS AND METHODS

The study was conducted in the Malanje Food Company's experimental field for two cropping campaigns (2015/16 and 2017/18). The forty (40) cassava genotypes assessed were provided by the Agronomic Investigation Institute (IIA)'s germplasm maintained in Malanje Agricultural Experimental Station, and in IDA of Cuanza Norte and Uíge. These provinces are located at latitude 8^o 49' South and longitude 13^o 13' East, at 368 m above sea level (IGCA, 2016) and covered a total area of 8,960 Km^2. Details on the forty (40) genotypes are presented in Table 1.

The local soil was classified as fersialitic (Diniz, 1973). According to INAMET (2004), the climate of the region was humid subtropical, the annual mean temperature was 26°C with a thermal amplitude of 14°C, a relative humidity between 80 and 85%, and a mean annual

Figure 2. Mechanical harvesting of the roots by plots, at the CAM experimental station, after the vegetative cycle of the crop, with the aid of coupled to the tractor (P900).

rainfall between 1000 and 1200 mm well distributed throughout the year.

The trial was arranged in a completely randomized block design with four repetitions. Each plot encompassed five rows of 10 plants, thus totalizing 50 plants per plot. Each row was 10 m long, spaced 0.90 m from each other. The distance between plants was 0.90 m.

The soil was plowed and harrowed before planting. It was applied 350 kg ha^{-1} of compound fertilizer (N-P-K: 12-24-12). The cover fertilizer was applied 250 kg ha^{-1} of N-P-K (16-8-12) six months after planting. Planting was mechanically performed with an 80 HP tractor (ISO- 9001, Mainland, China). The tractor was coupled to a two-row cassava planter (Bazuca 1) for 13.5 cm long stakes and horizontally placed in 0.10 m-deep grooves.

Stakes were treated before use by immersing for five minutes in a solution containing 80% Maconzebe (1 kg), 80% Fipronil (1 kg), Boron (1 L), Manganese (1 L) at 1500 L/water. Weeds were controlled manually with hoes at different development phases and stages. The herbicides Capizade and Flumioxazine were used at planting in order to avoid weeds during the initial growth of cassava plants.

Cuts were performed in December 02, 2016 and in February 21, 2018 at maturity. All plants of the five rows of each plot were harvested. The 10 parameters measured were (i) number of branches (NB), (ii) plant height (PH), (iii) stem diameter (SD), (iv) length of internodes (ID), (v) height of the first branch (HFB), (vi) number of tubers (NR), (vii) root diameter (RD), (viii) root length (RL), (ix) shoot yield (SY), and (x) root yield (RY). NB resulted from the ratio of the sum of the number of sprouts in the stem cutting over the number of plants subjected to evaluation. PH was measured from ground level up to the most distal tip. SD was measured with a caliper at 10 cm from the ground. ID was the mean distance between knots of the plant stems. HFB was measured from ground to the first branch. NR was the ratio of the number of roots in the stem cuttings over the number of plants subjected to evaluation. RD was the mean diameter of ten roots randomly sampled in each experimental plot. RL was the mean length of ten randomly sampled roots in each experimental plot. SY was recorded by weighing the shoot of all useful plants in the experimental plots. RY of a cultivar was the weight of roots of all useful plants of the corresponding experimental plots.

Harvests were mechanized and preceded by cutting of the areal part at maturity (Figure 2). The harvest was performed with a tuber crops harvester (P9000) coupled to the tractor.

Data collected were subjected to individual and combined analyses of variance. Mean values of the genotypes were grouped using the Scott-Knott test. Pearson's correlation coefficients of the variables were also estimated. All the above-mentioned analyses were performed using the Statistics R Software (R Core Team, 2018).

The multiplicative index (ELSTON, 1963) was calculated using the following formula:

$$I_{Ei} = \log \prod_{j=1}^{m} (x_{ij} - k_j) = \log [(x_{i1} - k_1)(x_{i2} - k_2) \ldots (x_{in} - k_n)],$$

Where, I_{Ei} is the multiplicative index; x_{ij} is the mean of trait *j* measured in genotype *i*, and *k* is the lowest selectable value $\left[K_j = \frac{n\,(min.\ xij) - máx.\ xij}{n-1}\right]$; n is the number of genotypes, and min. x_{ij} and max x_{ij} are the lowest and highest mean of trait *j,* respectively.

The sum of classification index (Mulamba and Mock, 1978) was provided by the expression $\left[I_{MM} = \sum_{j=1}^{m} n^{ij}\right]$, where I_{MM} is the sum of classification index and n_{ij} is the number of classification of genotype *I* in relation to trait *j*.

The Euclidian distance was adopted for the index based on the genotype-ideotype distance (Schwarzbach, 1972; Wricke and Weber, 1986):

$$\left(D_{ij} = \sqrt{\sum_{j=1}^{m} d^{ij^{2}}}\right)$$

Where, in D_{ij} is the Euclidian distance between genotype *I* and ideotype *I*, and d*ij* is the standard deviation between the mean of trait *j* measured in genotype *i* (x_{ij}) and the value attributed to the ideotype in this trait (x_{ij}), i.e., $d_{ij} = (x_{ij} - x_{Ij})/\sigma_j$. Standardization avoids the possibility of having traits measured in larger units influencing the value of the index more than other traits and, consequently, influencing the classification of cassava genotypes.

The ideal phenotypic value, the higher mean values of plant height (PH), number of tubers (NR), root yield (RY) and shoot yield (SY) and the mean values of the other traits were taken into account in the definition of the ideotype necessary for the calculation of the genotype-ideotype distance. Values attributed to the ideotype were NB = 2.32, PH = 193.88 cm, SD = 8.98 cm, ID =

8.33 cm, HFB = 46.68 cm, RN = 2.63, RD = 21.95 cm, RL = 30.44 cm, SY = 32.26 kg, and RY = 46.02 kg.

RESULTS AND DISCUSSION

Factors obtained linking the highest and lowest mean frame of the residues from the individual analysis of the 10 traits used form the trials conducted in 2015/2016 and 2017/2018; they recorded values lower than 7 indicating an homogeneity of variances observed in experimental errors. Therefore, the option was made for a joint analysis (Table 2). Studies related to individual analysis of variance have been developed in different cultures including cassava (Vieira et al., 2015a,b; Vieira et al., 2016; Fernandes et al., 2016), tomatoes (Costa et al., 2015), and tree species (Oliveira et al., 2014).

The joint analysis of variance for all the traits showed no genotype x campaign interaction. However, the lack of genotype x campaign interaction could be associated with the extreme variance observed in some of the treatments that could have masked real differences between accessions (Table 3).

Almeida et al. (2014a) assessed the morphological and yield evaluation applied to peanut produced by small farmers in Bahia Reconcavo and they did not observe a genotype x day after emergence (DAE) interaction for any of the variables considered in their study.

The coefficient of experimental variation in the joint analysis of variance ranged from 12.76% in PH to 49.02% in SY. These results were comparable to those obtained in a *M. esculenta* interspecific hybrids trial by Oliveira (2011) where CV varied from 12.79 to 57.08% for length x central lobe width (LCLW). However, RD presented value higher than that found in the present study.

It is known that shoot yield is a variable of extreme relevance for cassava cultures, since it represents the amount of fresh matter produced per plant. This variable can be used in human diets, in forage production for animal consumption and, mainly, in cassava cuttings (maniva) obtained for new cultivations (Fernandes et al., 2016). Root diameter is also important for cassava root production. Thicker roots are the favorite because smaller diameters impair the shelling operation management. Therefore, this process does not help cassava processing, since small roots are used for animal feeding and, sometimes, rejected and left in the field. It is worth highlighting that the height of the first branch contributes to easier upkeep operations. According to Vieira et al. (2013), varieties presenting the highest first branch or that do not present any branch and high plant height are the favorite ones, since they are directly related to easy cultural traces, to the availability of branches for new cultivations, to easy mechanized cultivation and easy harvest.

