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Morphological Characterization of Cassava Accessions (*Maniohot* spp) Collected in Maniema (RDC)

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ABSTRACT

The objective of this work was to differentiate the cultivars of cassava produced in the Province of Maniema on the basis of descriptors selected among the descriptors of cassava. The fifteen cassava cultivars collected were evaluated in a field plant system. The descriptive analysis showed phenotypic differences in certain characters such as: color of the apical leaf, shape of the apical leaf, height, diameter at the collar. Ascending hierarchical classification (CHA) made it possible to structure these cultivars into 3 groups of agromorphological diversity. In conclusion, the cassava cultivars grown in the province of Maniema have a great diversity of forms which can constitute a good basis of selection for cassava producers in the Province in particular and in the Democratic Republic of Congo (DRC) in general.

Keywords: characterization, agromorphological, cassava, Maniema

INTRODUCTION

Cassava leads production and has more than 800 million consumers (Wydra and Verdier, 2002) and thus constitutes the staple food of many tropical countries in Africa, Asia, and America. As such, it is considered a strategic food in the fight against nutrition problems plaguing African countries (Agbor Egbe et al., 1995; Djouble, 2005; ACF, 2009; Minengu et al., 2009). Among the root and tuber crops in tropical Africa, cassava (Manihot esculenta Crantz), occupies the largest surface area and especially in regions with high population density (tropical zones of forests and savannahs) where it constitutes the basis of the human nutrition (Nweke, 2002). Of the more than 800 million human beings it feeds, the majority are Africans (IFAD, 2008). In 2012, the harvest reached records, thanks to the development of trade in cassava products and strong growth in production in Africa (Agwu et al., 2007; FAO, 2020).

The analysis of genetic diversity firstly allows us to understand its spatial structure and to gather information linked to its domestication and its diffusion. Likewise, morphological descriptors reveal diversity as it is perceived and selected by local farmers, the main actors in the management of varietal diversity (Elias et al., 2001; McKey et al., 2001; Pinton & Emperaire, 2001). Today, the conditions which prevailed in the establishment of this diversity are changing very quickly under the pressure of various factors: increasing insertion into the market, intensification of links with the city, a change in eating habits, transformations in the modes of transmission of knowledge, etc. The sustainability of this agrobiodiversity is thus called into question, because these factors are the sources of variations within agricultural biodiversity, particularly the accessions of cultivated cassava (McKey et al., op.cit.).

As for the whole country, this genetic diversity of cassava was also observed in Maniema, during the epidemiological investigation, as part of the project on the African cassava mosaic carried out by CARITAS (2014) which counted a number of of cassava clones in the main

cassava-producing localities. Thus, the need for a succinct characterization on the basis of the agronomic evaluation, proves urgent not only to establish a precise catalog for this crop, but also to increase precision when it comes to genetic improvement work of this same culture. All these concerns linked to the lack of information on the real characteristics of the great diversity of cassava cultivars in their production areas in general and in the Maniema Province in particular, lead to some questions: Overall, the question is as follows: What are the cultivars of cassava grown in the Maniema Province? From this main question, two other secondary ones are asked as follows:

What are the agromorphological characteristics of the cassava cultivars present in the production areas of the Maniema Province? The answers to these questions are presented in different types of hypotheses which are, one central and the others secondary to it. This research generally believes that, as Maniema Province is largely forested, the diversity of cassava cultivars is great. Indeed, this diversity can be demonstrated on the basis of characteristics. Thus, the other hypotheses linked to the main one are:

- The differences in values relating to agromorphological characteristics (size and dimension of the stem, number of nodes, number of lobes per leaf, etc.) are remarkable between the cultivars placed in collections in the Province from Maniema; The general objective of this research is to differentiate the cultivars of cassava produced in the Province of Maniema based on the characteristics observed on the individuals of each of the said cultivars. Operationally, this study aims to:

- Determine the main agromorphological characteristics of the cassava cultivars identified and collected in the Province of Maniema

MATERIALS AND METHODS

Study Environment

The study field was installed in Kindu, the capital of the Maniema Province which includes 7 Territories which are: Kailo, Lubutu, Punia, Pangi, Kibombo, Kasongo and Kabambare constituting the cassava production zone (IPA, 2017).

