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Selection of Descriptors in a Morphological Characteristics Considered In Cassava Accessions By Means Of Multivariate Techniques

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Abstract: *An experiment was conducted to determine the selection of morphological descriptors in cassava crop by multivariate techniques with the aim of optimizing the use of this technique in order to provide reliable, useful information for the program of genetic improvement and conservation of the species. The phenotypical characterization was performed in 200 genotypes, using 35 descriptors. These genotypes came from Embrapa Cassava and Tropical Fruits, located in the municipality of Cruz das Almas - BA. 19 qualitative and 16 quantitative variables were used. The selection of descriptors was performed by means of principal components analysis (quantitative) and entropy (multi-categories). The efficiency of elimination was analyzed by a comparative study between the components formed, taking into account all the 35 descriptors. Namely, root length and diameter, number of roots per plant, root weight per plant, starch content and HCN in the root, distance between leaf scars, number of stems from the manioc cuttings mother, height of the first branch, length of the middle lobe and the petiole. Color was measured in various places, namely in the film from root; root bark without film, stem, petiole and color of terminal branches. The form of the lobe was also measured It was concluded that the disposal of 57% of descriptors caused no loss of information, however, it minimized the costs and streamlined the management of collections of germplasm of cassava.*

Index terms: *Variability, characteristics morphoagronomic, discarding descriptors*.

I. Introduction

Cassava (Manihot esculenta Crantz) is a major tropical crop and a rich source of carbohydrates. It is the main food source for more than 700 million people in the world; it is ranked the fourth source of carbohydrate after rice, sugarcane, and corn in the developing world [2].

Plant breeders rights have led to the demand of germplasm characterization. Breeders do not only protect their varieties but they get additional information about the level of diversity and genetic constitution of existing germplasm [3]

Daher [6] stressed that, an increase of the number of descriptors resulted in the presence of traces redundant, because they are usually associated with various characters. Thus, the definition of a minimum set of descriptors reduces the need for data collection without causing reduction in the reliability of the results [17].

In the disposal of redundant characters, analysis of the principal components have been shown to optimize the identification of descriptors with better capacity for accessions demanding. The effectiveness of the principal components analysis was checked by comparison between the groups formed by all descriptors and the selected using various methods of grouping [4]; [7]; [1].

Variance of main components decreases from the first to the last. Therefore, last components are responsible for explaining a very small fraction of the total variance. Thus, the variable that dominates (greater coefficient) the component of lower self-value, is the least important in explaining the total variance and therefore liable to discard [16].

Cluster analysis is a technique that can be used as a solution to group and or describe a group of individuals. Having in view that they consider, simultaneously, the entire set of descriptors evaluated.

Multivariate techniques is one of the factors that have driven the studies on genetic diversity among genotypes [13]. The multivariate analyzes are useful tools for identifying descriptors with higher informational content for

characterization of germplasm and genetic improvement, since it provides information to eliminate features that contribute little to total variation [5].

II. Material And Methods

Characterization was done by means of 35 morphological and agronomic descriptors, 200 accessions from Active Germplasm Bank of cassava Embrapa Cassava and Tropical Fruits, (Fukuda et al. , 1997). The 16 quantitative descriptors used in characterization were: root length (cm) (CRR); root diameter (cm) (DRR); number of roots per plant (NRP); weight of the roots per plant (kg) (RRW); starch content of root (%) (TAS); HCN content in root (HCN); distance between leaf scars (cm) (DCF); number of stems from the manioc cuttings mother (NHN); height of the first branch (m) (ARH), plant height (APP); weight of rods and strains by plants (RCW); number of lobules (NLN); length of the lobe medium (cm) (CLL); width of middle lobe (cm) (LLW); length of the petiole (cm) (CPL) and weight of 6702 kg (pl-1) (FWF); The 19 qualitative descriptors used in characterization were: the film surface of the root (SPR); color film from root (CPC); highlight film from root (DPR); color of the root bark without film (color of the cortex) (CCC); color of flesh (CPP); the form of the root (RRF); flower stalk of the root (PRP); presence of strapping in root (PCC); ease of detachment of the root (FDE); Prominence of leaf scars (PCF); stem color (CCCs); habit of branching (BHR); color of terminal branches (CRT); color of mature leaf (CFA); color of broto terminal (CBT); pubescence of young leaves (PFJ); the form of the lobe (FLS); sinuosity of the lobe (SSL) and color of the petiole (CDP);

Percentage of qualitative descriptors was calculated by the frequency of each category and the level of entropy of characters through the coefficient of entropy, Rényi's series [20]. Descriptors that presented entropy level less than 0.75 were discarded.