With regard to the number of branches (NB), which has significant influence on root yield, genotypes Verdinha, Ngana Rico 2, Kinzela, Waticamana, Mpelo, Kalawenda, Cassandi, Jaca Branca, Gonçalo and Guita were statistically different from the others ($p < 0.01$). These genotypes presented the highest values that varied from 2.51 for Guita to 3.40 for Verdinha (Table 4).

Varieties Tio Jojo, Kimbanda, Precoce de Angola, NganaYuculu, Banana, Jaca Vermelha, Malanje, Mundele Paco, Kalazula, Rio Dange, Vermute, Kambaxi, Munenga, Kalawenda, Kinzela; Kapumba, Muringa, Mata Capim, Hoto and Pé de perdiz stood out for variable ‘plant height’, since they recorded values that ranged from 194.13 to 224.11 cm (Table 4). Although there were no reports about the ideal height of cassava plants, authors such as Devide et al., (2009) and Guimarães (2013) believe that farm management and treatments tend to be easier when plants are taller, mainly in areas subjected to mechanized harvest, as well as tend to facilitate the consortium with other cultures such as beans and maize.

Plant height must not present excessive values (higher than 3 m), since it could allow plant bedding in areas subjected to strong wind and presenting fertile soils, as reported by Otsubo et al. (2009). These authors assessed cassava cultivated for industrial use in Cerrado areas in Mato Grosso do Sul State. Results from this study corroborated Foloni et al. (2010)’s finding from the assessment of cassava cultivars in Western São Paulo State where they recorded significant difference in plant height. The variation observed in plant height concerned environment influence and genotypic components. Such facts were also reported by Filho et al. (2000), Rimoldi et al. (2003), Rimoldi et al. (2006), Otsubo et al. (2009) and Vieira et al. (2015a, b), who recorded plants height of 252 cm in the assessment of the agronomic performance of sweet cassava accessions in Cerrado area of Minas Gerais State.

Genotypes Mata Capim, Tio Jojo, Kimbanda, Jaca Branca, Jaca vermelha, Banana, Malanje, Mundele Paco and Muring stood out for variable ‘internode distance (ID)’. The highest values recorded for root number (RN) were observed in genotypes Maria dia Pedro, Tio Jojo, Verdinha, Jaca Branca, TMS3, Banana, Baco, Vermute, Chico dia kombe, Precoce de Angola, Kalami, Baco, Katenda, Ngana Rico 2 and NganaYuculu and Muringa. It is known that the development of cassava plants is defined by the number of roots. These results indicated that the root number was well constituted in the initial development phases of the genotypes (Table 4).

Genotypes Waticamana, Kambaxi, Tio Jojo, Munenga, Kimbanda, Kalazula, Cassandi, Vermute, Guita, Precoce de Angola, Kalami, Katenda, Ngana Rico 2, Gonçalo, Suingui, NganaYuculu and Kinzela presented higher root yields (RY). Vieira et al. (2015a, b) assessed eight industrial cassava genotypes and observed that genotype BGMC 996 was the only one standing out in the root yield (RY) trait.

Table 5 depicts the means and posts of variables used

Table 2. Summary of individual analysis of variance for vegetative and root production traits.

Source of variation	Df	QM									
		NB	PH	SD	IE	HFB	RN	RD	RL	SY	RY
Campaign 2015/2016											
Blocks	3	0.37^{ns}	359.72^{ns}	19.60*	2.54^{ns}	445.60^{ns}	4.73^{ns}	46.52**	188.79**	30.54^{ns}	926.12*
Genotype	39	1.00*	683.69^{ns}	1.13^{ns}	2.06^{ns}	390.80^{ns}	1.36^{ns}	10.81^{ns}	51.64^{ns}	34.26^{ns}	463.89*
Residue	117	0.64	644.67	1.05	1.77	338.02	1.19	7.99	43.79	31.41	299.98
Overall mean		2.59	162.48	6.70	8.46	48.03	2.38	22.85	28.91	13.35	39.57
CV (%)		30.83	15.63	15.33	15.73	38.28	45.78	12.37	22.89	41.99	43.77
Camapaign 2017/2018											
Blocks	3	4.81*	1238.39^{ns}	20.59**	1.19^{ns}	570.27**	5.06*	179.60**	321.11**	6518.54**	15560.93**
Genotypes	39	0.09^{ns}	1130.39**	2.97^{ns}	2.25^{ns}	226.16*	2.71*	9.86^{ns}	31.45^{ns}	593.11^{ns}	556.38^{ns}
Residue	117	0.10	583.12	2.37	1.61	134.59	1.60	14.21	42.79	468.67	460.74
Overall mean		2.10	225.27	11.25	8.20	45.34	2.88	21.04	31.97	51.17	52.47
CV (%)		14.87	10.72	13.69	15.49	25.59	44.00	17.92	20.46	42.31	40.91

** and *significant at 1% and 5%, respectively, ^{ns}, non-significant at 5% probability, Df, degree of freedom; NB, number of branches; SD, stem diameter; ID, internode length; HFB, height of the first branch; RN, number of roots; RD, root diameter; RL, root length; SY, shoot yield; RY, root yield.

Table 3. Summary of joint analysis of variance for vegetative and root production traits

Source of variation	Df	QM									
		NB	PH	SD	ID	HFB	RN	RD	RL	SY	RY
Blocks (Campaigns)	6	2.59**	799.06^{ns}	20.10**	1.87^{ns}	507.93*	4.89**	113.06**	254.95**	3274.54**	8243.53**
Genotypes	39	0.64**	1197.82**	2.18^{ns}	2.43^{ns}	329.87^{ns}	2.72**	10.57^{ns}	41.74^{ns}	325.01^{ns}	679.39**
Campaign	1	18.88**	315350.22**	1661.07**	5.69^{ns}	577.84^{ns}	19.82**	262.99**	748.41**	14439.54**	13312.80**
Gen. x Campai	39	0.45^{ns}	616.25^{ns}	1.92^{ns}	1.88^{ns}	287.10^{ns}	1.35^{ns}	10.10^{ns}	41.34^{ns}	302.36^{ns}	340.88^{ns}
Residue	234	0.37	613.90	1.71	1.69	236.31	1.39	11.10	43.29	250.04	380.36
Overall mean		2.35	193.87	8.98	8.33	46.68	2.63	21.94	30.44	32.26	46.02
CV (%)		25.84	12.78	14.58	15.62	32.93	44.93	15.18	21.61	49.02	42.38

**and *significant at 1% and 5%, respectively, in the F test. ^{ns}non-signifcant at 5% probability. Gen, genotype; Campai, campaign; Df, degree of freedom; NB, number of branches; SD, stem diameter; ID, internode length; HFB, height of the first branch; RN, number of roots; RD, root diameter; RL, root length; SY, shoot yield; RY, root yield.

to calculate the Sum of Posts Index (I_{MM}), which ranked genotypes Tio Jojo, Ngana Yuculu, Kimbanda and Jaca Vermelha in the first, second, third and fourth positions, respectively. Genotypes Vermute, Ngana Rico 2, Jaca Branca and Banana ranked the fifth, sixth and eight position, respectively, based on the classification order of the index (Table 5).