Location of the Experimental Field

The study was carried out in the capital of the Province of Maniema in the Malonga block, located north of the town of Kindu 8 km away. The study was carried out from August 17, 2022 to August 31, 2023, the geographical coordinates of the site are: Longitude 26° 35' E; Latitude 2° 56'; 496m Altitude, (tool used GPS).

In Maniema Province, the equatorial forest describes an arc starting from Kindu via Shabunda and Walikale to join the equatorial forest of the South of Béni. Starting from the South of Maniema at the level of the South of Uvira to the limit with the Province of Tanganyika, we find mosaics of wooded savannahs and forest galleries reflecting the degradation of the forest by human action. The fauna is rich and varied. Two large plant formations cover Maniema: the dense humid forest and the savannah. Dense forest covers the territories of Lubutu, Punia, and Pangi and part of Kailo and Kibombo. This forest is rich in valuable forest species. The gallery forests cover the territories of Kasongo, Kibombo as well as part of the territory of Kabambare where the gallery forest is called Nyemwa, hence the origin of the name Maniema (Makondambuta, 1997).

Material

Biological material

The biological material used consisted of cuttings of cassava cultivars taken from farmers in the cassava production area in the Province (Moke et al., 2023). Table 1 illustrates the cassava cultivars collected from farmers' fields in the production area.

Table 1: Cassava cultivars collected in the study area

N°	Vernacular names with initials	Territory of origin
01	KENDEWE (KEND)	PUNIA
02	KABOMBO (KABO)	KABAMBARE
03	MOMAMA (MOMA)	LUBUTU
04	N'SANCI (NSAN)	PUNIA
05	KANDEKE MUCHICHA (KANDE)	KAILO
06	MOPELA (MOPE)	PUNIA
07	NZOGU (NZOG)	KIBOMBO
08	KELENGA (KELA)	PANGI
09	KANKWALE (KANK)	KAILO
10	MWEZI SITA (MWEZ)	KASONGO
11	KAVIDE (KAVI)	LUBUTU
12	KELENGA DOUCE (KELD)	PANGI
13	KASANKAKU (KASA)	KIBOMBO
14	GLAZIOVII (GLAZ)	KAMBAMBARE
15	ILONA (ILON)	KASONGO

Source: Moke et al. (2023)

Methods

A study relating to the characterization of cassava cultivars (Manihot esculenta) cultivated in the production zone was carried out in the capital of the Province of Maniema in the Malonga block, located north of the town of Kindu 8 km away, aiming to highlight the agromorphological characteristics of different cultivars of cassava (Manihot esculenta) in Maniema Province (DRC).

Methodological approach

It is based on observation and experimentation.

Observation

This technique helped to find a general idea on the agromorphological characteristics of the cultivars by making direct observation (vegetative parameters) during data collection in the experimental field.

Experimental design

The design was made up of elongated plots distributed in a block, and each line represented a selected cultivar and a plant constituted an experimental unit; in addition, each line counted 41 feet and the whole constituted a rectangular block. The contours of the block formed strips of 2.5 m for each of them. Thus, the total surface area of the experimental block was 945 m2 including 640 m2 of space covered by the cultivars, considering a spacing of 1 m x 1 m for 15 cultivars, plus 1 cultivar (X0) of improved variety (Ilona) on both borders. Finally, the layout of the field test is shown in Figure 1.

X0	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X0
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X………

Figure 1: Arrangement of cultivars in the field

Legend: X0= Border cultivar; X1 = KEND: Cultivar KENDEWE; X2 = KABO: Cultivar KABOMBO; X3 = MOMA: Cultivar MOMAMA; X4 = NSAN: Cultivar NSANCI; X5 = KAND: Cultivar KANDEKE MUCHICHA; X6 =MOPE: Cultivar MOPELA; X7 = NZOG: Cultivar NZOGU; X8 = KELE A: Cultivar KELENGA; X9 = KANK: Cultivar KANKALE; X10 = MWEZ: Cultivar MEZI SITA; X11 = KAVID: Cultivar KAVIDE; X12 = KELE D: Cultivar KELENGA; X13 = KASA: Cultivar KASANKAKU; X14 = GLAZ: Cultivar GLAZIOVII; X15 = ILON: Cultivar ILO

Data collection

To measure the growth levels of the aerial parts (vegetative parameters), observations were carried out starting with the resumption of cuttings up to 15 days maximum and afterward, the collection of other observations in accordance with the descriptors. All the values obtained in this study were each time compared to the universal cassava descriptors implemented by IITA (Fukuda et al., 2010; Mahungu et al., 2013). These morphological descriptors have already been used in the study of the agromorphological diversity of cassava in Benin (Agré et al., 2015; N'zué et al., 2014).