The selection of quantitative descriptors was performed by analysis of principal components with the use of standardized mean Euclidean distance, the time that the accesses are established without obedience to any experimental design [5]. This analysis involved all the characters and was performed on the basis of the average of the measurements taken for each descriptor, from the correlation matrix, using the PRINCOMP procedure of SAS version 9.0 [22].

The identification of redundant descriptors was carried out, in two procedures: 1) direct selection, proposal by Jolliffe [11], which involved the elimination of the characters that showed greater weighting coefficient in absolute value (eigenvector), the main component of smallest eigenvalue, starting from the last component until some whose eigenvalue not exceeded 0.70 used in SAS software [22]; and 2) Selection based on coefficient of Singh [23], by means of computational program GENES [5]. However, the final disposal was carried out based on the information obtained in the two procedures, being indicated to discard the descriptor identified simultaneously in both procedures. The Pearson correlation coefficients were estimated between all characters seeking to assist in the decision regarding the disposal of a given character redundant, used in SAS software [22].

III. Results And Discussion

The magnitude of the coefficients of variation (CV) was 5.57 % to 42.37 %, of respective mode, for variables related to starch content of root (TAS), and for the weight of the foliage (FWF) and number of roots per plant (NHN). However, these results can be considered as average, when compared with other similar work with the cultivation of cassava [10]; [19]; [27].

The greatest variations among quantitative variables observed were the root length (CRR) (16.50 to 38.30 cm), showing an average of 27.59; starch content of root (TAS) (25.90 to 37.90%), with an average of 32.72; length of the petiole (CPL) (8.30 to 35.50 cm), which had a mean of 22.56.

The minor variations have succeeded for the variables, weight of foliage (FWF) (0.30 to 1.80 kg), presenting an average of 0.82; weight of rods and strains by plants (RCWS) (0.40 to 2.90), showing an average of 1.38; root weight per plant (RRW) (0.70 to 3.90 kg), presenting an average of 1.97; The variables, weight of foliage, weight of rods and strains by plants and root weight per plant are linked to plant architecture, seen that, although there are no reports of what would be the ideal, it is known that, the weight of the foliage, weight of rods and strains by plants and root weight are important, because they facilitate the achievement of cultural.

It was observed that, for the normality test, the results indicated that all the variables had a normal distribution, since the variables were not significant by the Shapiro-Wilks test at 5% significance level (Table 1).

The variables that showed low entropy were color of the mature leaf (0.17), prominence of leaf scars (0.33), sinuosity of the lobe (0.34), color of flesh (0.39), pubescence of young leaves (0.49), the film surface of the root (0.56), presence of strapping in root (0.62), ease of detachment from root (0.65), highlight the film from root (0.67), the stem root (0.69) (Table 2). Low values for entropy are associated with a smaller quantity of

phenotypic category for the descriptor applied and greater instability in the proportion between frequency of accesses in different phenotypic categories [15].

Table 1. Minimum, maximum, and mean Values, standard deviation, coefficient of variation and normality test for quantitative variables. Cruz das Almas, 2013.

Variables	Minimum	Maximum	Mean	Standard deviation	CV	Normality test
CRR	16,50	38,30	27,59	3,64	13,19	0,99^{ns}
DRR	4,10	8,50	5,82	0,75	12,94	0,99^{ns}
NRP	3,30	22,00	9,63	3,09	32,14	0,96^{ns}
RRW	0,70	3,90	1,97	0,54	27,55	0,99^{ns}
TAS	25,90	37,90	32,72	1,82	5,57	0,96^{ns}
HCN	3,00	9,00	7,19	1,24	17,26	0,90^{ns}
DCF	5,20	22,00	9,93	2,08	20,98	0,90^{ns}
NHN	1,00	4,00	1,64	0,70	42,37	0,77^{ns}
ARH	0,30	1,80	0,82	0,25	30,34	0,96^{ns}
APP	1,50	3,30	2,47	0,29	11,62	0,99^{ns}
RCW	0,40	2,90	1,38	0,43	31,55	0,97^{ns}
NLN	1,00	9,00	6,26	1,09	17,34	0,66^{ns}
CLL	9,40	20,40	14,50	1,91	13,17	0,99^{ns}
LLW	2,10	6,10	4,24	0,79	18,70	0,99^{n}
CPL	8,30	35,50	22,56	5,58	24,65	0,98^{ns}
FWF	0,30	3,40	1,43	0,60	42,37	0,95^{ns}