Genotype Tio Jojo ranked first for plant height (PH), height of the first branch (HFB) and root yield (RY); fourth for internode length (ID), twelfth for shoot yield (SY), thirteenth for stem diameter (SD) and root number (RN), fifteenth for root length (RL), twentieth for root diameter (RD) and the smallest number of branches (NB). Genotype Tio Jojo ranked first according to the sum of classification index (Table 5), which was similar to its rank in the multiplicative index (Table 6). This positive result recorded by variety Rio Jojo was also observed in agronomic featuring (Table 4). This variety stood out for plant height, internode length, root number and root yield, and this result revealed a promising genotype that can be recommended to cassava growers.

Ngana Yuculu ranked seven in the index suggested by Elston (1963); therefore, this variety ranked second in the sum of classification index. According to Garcia (1999), the use of this index is simple and does not require making adjustments in the means, just as it happens in the multiplicative index. It is necessary adjusting the units of traits in order to find the lowest selectable value (kj); therefore, this is the methodological differential. Such factor likely influenced the change on genotype ranking. The same ranking changes were observed for genotypes Kimbanda, Jaca Vermelha, Banana, Jaca Branca, Ngana

Table 4. Grouping of mean values of the agro-morphological traits for which the ANOVA detected significant differences.

Genotypes	NB	PH (cm)	SD (cm)	ID (cm)	HFB (cm)	RN	RD (cm)	RL (cm)	SY (kg)	RY (kg)
Waticamana	2.65[a]	189.04[b]	8.80[a]	8.51[b]	50.75[a]	2.59[b]	20.75[a]	32.93[a]	30.13[a]	56.08[a]
MariadiaPedro	2.20[b]	178.03[b]	8.34[a]	7.88[b]	46.12[a]	3.06[a]	21.08[a]	34.50[a]	20.56[a]	32.40[b]
Hoto	2.20[b]	194.99[a]	8.34[a]	8.38[b]	49.13[a]	2.41[b]	21.94[a]	30.20[a]	30.38[a]	41.11[b]
MataCapim	2.20[b]	195.58[a]	8.79[a]	8.76[a]	44.87[a]	1.91[b]	22.91[a]	30.99[a]	37.13[a]	43.53[b]
Kambaxi	2.14[b]	200.49[a]	9.37[a]	8.33[b]	41.21[a]	1.99[b]	20.73[a]	30.19[a]	22.00[a]	54.95[a]
PacoVermelho	2.18[b]	178.45[b]	9.03[a]	8.45[b]	38.17[a]	2.69[b]	19.64[a]	30.20[a]	42.50[a]	36.33[b]
TioJojo	2.13[b]	224.11[a]	9.21[a]	9.09[a]	61.24[a]	2.86[a]	21.99[a]	31.01[a]	36.06[a]	66.72[a]
Verdinha	3.40[a]	187.44[b]	8.52[a]	7.90[b]	50.30[a]	3.84[a]	20.64[a]	30.85[a]	34.50[a]	44.40[b]
Pédeperdiz	2.39[b]	194.13[a]	8.96[a]	8.26[b]	54.77[a]	2.01[b]	20.50[a]	28.46[a]	27.63[a]	45.24[b]
Pacobranco	2.07[b]	180.61[b]	8.07[a]	8.07[b]	36.11[a]	2.29[b]	23.58[a]	27.84[a]	34.94[a]	45.02[b]
Munenga	2.37[b]	199.14[a]	9.06[a]	8.03[b]	40.86[a]	2.43[b]	21.24[a]	27.61[a]	26.19[a]	48.29[a]
Kimbanda	2.39[b]	218.79[a]	8.72[a]	10.02[a]	57.88[a]	2.48[b]	22.44[a]	30.09[a]	31.13[a]	64.09[a]
Suzi	2.45[b]	190.95[b]	9.90[a]	7.80[b]	42.62[a]	2.20[b]	22.96[a]	29.36[a]	25.69[a]	36.67[b]
JacaBranca	2.58[a]	190.09[b]	9.09[a]	8.77[a]	55.24[a]	2.86[a]	22.58[a]	31.41[a]	23.75[a]	46.06[b]
JacaVermelha	2.34[b]	207.36[a]	9.44[a]	9.05[a]	41.69[a]	2.40[b]	23.46[a]	31.31[a]	33.31[a]	41.54[b]
Kalazula	2.28[b]	202.28[a]	9.65[a]	8.24[b]	52.11[a]	2.52[b]	21.61[a]	27.71[a]	39.63[a]	52.80[a]
NganaRico1	2.45[b]	174.05[b]	8.04[a]	8.11[b]	47.67[a]	1.92[b]	21.98[a]	29.18[a]	23.13[a]	44.05[b]
TMS3	2.10[b]	188.37[b]	9.68[a]	8.22[b]	43.60[a]	3.05[a]	22.94[a]	33.06[a]	25.13[a]	37.56[b]
Banana	2.25[b]	210.65[a]	9.95[a]	8.97[a]	48.90[a]	3.93[a]	20.63[a]	35.51[a]	19.00[a]	36.78[b]
RioDange	2.05[b]	201.38[a]	8.67[a]	8.15[b]	49.31[a]	1.95[b]	23.38[a]	28.87[a]	28.25[a]	40.50[b]
Cassandi	2.59[a]	183.99[b]	9.72[a]	8.22[b]	38.94[a]	2.21[b]	22.46[a]	30.30[a]	32.38[a]	51.91[a]
Vermute	2.05[b]	201.18[a]	9.16[a]	8.20[b]	43.41[a]	3.90[a]	22.68[a]	32.15[a]	40.56[a]	54.73[a]
Guita	2.51[a]	177.96[b]	8.31[a]	7.81[b]	37.17[a]	2.00[b]	22.75[a]	29.18[a]	31.38[a]	52.62[a]
Chicodiakombe	1.87[b]	191.08[b]	9.32[a]	8.39[b]	40.17[a]	2.9[a]	20.31[a]	27.84[a]	27.63[a]	33.74[b]
P.deAngola	2.26[b]	212.84[a]	8.59[a]	7.84[b]	59.91[a]	3.12[a]	20.14[a]	28.36[a]	37.38[a]	52.34[a]
Kalami	2.35[b]	180.52[b]	8.90[a]	7.60[b]	48.54[a]	2.88[a]	22.99[a]	30.14[a]	35.00[a]	48.36[a]
Baco	2.12[b]	179.49[b]	8.83[a]	8.03[b]	46.72[a]	3.16[a]	21.53[a]	32.54[a]	30.69[a]	36.46[b]
Katenda	2.28[b]	190.49[b]	8.76[a]	8.29[b]	50.77[a]	2.99[a]	21.25[a]	30.68[a]	32.75[a]	60.79[a]
Malanje	2.09[b]	207.10[a]	9.34[a]	9.59[a]	42.97[a]	2.54[b]	21.18[a]	24.13[a]	47.00[a]	40.51[b]
NganaRico2	2.96[a]	175.37[b]	8.46[a]	8.41[b]	47.53[a]	3.71[a]	23.91[a]	30.40[a]	32.25[a]	60.31[a]
Kalawenda	2.64[a]	198.37[a]	9.17[a]	7.76[b]	54.74[a]	2.52[b]	21.81[a]	28.85[a]	27.94[a]	33.76[b]
Gonçalo	2.55[a]	181.06[b]	9.13[a]	7.64[b]	41.01[a]	2.59[b]	22.96[a]	31.70[a]	32.00[a]	49.84[a]
MundelePaco	2.15[b]	205.02[a]	9.73[a]	9.29[a]	36.33[a]	2.13[b]	23.31[a]	32.63[a]	36.50[a]	33.36[b]
Suingui	2.16[b]	183.94[b]	8.54[a]	8.17[b]	50.15[a]	2.11[b]	22.43[a]	32.95[a]	32.38[a]	50.85[a]
NganaYuculu	2.17[b]	210.73[a]	9.59[a]	7.61[b]	49.09[a]	3.57[a]	23.41[a]	32.43[a]	40.00[a]	58.85[a]
Muringa	2.27[b]	196.10[a]	9.04[a]	8.99[a]	40.81[a]	2.77[a]	20.54[a]	34.96[a]	40.63[a]	36.45[b]

Table 4. Contd.