Statistical Analyzes of Data

The data collected were entered into an Excel spreadsheet in the form of an "accessions x morphological characters" matrix. The analysis of the morphological data was essentially descriptive. The evaluation of the structuring of the morphological diversity of the cultivars was made by a Correspondence Factor Analysis (AFM), an ascending hierarchical classification (CAH) and a discriminant factor analysis (AFD).

The quantitative data recorded were first subjected to a descriptive analysis. The means, minima, maxima, standard deviations and coefficients of variation were calculated for all the quantitative traits from the average values of the characters observed on each accession. An analysis of variance (ANOVA) was carried out between the different accessions for the quantitative variables in order to assess the level of variability of the plant material. Finally, the average values of the quantitative variables served as input data for an analysis of correlations between variables. The software used is that of R 4.3.1 on its RStudio interference.

Table 2: Qualitative descriptors observed during the experiment

Characteristics and stage of evaluation	Code	Phenotypic classes
Color of apical leaves (3MAP	CAPE	1: Light green, 2: Dark green, 3: Purple green, 4: Purple
Apical leaf pubescence (3MAP	PAPE	0: Absent, 1: Moderate, 2: Dense
Central lobe shape (6MAP	FFAD	1: Oblong, 2: Linear, 3: Oval, 4: Lanceolate

Table 3: Quantitative descriptors observed during the experiment

Characters	Code	Leaf biomass yield
Stem Diameter	DTIG	Fukuda *et al.*, 2010
Plant height at maturity	HPL	Fukuda *et al.*, 2010
Leaf biomass yield	RBMF	Fukuda *et al.*, 2010

RESULTS AND DISCUSSION

This part presents the results and their discussions in relation to the aerial characterization of the cultivars placed in the collection using quantitative and qualitative descriptors.

Aerial Morphological Characterization Quantitative Variables

Recovery rate (in %)

The recovery rates of cultivars placed in collections are shown in Figure 2.