^{ns} not significant by the Shapiro-Wilks test at 5% significance level. Root Length (cm) (CRR); Root Diameter (cm) (DRR); Number of roots per plant (NRP); root weight per plant (kg) (RRW); Starch content of root (%) (TAS); HCN content in root (HCN); Distance between leaf scars (cm) (DCF); Number of stems from the manioc cuttings mother (NHN); Height of the first branch (m) (ARH), plant Height (APP); Weight of rods and strains by plants (RCW) ;Number Lobes (NLN); Length of the lobe medium (cm) (CLL); Lobe width medium (cm) (LLW) ;Petiole length (cm) (CPL); Weight of foliage (kg/pl) (FWF)

Table 2. Qualitative Descriptors evaluated, phenotypic categories, percentage frequency and entropy level of collection of cassava accessions from Embrapa Cassava and Tropical Fruits. Cruz das Almas 2013.

Qualitative Descriptors	Category	Frequency (%)	Entropy Level
Film surface root	Smooth	24,50	0,56
	Rugous	75,50	
Color of the film from root	Cream	24,00	0,95
	Light Brown	16,50	
	Dark Brown	59,50	
Highlight of the film from root	Easy	39,50	0,67
	Hard	60,50	
Color of the root bark without film	White	56,00	0,97
	Cream	33,00	
	Yellow	1,00	
	Pinkish	10,00	
Color of flesh	White	89,50	0,39
	Cream	8,50	
	Yellow	2,00	
Form of Root	Cylindrical	33,50	1,37

	Conical	20,00	
	Cylindrical - Conical	24,00	
	Fusiform	22,50	
The Stem root	with peduncle/ Stalks	44,50	0,69
	without peduncle/ Stalks	55,50	
Presence of strapping in root	With tie	31,50	0,62
	Without tie	68,50	
Ease of detachment from root	Ease	64,50	0,65
	Hard	35,50	
Prominence of leaf scars	Little prominent	3,00	0,33
	Averagely Prominent	92,00	
	Very prominent	5,00	
Stem Color	Turn green	16,50	1,45
	Silver	35,00	
	Light Brown	31,50	
	Redden	10,00	
	Silver orange	7,00	

Tabela 2. Cont...

Qualitative Descriptors	Category	Frequency (%)	Entropy Level
Habit of branching	Undivided	22,50	1,03
	Dichotomic	51,50	
	Tricotomic	26,00	
Color of terminal branches	Green	57,50	0,85
	Yellow-green	36,50	
	Purple	6,00	
Color of mature leaf	Green	96,50	0,17
	Yellow-green	1,00	
	Purple	2,50	
Color of the terminal bud	Verde	34,50	1,09
	Green-Purple	38,50	
	Purple	27,00	
Pubescence of young leaves	Smooth	84,00	0,49
	Few hair	14,50	
	Many hair	1,50	
Shape of the lobe	Ovoid	3,50	1,03
	Elliptical	6,00	
	Lanceolate	70,00	
	Oblongo	1,00	
	Linear hostatilobalada	0,50	
	Linear pondurada	5,00	
	Ondulada estreitamente elítica	14,00	
Sinuosity of lobe	With Sinuosity	10,50	0,34
	Without Sinuosity	89,50	
Color of the petiole	Green	6,00	1,30
	Red	34,50	
	Reddish Green	30,00	
	Red greenish	28,50	
	Purple	1,00	

Oliveira [15] found for accessions of Manihot low entropy for the descriptors: sinuosity of leaf lobe, flowering, pollen and leaf color developed. It should also be noted that Vieira [26], featuring cassava germplasm found low entropy for the following keywords: stem growth habit, flowering, texture of the epidermis of the root and the root constriction .