Kinzela	2.75[a]	197.3[a]	8.26[a]	79.0b	52.87[a]	20.9[b]	20.48[a]	27.73[a]	38.31[a]	52.95[a]
Mpelo	26.5[a]	186.34[b]	8.05[a]	8.34[b]	48.56[a]	1.65[b]	22.99[a]	28.76[a]	36.00[a]	41.24[b]
Gueti	2.32[b]	193.07[b]	9.20[a]	7.62[b]	44.27[a]	2.45[b]	22.76[a]	31.78[a]	39.38[a]	43.35[b]
Kapumba	2.29[b]	196.92[a]	9.34[a]	8.48b	40.84[a]	2.46b	20.95[a]	28.88[a]	29.19[a]	34.41[b]

Means followed by the same letter in the columns belong to the same group; according to Scott-Knott test; at 5% significance level; NB number of branches; SD, stem diameter; ID, internode length; HFB, height of the first branch; RN, number of roots; RD, root diameter; RL, root length; SY, shoot yield; RY, root yield.

Table 5. Original Means ($\bar{x}$) and post of variables used to calculate the Sum of Post Index (I_{SP}) for the 40 cassava genotypes.

Genotype	NB		PH		SDDC		ID		HFB		RN		RD		RL		SY		RY		I_{SP}
	$\bar{x}$	Posto	$\bar{x}$	Posto	$\bar{x}$	Posto	$\bar{x}$	Posto	$\bar{x}$	Posto	$\bar{x}$	Posto	$\bar{x}$	Posto	$\bar{x}$	Posto	$\bar{x}$	Posto	$\bar{x}$	Posto	
Waticamana	2.65	4	189.04	26	8.80	25	8.51	10	50.75	10	2.59	17	20.75	31	32.93	6	30.13	27	56.08	6	162 (10) (((10)[1]
Maria dia Pedro	2.20	25	178.03	37	8.34	34	7.88	32	46.12	22	3.06	8	21.08	29	34.50	3	20.56	39	32.40	40	269 (37)
Hoto	2.20	26	194.99	19	8.34	35	8.38	15	49.13	14	2.41	26	21.94	22	30.20	21	30.38	26	41.11	27	231 (28)
Mata Capim	2.20	27	195.58	18	8.79	26	8.76	9	44.87	23	1.91	39	22.91	12	30.99	16	37.13	10	43.53	23	203 (20)
Kambaxi	2.14	32	200.49	12	9.37	9	8.33	17	41.21	30	1.99	36	20.73	32	30.19	23	22.00	38	54.95	7	236 (30)
Paco Vermelho	2.18	28	178.45	36	9.03	21	8.45	12	38.17	37	2.69	16	19.64	40	30.20	22	42.50	2	36.33	35	249 (35)
Tio Jojo	2.13	33	224.11	1	9.21	13	9.09	4	61.24	1	2.86	13	21.99	20	31.01	15	36.06	12	66.72	1	113 (1)
Verdinha	3.40	1	187.44	28	8.52	32	7.90	30	50.30	11	3.84	3	20.64	33	30.85	17	34.50	16	44.40	21	192 (14)
Pé de perdiz	2.39	13	194.13	20	8.96	22	8.26	19	54.77	5	2.01	34	20.50	36	28.46	33	27.63	31	45.24	19	232 (29)
Paco branco	2.07	37	180.61	33	8.07	38	8.07	27	36.11	40	2.29	28	23.58	2	27.84	35	34.94	15	45.02	20	275 (38)
Munenga	2.37	15	199.14	13	9.06	19	8.03	28	40.86	32	2.43	25	21.24	27	27.61	39	26.19	33	48.29	17	248 (34)
Kimbanda	2.39	14	218.79	2	8.72	28	10.02	1	57.88	3	2.48	22	22.44	18	30.09	25	31.13	24	64.09	2	139 (3)
Suzi	2.45	11	190.95	23	9.90	2	7.80	35	42.62	28	2.20	30	22.96	9	29.36	26	25.69	34	36.67	32	230 (27)
Jaca Branca	2.58	8	190.09	25	9.09	18	8.77	8	55.24	4	2.86	14	22.58	16	31.41	13	23.75	36	46.06	18	160 (7)
Jaca Vermelha	2.34	17	207.36	6	9.44	8	9.05	5	41.69	29	2.40	27	23.46	3	31.31	14	33.31	17	41.54	25	151 (4)
Kalazula	2.28	20	202.28	9	9.65	6	8.24	20	52.11	8	2.52	20	21.61	24	27.71	38	39.63	6	52.80	10	161 (9)
Ngana Rico 1	2.45	12	174.05	40	8.04	40	8.11	26	47.67	19	1.92	38	21.98	21	29.18	27	23.13	37	44.05	22	282 (40)
TMS3	2.10	35	188.37	27	9.68	5	8.22	21	43.60	25	3.05	9	22.94	11	33.06	4	25.13	35	37.56	30	202 (19)
Banana	2.25	24	210.65	5	9.95	1	8.97	7	48.90	16	3.93	1	20.63	34	35.51	1	19.00	40	36.78	31	160 (8)
Rio Dange	2.05	38	201.38	10	8.67	29	8.15	25	49.31	13	1.95	37	23.38	5	28.87	30	28.25	29	40.50	29	245 (33)
Cassandi	2.59	7	183.99	30	9.72	4	8.22	22	38.94	36	2.21	29	22.46	17	30.30	20	32.38	19	51.91	13	197 (17)
Vermute	2.05	39	201.18	11	9.16	16	8.20	23	43.41	26	3.90	2	22.68	15	32.15	10	40.56	4	54.73	8	154 (5)
Guita	2.51	10	177.96	38	8.31	36	7.81	34	37.17	38	2.00	35	22.75	14	29.18	28	31.38	23	52.62	11	267 (36)
Chico dia kombe	1.87	40	191.08	22	9.32	12	8.39	14	40.17	35	2.89	11	20.31	38	27.84	36	27.63	32	33.74	38	278 (39)
P. de Angola	2.26	23	212.84	3	8.59	30	7.84	33	59.91	2	3.12	7	20.14	39	28.36	34	37.38	9	52.34	12	192 (15)
Kalami	2.35	16	180.52	34	8.90	23	7.60	40	48.54	18	2.88	12	22.99	7	30.14	24	35.00	14	48.36	16	204 (22)
Baco	2.12	34	179.49	35	8.83	24	8.03	29	46.72	21	3.16	6	21.53	25	32.54	8	30.69	25	36.46	33	240 (32)

Table 5. Contd.