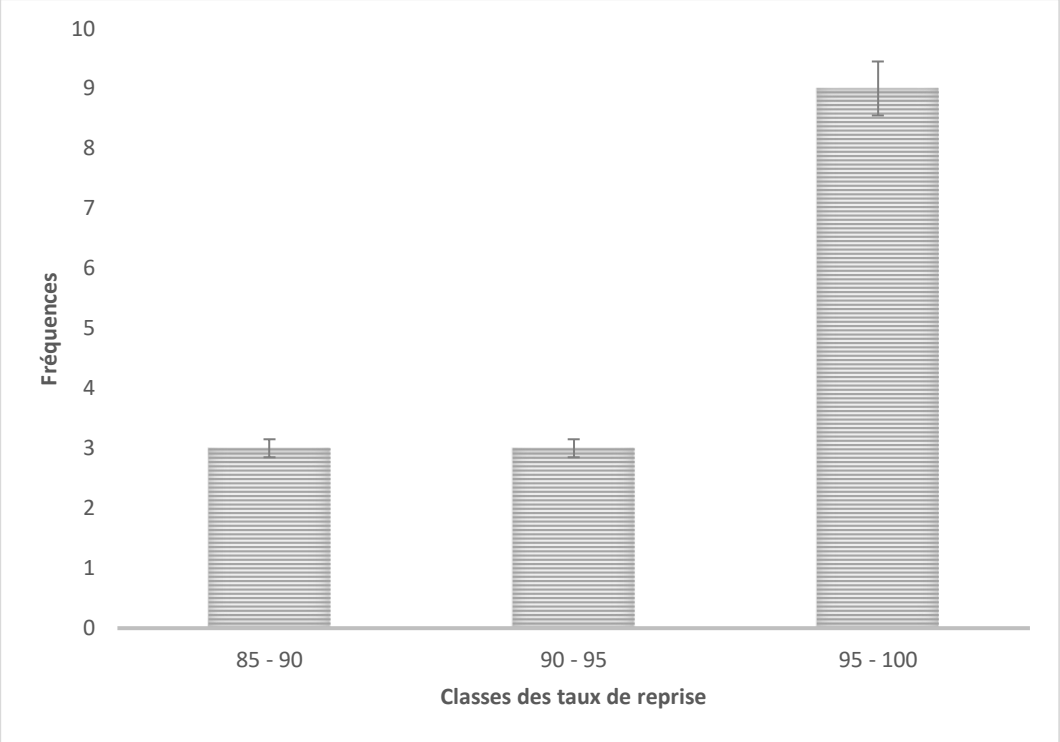

Figure 2: Classes of recovery rates after 15 days

Three groups of recovery rates were reported for the assembly of the collection, The KELD, GLAZ and KELA cultivars presented a rate which varied from 85 to 90% The KAND cultivars, KANK and MWEZ rather presented a recovery rate of 90 to 95% The 9 other cultivars recovered at more than 95% with 7 cultivars which achieved 100% of the recovery rate: KEND, KABO, MOMA, NSAN, NZOG, KASA and ILON.

Plant height

The different plant heights are recorded in Figure 3.

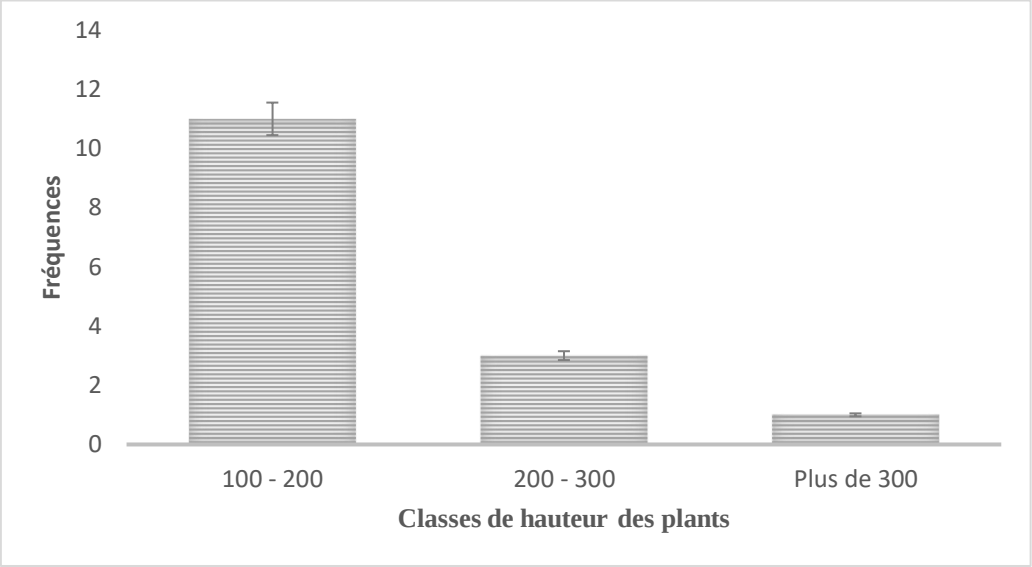

Figure 3: Plant height classes

Most of the cultivars measured a height of 100cm to 200cm, these are: KAVI, KASA, ILON, KELD, MWEZ, KELA, KANK, NZOG, KAND, NSAN Four cultivars have mesusé 200 to 300 cm among others: MOPE, MOMA, KABO, KEND A single cultivar measured more than 300 cm (GLAZI).

Plant stem diameters

Stem diameters are recorded in Figure 4.