Variables that showed higher entropies were stem color (1.45) , root form (1.37), color of the petiole (1.30) , the terminal bud color (1.09) , so the lobe (1 , 03) branching habit (1.03) , the color of the root bark peeled (0.97) , the root color film (0,95) , the color of the terminal branches (0.85) once presented large number of categories and a more balanced ratio between the frequency of accesses in different phenotypic classes (Table 2) , which reveals genetic variability among accessions . Vieira [27] found for cassava germplasm larger entropies for the external color of the stem, petiole color, shape and color of the central lobe of the apical leaf descriptors. In the study of Manihot germplasm by Oliveira [15], the largest entropies were found for petiole color, shape of the central lobe, outside color of stem and number of lobes descriptors.

Among the parameters evaluated descriptors, those that showed a significant positive correlation was petiole length with the length of the middle lobe and 0.71** number of lobes (NLN) length of middle lobe with 0.42 ** (Table 3). However, it shows that the increment of choice of morphological descriptors is directly associated to petiole length and the length of the middle lobe. Although the length of the root represents an important component in petiole length, no significant correlation was observed between root diameters. However, there was a negative correlation between root diameter and number of roots per plant - 0.22**, root diameter and root starch -0.19 **, root weight per plant and distance between leaf scars -0.22 ** , root length and plant height - 0.23 ** , number of stems from maniva mother and petiole length - 0.26 ** , height and weight of the first branch of foliage -0 , 21 **.

Based on the coefficient of Singh [23] , the variable length of the petiole , appeared as the character of greatest importance among the sixteen variables evaluated , also had the highest percentage of contribution for genetic divergence (43.94 %) being accounts for the largest proportion of all data variability (Table 4).

When analyzing the estimates of the eigenvalues associated with the major components and their respective totals and accumulated variations obtained for the 16 quantitative morphological characters, it is noticed that the first two components could explain 32.56 % of the total cumulative variance because it was concentrated to 9th main component, accounting for 83.76 % of the variation available in the collection of descriptors (Table 5). Pereira [17] emphasize that the distribution of the variance is associated with the nature and number of characters used in the analysis and focuses on the first principal components are used when only a few descriptors of agronomic interest or a group (plant, flowering, fruit and agronomic). Dias [7], who found an accumulation of 71.37 %, observed this fact.

When evaluating the preliminary discharge for the quantitative descriptors , using the estimates of the weighting coefientes eigenvector associated with the main components it was found that the first character was indicated petiole length , since it had the highest weight in module with the last major component (-0.55), followed by characters of the middle lobe length , plant height , weight of foliage, stems and strains weight per plant , number of lobes , the width of the middle lobe , of which the largest eigenvalues occurred in module main components CP11 (RCW) , CP12 (NLN) and CP13 (CLL) , respectively (Table 6) . In this procedure , seven characters were considered redundant as a result of disposal : CPL , CLL , APP , FWF , RCW , NLN and LLW . Importantly, this procedure can be considered drastic, because it eliminated nine of the sixteen quantitative morphological characters used as descriptors of cassava.

On disposal made by selection with Joliffe [11], indicated only seven characters in the following order : CPL , CLL , APP , FWF , RCW , NLN and LLW (Table 7) . When compared to the previous, it appears that this procedure seems more appropriate, but there was indication of disposal for most characters used in the selection of descriptors. Based on the simultaneous analysis of the two procedures, five characters were coincident, however, were part of the final disposal the following descriptors: APP, FWF, RCW , NLN and LLW .

Therefore, this decision has attenuated the drasticidade by selection of Singh [23] and minimized possible errors in discard, in addition to having allowed a reduction of 31.25% of the evaluated traits, causing reduction in costs and in the evaluation and characterization of germplasm of cassava.

Table 3. Pearson's correlation Coefficient for the quantitative variables. Cruz das Almas, 2013.

	DRR	NRP	RRW	TAS	HCN	DCF	NHN	ARH	APP	RCW	NLN	CLL	LLW	CPL	FWF
CRR	-0,08^{ns}	0,08^{ns}	0,39**	0,21^{ns}	0,08^{ns}	-0,09^{ns}	-0,10^{ns}	-0,07^{ns}	-0,23**	-0,13^{ns}	0,11^{ns}	0,11^{ns}	0,07^{ns}	0,01^{ns}	-0,12^{ns}
DRR		-0,22**	0,30**	-0,19**	0,12*	-0,09^{ns}	-0,11^{ns}	0,09^{ns}	-0,02^{ns}	-0,01^{ns}	0,08^{ns}	-0,06^{ns}	-0,13^{ns}	0,13^{ns}	0,04^{ns}
NRP			0,47**	0,08^{ns}	0,01^{ns}	-0,01^{ns}	0,05^{ns}	0,05^{ns}	0,01^{ns}	0,13*	-0,04^{ns}	0,13^{ns}	-0,03^{ns}	-0,08^{ns}	-0,05^{ns}
RRW				0,02^{ns}	-0,03^{ns}	-0,22**	-0,05^{ns}	0,08^{ns}	-0,19**	-0,01^{ns}	0,09^{ns}	0,04^{ns}	-0,03^{ns}	0,02^{ns}	-0,10^{ns}