Katenda	2.28	21	190.49	24	8.76	27	8.29	18	50.77	9	2.99	10	21.25	26	30.68	18	32.75	18	60.79	3	174 (11)
Malanje	2.09	36	207.10	7	9.34	10	9.59	2	42.97	27	2.54	19	21.18	28	24.13	40	47.00	1	40.51	28	198 (18)
Ngana Rico 2	2.96	2	175.37	39	8.46	33	8.41	13	47.53	20	3.71	4	23.91	1	30.40	19	32.25	21	60.31	4	156 (6)
Kalawenda	2.64	6	198.37	14	9.17	15	7.76	36	54.74	6	2.52	21	21.81	23	28.85	31	27.94	30	33.76	37	219 (25)
Gonçalo	2.55	9	181.06	32	9.13	17	7.64	37	41.01	31	2.59	18	22.96	10	31.70	12	32.00	22	49.84	15	203 (21)
Mundele Paco	2.15	31	205.02	8	9.73	3	9.29	3	36.33	39	2.13	31	23.31	6	32.63	7	36.50	11	33.36	39	178 (12)
Suingui	2.16	30	183.94	31	8.54	31	8.17	24	50.15	12	2.11	32	22.43	19	32.95	5	32.38	20	50.85	14	218 (24)
NganaYuculu	2.17	29	210.73	4	9.59	7	7.61	39	49.09	15	3.57	5	23.41	4	32.43	9	40.00	5	58.85	5	122 (2)
Muringa	2.27	22	196.10	17	9.04	20	8.99	6	40.81	34	2.77	15	20.54	35	34.96	2	40.63	3	36.45	34	188 (13)
Kinzela	2.75	3	197.53	15	8.26	37	7.90	31	52.87	7	2.09	33	20.48	37	27.73	37	38.31	8	52.95	9	217 (23)
Mpelo	2.65	5	186.34	29	8.05	39	8.34	16	48.56	17	1.65	40	22.99	8	28.76	32	36.00	13	41.24	26	225 (26)
Gueti	2.32	18	193.07	21	9.20	14	7.62	38	44.27	24	2.45	24	22.76	13	31.78	11	39.38	7	43.35	24	194 (16)
Kapumba	2.29	19	196.92	16	9.34	11	8.48	11	40.84	33	2.46	23	20.95	30	28.88	29	29.19	28	34.41	36	236 (31)

[1]values between parameters indicate the final rank of the genotype. NB, number of branches; SD, stem diameter; ID, internode length; HFB, height of the first branch; RN, number of roots; RD, root diameter; RL, root length; SY, shoot yield; RY root yield.

Rico 2 and Vermute (Table 5).

Genotypes Ngana Yuculu and Ngana Rico 2 ranked fifth and fourth, respectively, for traits RN (3.5 and 3.7), RY (58.8 Kg and 60 Kg) and SY (40.0 Kg). However, the low position of genotype Ngana Rico 2 for variable shoot yield did not make genotype recommendation feasible.

Genotypes Tio Jojo, Kimbanda, Vermute, and Kalazula ranked first, second, third, and fourth, respectively, based on the multiplicative index. On the other hand, genotypes Jaca Vermelha, Jaca Branca, Ngana Yuculu, and Waticamana ranked fifth, sixth, seventh, and eight, respectively, based on the order of classification of scores or on the centered means (x_i - k_j) of the index (Table 6).

Genotype Tio Jojo ranked first in the multiplicative index and showed genetic material selectable, since it recorded the best means for traits PH (224.11 cm), HFB (61.24 cm), RY (66.7 Kg). These traits are relevant for the selection of a superior genotype.

Kimbanda ranked second in the multiplicative index and presented the second best performance in traits PH (218.79 cm), HFB (57.88 cm) and RY (64.09 Kg), besides ranking first in ID (10.02 cm). The high shoot yield highlighted the multiuse potential (human and animal diets) of genotype Kimbanda (Table 6).

Kimbanda ranked between the seventh and the tenth position in the other traits. However, such ranking did not limit the genotype selection, since this variety stood out for most relevant traits.

Vermute ranked third in the multiplicative index and eleventh for character PH, twenty sixth for HFB and eighth for RY (Table 6). Vermute also ranked fourth for character SY (40.56 cm). However, the genotype recorded the second highest mean for trait RN (3.90).

Kalazula ranked fourth based on the classification of multiplicative index and sixth for traits SY (39.63 Kg) and SD (9.65 cm), eighth for HFB (52.11 cm) and tenth for RY (52.80 Kg). Kalazula ranked ninth for the mean of trait PH (201.28 cm). This variety recorded intermediate means in the other traits. Means observed for this genotype were higher than the national mean, although it was among the six more productive genotypes. This result does not make its selection feasible.

Genotype Jaca Vermelha ranked the fifth position in the multiplicative index and recorded the sixth highest mean for PH (207.36 cm), twenty-ninth for HFB (41.69 cm), twenty-fifth for RY (41.54 Kg). Jaca Vermelha also ranked the fourth position for trait ID (9.05 cm) and third for RD (23.46 cm). However, the low performance of genotype Jaca Vermelha in the other traits resulted in its low ranking in the multiplicative index (Table 6).

Genotype Jaca Branca ranked six in the multiplicative index and presented the fourth highest mean for HFB (55.24 cm), eighth for NB (2.58) and seventh for ID (8.77). It is worth highlighting that the low performance of Jaca Branca in the other traits resulted in its low ranking in the multiplicative index.

Table 6. Original ($\bar{x}$) and centered means (x_i - k_j) of the assessed variables used to calculate the multiplicative index (I_M) of cassava genotypes.