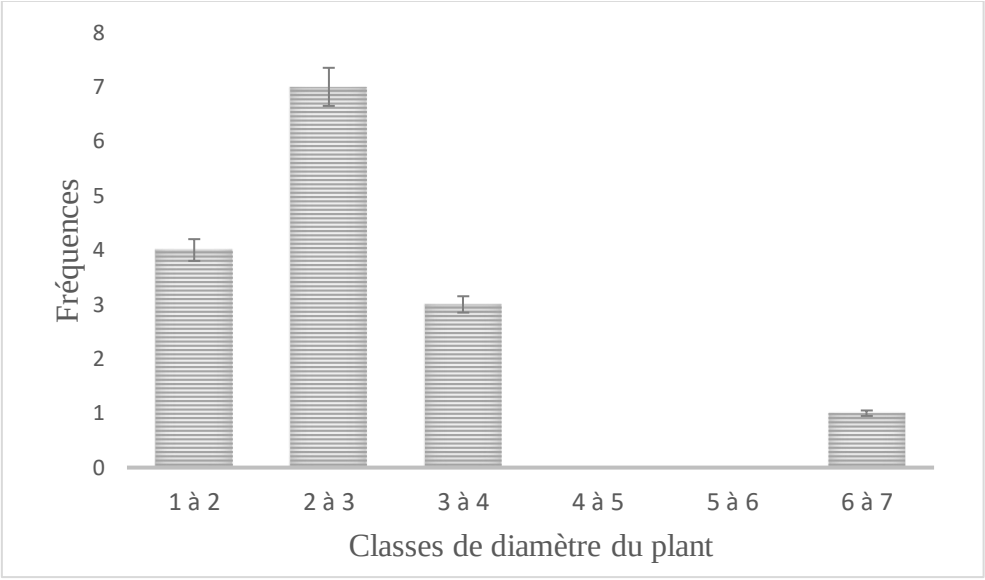

Figure 4: Plant diameter classes

The largest diameter was found in the GLAZ cultivar (7.01 cm). Eleven cultivars measured a stem diameter of 1.9 to 2.9 cm, these are: KELD, MWEZ, KELA, KANK, NZOG, KAND, NSAN, MOPE, MOMA, KABO, KEND Three cultivars KAVI, KASA, ILON, measured a diameter of 2.9 to 3.9cm.

Leaf yield

The leaf yields of the different cultivars are shown in Figure 5.

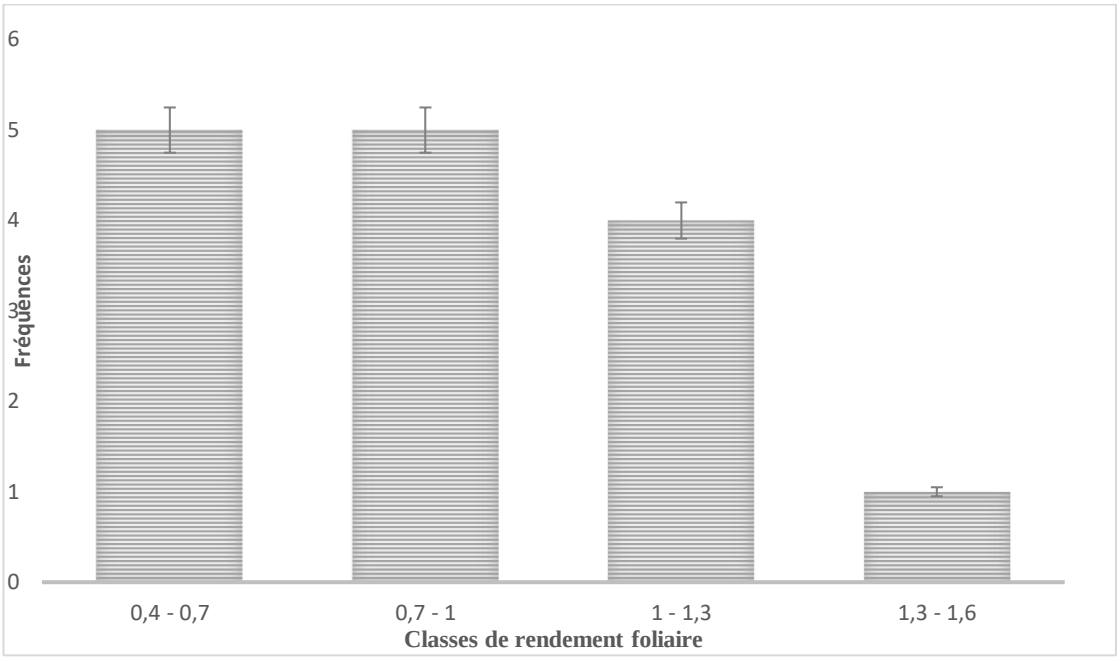

Figure 5: Leaf yield classes

Ten cultivars respectively gave leaf biomass yields of 0.4-0.7 t/ha and 0.1/ha. Average leaf biomass yields of 1 to 1.3 t/h were found in the ILON, KASA, KAV cultivars. The highest leaf biomass yield of 1.3 to 1.6 t/ha was found in the GLAZ cultivar.