TAS	0,02^{ns}	-0,18**	0,04^{ns}	-0,03^{ns}	0,02^{ns}	0,13^{ns}	0,10^{ns}	0,14^{ns}	0,15*	0,14*	0,08^{ns}
HCN		-0,04^{ns}	0,05^{ns}	-0,03^{ns}	-0,14*	-0,07^{ns}	0,15*	0,02^{ns}	0,02^{ns}	0,10^{ns}	-0,08^{ns}
DCF			0,18*	0,27**	0,46**	0,13*	-0,13*	-0,09^{ns}	-0,02^{ns}	-0,26**	0,09^{ns}
NHN				0,14*	0,08^{ns}	0,07^{ns}	0,09^{ns}	-0,09^{ns}	-0,07^{ns}	-0,03^{ns}	0,02^{ns}
ARH					0,46**	0,11^{ns}	0,18*	0,29**	0,07^{ns}	0,21**	-0,21**
APP						0,49**	0,02^{ns}	0,16^{ns}	0,00^{ns}	0,10^{ns}	0,36**
RCW							0,15*	0,21**	0,19**	0,29**	0,51**
NLN								0,42**	0,31**	0,51**	-0,09^{ns}
CLL									0,55**	0,71**	-0,09^{ns}
LLW										0,52**	-0,10^{ns}
CPL											0,04^{ns}

** and * Significant at 1% and 5 %, respectively, by the t-test ^{ns} not significant at 5% significant. Quantitative variables: Root Length (cm) (CRR); Diameter (cm) (DRR); Number of roots per plant (NRP); root weight per plant (kg) (RRW); Starch content of root (%) (TAS); HCN content in root (HCN); Distance between leaf scars (cm) (DCF Number of stems from the manioc cuttings mother (NHN); Height of the first branch (m) (ARH), plant Height (APP); Weight of rods and strains by plants (RCW) ;Number Lobes (NLN); Length of the lobe medium (cm) (CLL); Lobe width medium (cm) (LLW) ;Petiole length (cm) (CPL); Weight of foliage (kg/pl) (FWF).

Table 4. Relative Contribution of characters for diversity according Singh (1981). Cruz das Almas, 2013.

Descriptors	**S.j**	**S.j (%)**
Root length	526905.44	18.79
Root Diameter	22584.64	0.81
Number of roots per plant	380733.99	13.58
Root weight per plant	11765.91	0.42
Starch Content of root	132473.51	4.72
HCN content in the root	61231.00	2.18
Distance between leaf scars	172556.96	6.15
Number of stems from the manioc cuttings mother	19216.00	0.69
Height of the first branch	2477.75	0.09
Plant Height	3274.31	0.12
Weight of rods and strains by plants	7402.27	0.26
Lobes number	46896.00	1.67
Length of middle Lobe	145021.19	5.17
Middle Lobe Width	24985.75	0.89
Petiole Length	1231979.75	43.94
Weight of Foliage	14497.99	0.52

Table 5. Estimates of eigenvectors associated with the main components and their variances and total accumulated, obtained from 16 characters evaluated in 200 cassava accessions. Cruz das Almas, 2013.