Genotypes	NB		PH		SD		ID		HFB		RN		RD		RL		SY		RY		I_M
	$\bar{x}$	xij - kj	$\bar{x}$	xij - kj	$\bar{x}$	xij - kj	$\bar{x}$	xij - kj	$\bar{x}$	xij - kj	$\bar{x}$	xij - kj	$\bar{x}$	xij - kj	$\bar{x}$	xij - kj	$\bar{x}$	xij - kj	$\bar{x}$	xij - kj	
Waticamana	2.65	0.82	189.04	16.27	8.80	0.81	8.51	0.97	50.75	15.28	2.59	1.00	20.75	1.22	32.93	9.09	30.13	11.85	56.08	24.56	5.71 (8) (8)[1]
Maria dia Pedro	2.20	0.37	178.03	5.26	8.34	0.35	7.88	0.34	46.12	10.65	3.06	1.47	21.08	1.55	34.50	10.66	20.56	2.28	32.40	0.88	2.08 (39)
Hoto	2.20	0.37	194.99	22.22	8.34	0.35	8.38	0.84	49.13	13.66	2.41	0.82	21.94	2.41	30.20	6.36	30.38	12.10	41.11	9.59	4.68 (19)
Mata Capim	2.20	0.37	195.58	22.81	8.79	0.80	8.76	1.22	44.87	9.40	1.91	0.32	22.91	3.38	30.99	7.15	37.13	18.85	43.53	12.01	5.13 (12)
Kambaxi	2.14	0.31	200.49	27.72	9.37	1.38	8.33	0.79	41.21	5.74	1.99	0.40	20.73	1.20	30.19	6.35	22.00	3.72	54.95	23.43	4.15 (33)
Paco Vermelho	2.18	0.35	178.45	5.68	9.03	1.04	8.45	0.91	38.17	2.70	2.69	1.10	19.64	0.11	30.20	6.36	42.50	24.22	36.33	4.81	2.66 (36)
Tio Jojo	2.13	0.30	224.11	51.34	9.21	1.22	9.09	1.55	61.24	25.77	2.86	1.27	21.99	2.46	31.01	7.17	36.06	17.78	66.72	35.20	7.02 (1)
Verdinha	3.40	1.57	187.44	14.67	8.52	0.53	7.90	0.36	50.30	14.83	3.84	2.25	20.64	1.11	30.85	7.01	34.50	16.22	44.40	12.88	5.38 (11)
Pé de perdiz	2.39	0.56	194.13	21.36	8.96	0.97	8.26	0.72	54.77	19.30	2.01	0.42	20.50	0.97	28.46	4.62	27.63	9.35	45.24	13.72	4.59 (21)
Paco branco	2.07	0.24	180.61	7.84	8.07	0.08	8.07	0.53	36.11	0.64	2.29	0.70	23.58	4.05	27.84	4.00	34.94	16.66	45.02	13.50	2.11 (38)
Munenga	2.37	0.54	199.14	26.37	9.06	1.07	8.03	0.49	40.86	5.39	2.43	0.84	21.24	1.71	27.61	3.77	26.19	7.91	48.29	16.77	4.46 (23)
Kimbanda	2.39	0.56	218.79	46.02	8.72	0.73	10.02	2.48	57.88	22.41	2.48	0.89	22.44	2.91	30.09	6.25	31.13	12.85	64.09	32.57	6.85 (2)
Suzi	2.45	0.62	190.95	18.18	9.90	1.91	7.80	0.26	42.62	7.15	2.20	0.61	22.96	3.43	29.36	5.52	25.69	7.41	36.67	5.15	4.25 (29)
Jaca Branca	2.58	0.75	190.09	17.32	9.09	1.10	8.77	1.23	55.24	19.77	2.86	1.27	22.58	3.05	31.41	7.57	23.75	5.47	46.06	14.54	5.91 (6)
Jaca Vermelha	2.34	0.51	207.36	34.59	9.44	1.45	9.05	1.51	41.69	6.22	2.40	0.81	23.46	3.93	31.31	7.47	33.31	15.03	41.54	10.02	5.93 (5)
Kalazula	2.28	0.45	202.28	29.51	9.65	1.66	8.24	0.70	52.11	16.64	2.52	0.93	21.61	2.08	27.71	3.87	39.63	21.35	52.80	21.28	5.94 (4)
Ngana Rico 1	2.45	0.62	174.05	1.28	8.04	0.05	8.11	0.57	47.67	12.20	1.92	0.33	21.98	2.45	29.18	5.34	23.13	4.85	44.05	12.53	1.85 (40)
TMS3	2.10	0.27	188.37	15.60	9.68	1.69	8.22	0.68	43.60	8.13	3.05	1.46	22.94	3.41	33.06	9.22	25.13	6.85	37.56	6.04	4.87 (16)
Banana	2.25	0.42	210.65	37.88	9.95	1.96	8.97	1.43	48.90	13.43	3.93	2.34	20.63	1.10	35.51	11.67	19.00	0.72	36.78	5.26	4.83 (18)
Rio Dange	2.05	0.22	201.38	28.61	8.67	0.68	8.15	0.61	49.31	13.84	1.95	0.36	23.38	3.85	28.87	5.03	28.25	9.97	40.50	8.98	4.35 (27)
Cassandi	2.59	0.76	183.99	11.22	9.72	1.73	8.22	0.68	38.94	3.47	2.21	0.62	22.46	2.93	30.30	6.46	32.38	14.10	51.91	20.39	5.07 (15)
Vermute	2.05	0.22	201.18	28.41	9.16	1.17	8.20	0.66	43.41	7.94	3.90	2.31	22.68	3.15	32.15	8.31	40.56	22.28	54.73	23.21	6.08 (3)
Guita	2.51	0.68	177.96	5.19	8.31	0.32	7.81	0.27	37.17	1.70	2.00	0.41	22.75	3.22	29.18	5.34	31.38	13.10	52.62	21.10	3.01 (35)
Chico dia kombe	1.87	0.04	191.08	18.31	9.32	1.33	8.39	0.85	40.17	4.70	2.89	1.30	20.31	0.78	27.84	4.00	27.63	9.35	33.74	2.22	2.51 (37)
P. de Angola	2.26	0.43	212.84	40.07	8.59	0.60	7.84	0.30	59.91	24.44	3.12	1.53	20.14	0.61	28.36	4.52	37.38	19.10	52.34	20.82	5.11 (13)
Kalami	2.35	0.52	180.52	7.75	8.90	0.91	7.60	0.06	48.54	13.07	2.88	1.29	22.99	3.46	30.14	6.30	35.00	16.72	48.36	16.84	4.37 (26)
Baco	2.12	0.29	179.49	6.72	8.83	0.84	8.03	0.49	46.72	11.25	3.16	1.57	21.53	2.00	32.54	8.70	30.69	12.41	36.46	4.94	4.18 (31)
Katenda	2.28	0.45	190.49	17.72	8.76	0.77	8.29	0.75	50.77	15.30	2.99	1.40	21.25	1.72	30.68	6.84	32.75	14.47	60.79	29.27	5.69 (9)
Malanje	2.09	0.26	207.10	34.33	9.34	1.35	9.59	2.05	42.97	7.50	2.54	0.95	21.18	1.65	24.13	0.29	47.00	28.72	40.51	8.99	4.34 (28)
Ngana Rico 2	2.96	1.13	175.37	2.60	8.46	0.47	8.41	0.87	47.53	12.06	3.71	2.12	23.91	4.38	30.40	6.56	32.25	13.97	60.31	28.79	5.55 (10)
Kalawenda	2.64	0.81	198.37	25.60	9.17	1.18	7.76	0.22	54.74	19.27	2.52	0.93	21.81	2.28	28.85	5.01	27.94	9.66	33.76	2.24	4.38 (25)
Gonçalo	2.55	0.72	181.06	8.29	9.13	1.14	7.64	0.10	41.01	5.54	2.59	1.00	22.96	3.43	31.70	7.86	32.00	13.72	49.84	18.32	4.42 (24)
Mundele Paco	2.15	0.32	205.02	32.25	9.73	1.74	9.29	1.75	36.33	0.86	2.13	0.54	23.31	3.78	32.63	8.79	36.50	18.22	33.36	1.84	4.21 (30)
Suingui	2.16	0.33	183.94	11.17	8.54	0.55	8.17	0.63	50.15	14.68	2.11	0.52	22.43	2.90	32.95	9.11	32.38	14.10	50.85	19.33	4.84 (17)
NganaYuculu	2.17	0.34	210.73	37.96	9.59	1.60	7.61	0.07	49.09	13.62	3.57	1.98	23.41	3.88	32.43	8.59	40.00	21.72	58.85	27.33	5.90 (7)

Table 6. Contd.

Muringa	2.27	0.44	196.10	23.33	9.04	1.05	8.99	1.45	40.81	5.34	2.77	1.18	20.54	1.01	34.96	11.12	40.63	22.35	36.45	4.93	5.08 (14)
Kinzela	2.75	0.92	197.53	24.76	8.26	0.27	7.90	0.36	52.87	17.40	2.09	0.50	20.48	0.95	27.73	3.89	38.31	20.03	52.95	21.43	4.48 (22)
Mpelo	2.65	0.82	186.34	13.57	8.05	0.06	8.34	0.80	48.56	13.09	1.65	0.06	22.99	3.46	28.76	4.92	36.00	17.72	41.24	9.72	3.07 (34)
Gueti	2.32	0.49	193.07	20.30	9.20	1.21	7.62	0.08	44.27	8.80	2.45	0.86	22.76	3.23	31.78	7.94	39.38	21.10	43.35	11.83	4.68 (20)
Kapumba	2.29	0.46	196.92	24.15	9.34	1.35	8.48	0.94	40.84	5.37	2.46	0.87	20.95	1.42	28.88	5.04	29.19	10.91	34.41	2.89	4.17 (32)
Ki	1.83		172.77		7.99		7.54		35.47		1.59		19.53		23.84		18.28		31.52		

[1]values between parameters indicate the final rank of the genotypes; NB, number of branches; SD, stem diameter; ID, internode length; HFB, height of the first branch; RN, number of roots; RD, root diameter; RL, root length; SY, shoot yield; RY root yield.