Aerial morphological characterization qualitative variables

Shape of lobes

The different shapes of leaf lobes of different cultivars are shown in Figure 6.

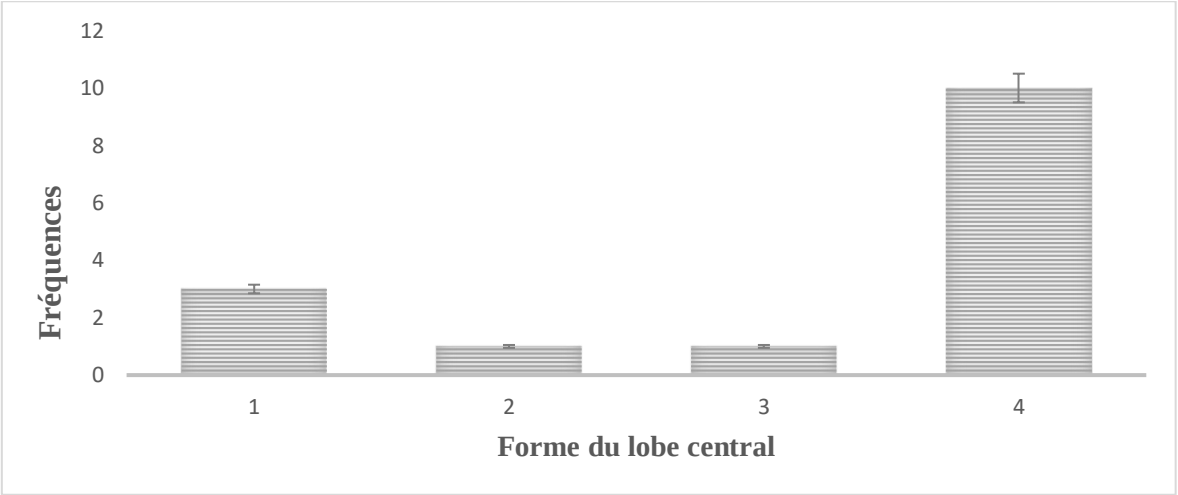

Figure 6: Shape of the central lobes of the leaves

The majority of cultivars (10) presented the shape of the central lobe Lanceolate (4). These are MOMA, NSAN, KANDE, NZOG, KELEA, KANK, MWEZ, KELD, KASA, ILON Three cultivars KEND, KABO, MOPE. For the central lobe shape (1) Oblong Two cultivars presented, for one the linear central lobe shape (2): KAVI and the other Oval (3): GLAZ.

Color of apical leaves

The colors of the apical leaves are shown in Figure 7.