Principal Component	**Eigenvectors**	**Total Variance (%)**	**Total accumulated Variance (%)**
1	2.84	17.72	17.72
2	2.37	14.84	32.56
3	1.60	9.99	42.55
4	1.45	9.06	51.61
5	1.37	8.56	60.17
6	1.11	6.93	67.10
7	0.96	6.00	73.10
8	0.91	5.72	78.81
9	0.79	4.94	83.76

10	0.64	3.99	87.74
11	0.55	3.46	91.20
12	0.41	2.57	93.77
13	0.32	1.98	95.75
14	0.26	1.64	97.38
15	0.23	1.43	98.82
16	0.19	1.18	100.00

Table 6. Estimates of coefficients weighting associated with the main components of eigenvectors lower than 0.70 and identification of characters with indication for disposal, in each component, by direct selection of 200 accessions of cassava. Cruz das Almas, 2013

Descriptors	Main components [-1]						
	CP10	CP11	CP12	CP13	CP14	CP15	CP16
CRR	-0,18	-0,21	-0,09	-0,10	0,07	0,29	0,15
DRR	0,37	0,05	0,08	-0,17	0,11	0,21	0,36
NRP	0,04	0,16	0,20	-0,05	0,01	0,39	0,27
RRW	0,19	0,01	0,00	0,18	0,03	-0,44	-0,46
TAS	0,10	0,13	0,01	-0,11	-0,07	-0,06	0,03
HCN	-0,04	-0,12	-0,06	0,08	0,04	-0,13	-0,06
DCF	0,38	0,32	0,31	-0,20	-0,29	-0,02	-0,19
NHN	0,21	-0,30	0,05	-0,02	0,13	0,01	0,07
ARH	-0,23	-0,21	-0,27	0,32	-0,43	0,05	0,16
APP	.	.	.	.	0,73	0,08	-0,16
RCW	.	.	-0,55	-0,48	-0,17	-0,16	0,06
NLN	.	0,73	0,02	0,11	0,03	-0,03	0,08
CLL	.	.	.	.	.	-0,48	0,35
LLW	0,62	0,06	-0,31	0,41	0,15	0,08	0,11
CPL	.	.	.	.	.	.	-0,55
FWF	.	.	.	0,52	-0,27	0,01	0,14

[-1] CP - Main components.

Root Length (cm) (CRR); Root Diameter (cm) (DRR); Number of roots per plant (NRP); root weight per plant (kg) (RRW); Starch content of root (%) (TAS); HCN content in root (HCN); Distance between leaf scars (cm) (DCF); Number of stems from the manioc cuttings mother (NHN); Height of the first branch (m) (ARH), plant Height (APP); Weight of rods and strains by plants (RCW) ;Number Lobes (NLN); Length of the lobe medium (cm) (CLL); Lobe width medium (cm) (LLW) ;Petiole length (cm) (CPL); Weight of foliage (kg/pl) (FWF)

Table 7. Variables pre-selected and selected based on procedures of Singh (1981) and Jolliffe (1972). Cruz das Almas, 2013.

Variáveis	Pré-selecionadas		Selecionadas
	Singh (1981)	Jolliffe (1972)	
CRR	Sel	Sel	Sel
DRR	Disc (7)[1]	Sel	Sel
NRP	Sel	Sel	Sel
RRW	Disc (4)	Sel	Sel
TAS	Disc (11)	Sel	Sel
HCN	Disc (10)	Sel	Sel
DCF	Sel	Sel	Sel
NHN	Disc (6)	Sel	Sel
ARH	Disc (1)	Sel	Sel
APP	Disc (2)	Disc (3)	Disc
RCW	Disc (3)	Disc (5)	Disc
NLN	Disc (9)	Disc (6)	Disc
CLL	Sel	Disc (2)	Sel
LLW	Disc (8)	Disc (7)	Disc
CPL	Sel	Disc (1)	Sel
FWF	Disc (5)	Disc (4)	Desc

[1]order of discard. Pre-selected Variables. Root Length (cm) (CRR); Root Diameter (cm) (DRR); Number of roots per plant (NRP); root weight per plant (kg) (RRW); Starch content of root (%) (TAS); HCN content in root (HCN); Distance between leaf scars (cm) (DCF); Number of stems from the manioc cuttings mother (NHN); Height of the first branch (m) (ARH), plant Height (APP); Weight of rods and

strains by plants (RCW) ;Number Lobes (NLN); Length of the lobe medium (cm) (CLL); Lobe width medium (cm) (LLW) ;Petiole length (cm) (CPL); Weight of foliage (kg/pl) (FWF)

IV. Conclusions

1. Twenty descriptors are important in the characterization of germplasm of manioc, being eleven relating to quantitative descriptors and nine qualitative.
2. The disposal of 57% of descriptors caused no loss of information, however, minimizes costs and streamlines the management of collections of germplasm of cassava.

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