Ngana Yuculu ranked seventh in the multiplicative index and recorded the fourth highest mean for traits PH and RD, and fifth for SY, RY and RN. Genotype Ngana Yuculu ranked seventh for SD (9.59), ninth for RL (32.43). Finally, genotype Waticamana ranked eighth in the multiplicative index and recorded the following performance: 5th for NB, 6th for RL and RY, 9th for ID and 10th for HFB.

Almeida et al. (2014b), Lessa et al. (2010), and Pedrozo et al. (2009) observed that the multiplicative index was efficient to estimate selection gains similar to those of indices proposed by Mulamba and Mock (1978), Pesek and Baker (1969), Smith (1936) and Hazel (1943). Pedrozo et al. (2009) observed that the multiplicative index recorded better selection efficiency than the sum of post (Mulamba and Mock, 1978) and the classic (Hazel, 1943; Smith, 1936) indices when they tested the efficiency of different indices in the selection of superior sugarcane genotypes.

Table 7 presents the values recorded for the genotype-ideotype distance index. There was no significant correlation among this index and the indices Sum of Post (I_{MM}) and the multiplicative mulamba index.

Values attributed to ideotype in this index presented positive and negative deviations for some of the variables, except for traits PH, RN, RY and SY, which recorded the highest means and the highest overall trait means. Negative deviation means that the value attributed to the ideotype was higher than the mean of that trait in the genotype that is taken into account ($x_{Ij} > x_{ij} \rightarrow d_{ij} = (x_{ij} - x_{Ij}) < 0$).

Genotypes Hoto, Mata Capim, Katenda and Gueti ranked first, second, third and fourth in the genotype-ideotype index, respectively. Kalami, Munenga, Kapumba and Suingui ranked fifth, sixth, seventh and eighth, respectively, based on the classification order of the index (Table 7).

The genotype Precoce is one of the favorites of Malanje farmers, since it adapts well to the soil and weather conditions in the country and due to the tradition of keeping the cultivation of materials used by their ancestors. This variety ranked the fifteenth position in the evaluation of Mulamba and Mock, thirteenth in the multiplicative index and thirty-first in the genotype-ideotype distance index.

Accordingly, there is the need of implementing new studies to analyze the agronomic potential of different genotypes in order to identify productive materials capable of diversifying cassava cultivation in the province in Angola.

There was close relation (0.8895**) based on the Spearman correlation between the multiplicative and sum of classification indices (Table 8). This study has highlighted a high degree of correspondence between the two variables described above. Similar result was recorded by Lessa et al. (2017), who selected cassava genotypes based on three non-parametric indices and found high correlation (0.8809**) between results recorded for the multiplicative indices and the sum of classification. They concluded that the referred indices allowed a more appropriate selection. Lessa et al. (2010) assessed banana tree diploid hybrids and observed high correlation (0.83**) between results recorded for multiplicative indices and the sum of classifications. They concluded that the referred indices enabled a more appropriate selection.

It is worth highlighting that, among the six genotypes selected through multiplicative indices and the sum of classification, four of them are from de Cuanza Sul (Tio Jojo, Kimbanda, Jaca Vermelha, Jaca Branca) and two, from Malanje (Ngana Yuculu, Vermute). However, the selection conducted through cassava indices is quite promising, and it can be used in cassava enhancement programs.

Conclusion

The morpho-agronomic traits used to assess the

Table 7. Original means ($\bar{x}$) and deviations of variables used to calculate the Euclidian distance from genotype to ideotype (D_{ij}) in cassava genotypes.