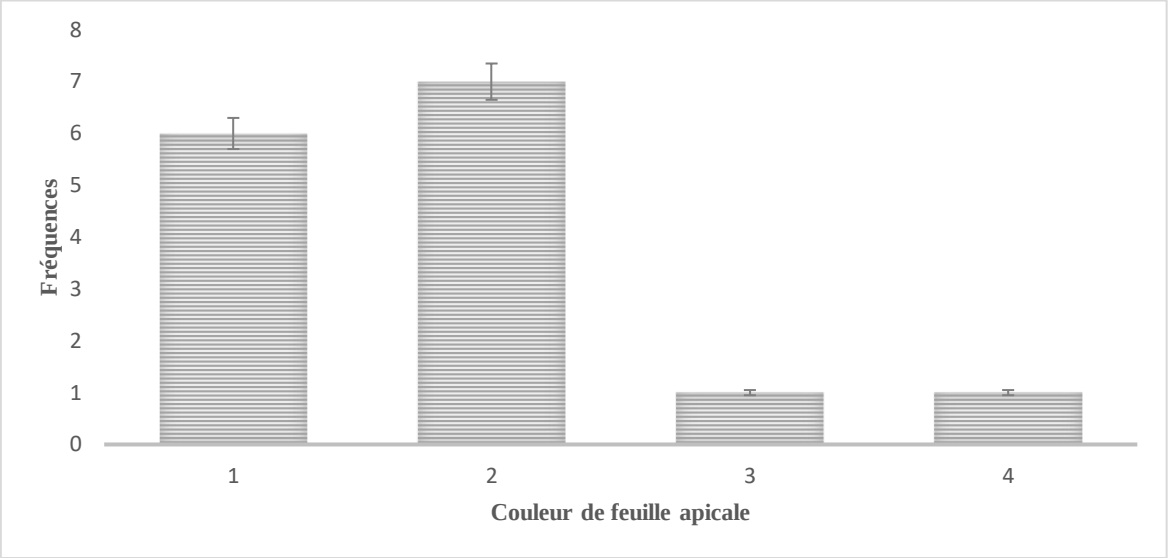

Figure 7: Color of the apical leaves

The color of the apical leaves varied from dark green (2) for the cultivars, KEND, MOPE, NZOG, KANK, MWEZ, GLAZ, ILON The light green color (1) was found in the cultivars: KABO, MOMA, NSAN, KELA, KELD, KASA The color purple (3) and Violet were found in the cultivars: KAVI and KAND.

Bud leaf pubescence

The level of bud leaf pubescence is recorded in Figure 8.

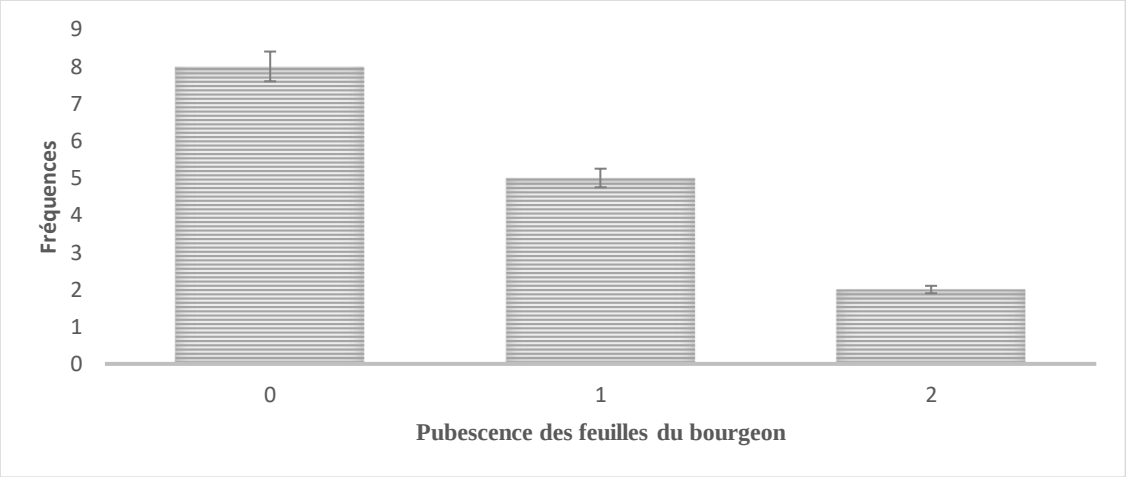

Figure 8: Pubescence of bud leaves

The bud leaves showed no pubescence on 8 cultivars observed. These are: KEND, MOM, NSAN, MOPE, NZOG, MWEZ, KELD, KASA, 5 other cultivars had moderate pubescence on their bud leaves: KABO, KELA, KANK, GLAZA, ILON a high density of pubescence (2) on the leaves of the bud was observed on two cultivars which are: KAND and KAVI.

Structuring of morphological variability

The structuring of morphological variability is shown in Figure 9.