Genotypes	NB		PH		SD		ID		HFB		NMR		DMR		CMR		PMPA		PMR		*Dij*
	$\bar{x}$	dij	$\bar{x}$	dij	$\bar{x}$	dij	$\bar{x}$	dij	$\bar{x}$	dij	$\bar{x}$	dij	$\bar{x}$	dij	$\bar{x}$	dij	$\bar{x}$	dij	$\bar{x}$	dij	
Waticamana	2.65	1.08	189.04	-0.40	8.80	-0.34	8.51	0.33	50.75	0.63	2.59	-0.07	20.75	-1.04	32.93	1.09	30.13	-0.33	56.08	1.09	2.35 (11)[1]
Maria dia Pedro	2.20	-0.52	178.03	-1.30	8.34	-1.22	7.88	-0.81	46.12	-0.09	3.06	0.74	21.08	-0.75	34.50	1.78	20.56	-1.84	32.40	-1.48	3.73 (33)
Hoto	2.20	-0.52	194.99	0.09	8.34	-1.22	8.38	0.09	49.13	0.38	2.41	-0.37	21.94	0.00	30.20	-0.11	30.38	-0.29	41.11	-0.53	1.56 (1)
Mata Capim	2.20	-0.52	195.58	0.14	8.79	-0.36	8.76	0.78	44.87	-0.28	1.91	-1.23	22.91	0.84	30.99	0.24	37.13	0.76	43.53	-0.27	2.01 (2)
Kambaxi	2.14	-0.73	200.49	0.54	9.37	0.75	8.33	0.00	41.21	-0.85	1.99	-1.09	20.73	-1.06	30.19	-0.11	22.00	-1.61	54.95	0.97	2.82 (20)
Paco Vermelho	2.18	-0.59	178.45	-1.26	9.03	0.10	8.45	0.22	38.17	-1.33	2.69	0.11	19.64	-2.01	30.20	-0.11	42.50	1.61	36.33	-1.05	3.39 (29)
Tio Jojo	2.13	-0.77	224.11	2.47	9.21	0.45	9.09	1.38	61.24	2.27	2.86	0.40	21.99	0.04	31.01	0.25	36.06	0.60	66.72	2.25	4.42 (36)
Verdinha	3.40	3.73	187.44	-0.53	8.52	-0.87	7.90	-0.78	50.30	0.56	3.84	2.08	20.64	-1.14	30.85	0.18	34.50	0.35	44.40	-0.18	4.66 (38)
Pé de perdiz	2.39	0.16	194.13	0.02	8.96	-0.03	8.26	-0.13	54.77	1.26	2.01	-1.06	20.50	-1.26	28.46	-0.87	27.63	-0.73	45.24	-0.09	2.37 (12)
Paco branco	2.07	-0.98	180.61	-1.08	8.07	-1.73	8.07	-0.47	36.11	-1.65	2.29	-0.58	23.58	1.42	27.84	-1.14	34.94	0.42	45.02	-0.11	3.45 (30)
Munenga	2.37	0.08	199.14	0.43	9.06	0.16	8.03	-0.54	40.86	-0.91	2.43	-0.34	21.24	-0.61	27.61	-1.24	26.19	-0.95	48.29	0.25	2.08 (6)
Kimbanda	2.39	0.16	218.79	2.04	8.72	-0.49	10.02	3.06	57.88	1.74	2.48	-0.25	22.44	0.43	30.09	-0.15	31.13	-0.18	64.09	1.96	4.58 (37)
Suzi	2.45	0.37	190.95	-0.24	9.90	1.77	7.80	-0.96	42.62	-0.63	2.20	-0.73	22.96	0.88	29.36	-0.47	25.69	-1.03	36.67	-1.02	2.87 (21)
Jaca Branca	2.58	0.83	190.09	-0.31	9.09	0.22	8.77	0.80	55.24	1.33	2.86	0.40	22.58	0.55	31.41	0.42	23.75	-1.34	46.06	0.00	2.38 (13)
Jaca Vermelha	2.34	-0.02	207.36	1.10	9.44	0.89	9.05	1.30	41.69	-0.78	2.40	-0.39	23.46	1.32	31.31	0.38	33.31	0.16	41.54	-0.49	2.57 (17)
Kalazula	2.28	-0.23	202.28	0.69	9.65	1.29	8.24	-0.16	52.11	0.85	2.52	-0.19	21.61	-0.29	27.71	-1.20	39.63	1.16	52.80	0.74	2.52 (16)
Ngana Rico 1	2.45	0.37	174.05	-1.62	8.04	-1.79	8.11	-0.40	47.67	0.15	1.92	-1.21	21.98	0.03	29.18	-0.55	23.13	-1.43	44.05	-0.21	3.17 (24)
TMS3	2.10	-0.87	188.37	-0.45	9.68	1.34	8.22	-0.20	43.60	-0.48	3.05	0.72	22.94	0.87	33.06	1.15	25.13	-1.12	37.56	-0.92	2.78 (19)
Banana	2.25	-0.34	210.65	1.37	9.95	1.86	8.97	1.16	48.90	0.35	3.93	2.23	20.63	-1.15	35.51	2.22	19.00	-2.08	36.78	-1.00	4.85 (40)
Rio Dange	2.05	-1.05	201.38	0.61	8.67	-0.59	8.15	-0.32	49.31	0.41	1.95	-1.16	23.38	1.25	28.87	-0.69	28.25	-0.63	40.50	-0.60	2.50 (15)
Cassandi	2.59	0.86	183.99	-0.81	9.72	1.42	8.22	-0.20	38.94	-1.21	2.21	-0.72	22.46	0.45	30.30	-0.06	32.38	0.02	51.91	0.64	2.46 (14)
Vermute	2.05	-1.05	201.18	0.60	9.16	0.35	8.20	-0.23	43.41	-0.51	3.90	2.18	22.68	0.64	32.15	0.75	40.56	1.30	54.73	0.94	3.19 (26)
Guita	2.51	0.58	177.96	-1.30	8.31	-1.28	7.81	-0.94	37.17	-1.48	2.00	-1.08	22.75	0.70	29.18	-0.55	31.38	-0.14	52.62	0.72	3.04 (22)
Chico dia kombe	1.87	-1.69	191.08	-0.23	9.32	0.66	8.39	0.11	40.17	-1.01	2.89	0.45	20.31	-1.42	27.84	-1.14	27.63	-0.73	33.74	-1.33	3.19 (25)
P. de Angola	2.26	-0.31	212.84	1.55	8.59	-0.74	7.84	-0.89	59.91	2.06	3.12	0.84	20.14	-1.57	28.36	-0.91	37.38	0.80	52.34	0.69	3.63 (31)
Kalami	2.35	0.01	180.52	-1.09	8.90	-0.15	7.60	-1.32	48.54	0.29	2.88	0.43	22.99	0.91	30.14	-0.13	35.00	0.43	48.36	0.25	2.08 (5)
Baco	2.12	-0.80	179.49	-1.18	8.83	-0.28	8.03	-0.54	46.72	0.01	3.16	0.91	21.53	-0.36	32.54	0.92	30.69	-0.25	36.46	-1.04	2.31 (10)
Katenda	2.28	-0.23	190.49	-0.28	8.76	-0.41	8.29	-0.07	50.77	0.64	2.99	0.62	21.25	-0.61	30.68	0.10	32.75	0.08	60.79	1.60	2.01 (3)
Malanje	2.09	-0.91	207.10	1.08	9.34	0.69	9.59	2.28	42.97	-0.58	2.54	-0.15	21.18	-0.67	24.13	-2.76	47.00	2.31	40.51	-0.60	4.67 (39)
Ngana Rico 2	2.96	2.17	175.37	-1.51	8.46	-0.99	8.41	0.15	47.53	0.13	3.71	1.85	23.91	1.71	30.40	-0.02	32.25	0.00	60.31	1.55	4.10 (35)
Kalawenda	2.64	1.04	198.37	0.37	9.17	0.37	7.76	-1.03	54.74	1.25	2.52	-0.19	21.81	-0.12	28.85	-0.70	27.94	-0.68	33.76	-1.33	2.60 (18)
Gonçalo	2.55	0.72	181.06	-1.05	9.13	0.29	7.64	-1.25	41.01	-0.88	2.59	-0.07	22.96	0.88	31.70	0.55	32.00	-0.04	49.84	0.41	2.3 0(9)
Mundele Paco	2.15	-0.70	205.02	0.91	9.73	1.44	9.29	1.74	36.33	-1.61	2.13	-0.85	23.31	1.19	32.63	0.96	36.50	0.67	33.36	-1.37	3.80 (34)
Suingui	2.16	-0.66	183.94	-0.81	8.54	-0.84	8.17	-0.29	50.15	0.54	2.11	-0.89	22.43	0.42	32.95	1.10	32.38	0.02	50.85	0.52	2.15 (8)
NganaYuculu	2.17	-0.62	210.73	1.38	9.59	1.17	7.61	-1.30	49.09	0.37	3.57	1.61	23.41	1.27	32.43	0.87	40.00	1.21	58.85	1.39	3.73 (32)

Table 7. Contd.

Muringa	2.27	-0.27	196.10	0.18	9.04	0.12	8.99	1.20	40.81	-0.91	2.77	0.24	20.54	-1.22	34.96	1.98	40.63	1.31	36.45	-1.04	3.27 (27)
Kinzela	2.75	1.43	197.53	0.30	8.26	-1.37	7.90	-0.78	52.87	0.96	2.09	-0.92	20.48	-1.28	27.73	-1.19	38.31	0.95	52.95	0.75	3.30 (28)
Mpelo	2.65	1.08	186.34	-0.62	8.05	-1.77	8.34	0.02	48.56	0.29	1.65	-1.68	22.99	0.91	28.76	-0.74	36.00	0.59	41.24	-0.52	3.09 (23)
Gueti	2.32	-0.09	193.07	-0.07	9.20	0.43	7.62	-1.28	44.27	-0.38	2.45	-0.31	22.76	0.71	31.78	0.59	39.38	1.12	43.35	-0.29	2.06 (4)
Kapumba	2.29	-0.20	196.92	0.25	9.34	0.69	8.48	0.27	40.84	-0.91	2.46	-0.29	20.95	-0.87	28.88	-0.68	29.19	-0.48	34.41	-1.26	2.15 (7)
Ideotype	2.35		193.88		8.98		8.33		46.68		2.63		21.95		30.44		32.26		46.02		

Table 8. Spearman correlation between the final ranks of genotypes through Sum of posts (I_{SP}), multiplicative indices (I_M) and the Euclidian Distance from the genotype to the ideotype (D_{ij}).

Indices	I_M	D_{ij}
I_{SP}	0.8895**	-0.2377^{ns}
I_M		0.0030^{ns}

** Significant at 1% probability in the t test, ^{ns} non-significant at 5% probability are coming.

40 cassava genotypes pointed out the existence of promising materials that can be used to diversify cassava cultivation in Angola. The sum of classification and genotype-ideotype distance indices allowed a more realistic ranking of cassava genotypes. The genotype-ideotype distance index did not present any correlation with the multiplicative and sum of classification indices as well. Genotypes Tio Jojo, Ngana Yuculu, Kimbanda, Vermute, Jaca Vermelha and Jaca Branca have the potential to be incorporated into cassava cultivation in Angola.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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