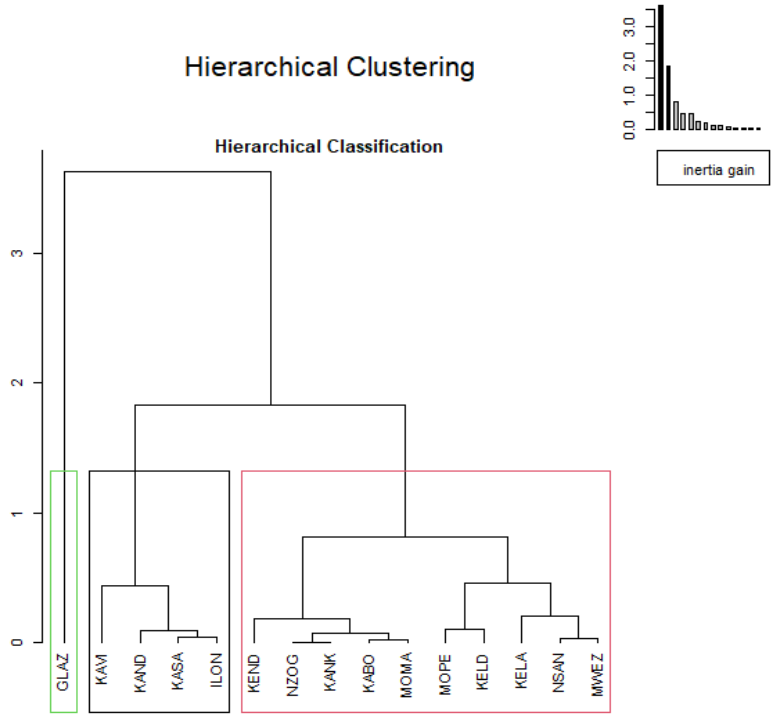

Figure 9: Dendrogram from the CAH of 15 accessions of M. esculenta Spp

Observation of Figure 9 shows that the ascending hierarchical classification (CHA) carried out on the basis of the Euclidean distance reveals three morphological groups. Group I is the largest with 10 accessions and group II containing 4 accessions and Group III the smallest with 1 accession. The first group contains 10 accessions of small sizes (average of 10 cultivars less than or equal to 179.89 cm), glabrous apical leaf, less developed leaves, while the accessions of group II have medium sizes, developed leaves. Within this group, local and introduced accessions are classified which would be genetically close having individuals characterized by variables with intermediate values and group three having a single individual characterized by large size (377 cm), diameter at the collar very developed (7.05 cm), number of lobes and length of petioles statically identical to those of group one, with a higher yield in leaf biomass of 1.3 to 1.6 t/ha.

DISCUSSION

The results of Figures 2, 3, 4, 5 generally show that the quantitative descriptors used determined a morphological variation of the cultivars studied in the collection on the aspects: Recovery rate, Plant height at maturity, diameter at the collar, and leaf biomass yield with a coefficient of variation respectively of: 16.29%, 27.99%, 31.76%, 48.49% in conjunction with the means of 6.2 ± 1.01, 195.22 ± 54 .65, 2.66 ± 1.29. The small difference observed for the recovery rate in the system is justified by the individual aptitudes of each cultivar. According to (Sylvestre, 1978), the recovery and emergence of new plants are factors in a good choice of planting material. By verifying the results of this study, it is necessary to confirm the good quality of the selected cuttings. Compared to the results obtained by (Egle, 1992) in his study on the variability of the yield components of cassava varieties in Togo, which did not show differences for this parameter and (Mahungu et al., 2013) in his description illustrative version of cassava varieties in distribution used as a practical guide for field agents states that the height ranges from 100 cm to 325 cm and that for this study the range of plant height goes from 100 cm to 300 cm.

It appears from reading Figures 6, 7, 8 that the qualitative descriptors submitted to the 15 cultivars in the collection generally demonstrated heterogeneity with a coefficient of variation ranging from 26.1% to 51.73%, which justifies the morphological diversity. between accessions. For the color of the apical leaf color the F = 0.0317 with a mean of 1.6 ± 0.74; the shape of the central lobe (F = 0.0273) with an average of 3.2 ± 1.26 These observations mean that the colors of the cultivars studied range from light green to purple for the apical leaves and for the shape of the Lanceolate lobe is dominant for the cultivars placed in collections. These results were also noted by Ramanandafy (2012) in his study on the collection of sanitized varieties of CMD (Cassava Mosaic Disease) and morphological characterization which found that the descriptors of the color of the apical leaves and the shape of the lobes differentiated the seven cultivars observed in Madagascar.

For the dendrogram on the other hand, these values are less comparable to those obtained by Djaha et al. (2017) where the largest size and the smallest were respectively 255 cm and 168 cm with the large diameter at the collar of 3.183 cm. This difference could be attributed to the number of accessions collected, the individual performance of these cultivars and the different environments where the studies were carried out; However, the use of morphological markers is influenced by the environment (Adoukonou-Sagbadja et al., 2007; Kaemmer et al., 1992). Molecular markers are preferred for such studies since they cannot be influenced by environmental factors. Moreover (Elias et al., 2001) showed in a comparison of the phenotypic traits of varieties cultivated by Native Americans carried out in an experimental garden, that the different accessions of a local group present a heritable genetic variation with regard to morphological and to the plasticity of expressions depending on the environment.

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