

# Prevalence of African mosaic and morphological characterization of cassava (*Manihot esculenta* Cranz) varieties in two agroecological zones of Cameroon

## Abstract

The aim of this work is to conduct an epidemiological study of African cassava mosaic and to characterize the diversity of local cultivars in circulation in the monomodal and bimodal rainforest zones of Cameroon. Disease-related parameters (incidence and severity index) were studied as well as morphological parameters (plant height, leaflet color, petiole color, lobe length, number of lobes, number of branches, petiole length). The results show that Ninety six cassava varieties were identified in with 89 local varieties and 07 improved varieties. Diseased plants showed a symptom severity index of 1 to 5, which could reduce production by half in the areas considered. The leaf color was dark green, the number of branches was 3, the lobe and petiole lengths were 16.46 and 22 cm respectively, while the number of lobes was 5 the disease incidence for the two agro-ecological zones as a whole is 57.58% for a symptom severity index of 3. The epidemiological study reveals that the disease incidence of both agro-ecological zones was 57.58 % for a symptom severity index of 2 corresponding to 40 %. In the humid forest zone with monomodal rainfall the average incidence was 49.74% and a leaf attack rate was 29.03% in the locality of Njombé (Cameroon's littoral region). At Ekona in southwestern Cameroon, the average incidence was 63% and a leaf attack index was 1 corresponding to 20%. In the bimodal rainforest zone (central Cameroon region), the average incidence was 60% for a leaf attack rate was 37.11%. The expected results highlight a relatively worrying situation. Principal Component Analysis (PCA) confirms the convergence of tolerance towards the mosaic and grouped the different varieties into more or less homogeneous groups according to the morphological and epidemiological cassava descriptors. The results of the present work show that the introduction of cassava local varieties tolerant to mosaic disease in milieu could be an alternative for the control of the cassava mosaic disease.

**Keywords:** African mosaic, variety, prevalence, characterization

## 1. Introduction

Hunger is the leading cause of death in the world [1] It kills more than war and is an endlessly repeated crime against humanity [2]. Cameroon is a country with a significant

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agricultural sector; however, climatic conditions are an important factor in the wide variation of agricultural products. Due to its good profitability, low cost of production, resistance to drought and predators [3], cassava is a top choice [4]. It is grown on the one hand for the tubers consumed in different forms and on the other hand for the leaves consumed as vegetables. The agro ecological conditions of Cameroon are favorable to its development. Its plasticity and its characteristic of reserve food explain its diffusion on the extent of the territory because, it is preserved and tolerates well the environmental stresses. However, the production potential of this plant in Cameroon is severely affected by diseases and plagues, in particular the mosaic virus disease. The magnitude of the losses caused by African mosaic disease implies efforts in terms of knowledge and implementation of means of control. The economic importance of cassava in Cameroon justifies a good knowledge of the extent of the damage caused by the disease, a knowledge of the local varieties present in the agro-ecological zones concerned in order to provide the most appropriate curative responses. The present work is a contribution to the implementation of a control strategy by providing scientific information. This work was therefore carried out with three specific objectives: characterize the diversity of cassava varieties in circulation in the study areas on the basis of morphological traits; evaluate the incidence and severity of African cassava mosaic disease and establish correlations between the severity of symptoms and the growth in length of the plants;

## **2. Material and methods**

### **2.1 Study site**

The work was carried out in two agro-ecological zones of Cameroon (zone IV and V). Zone I, humid forest zone with monomodal rainfall, with a temperature and humidity that vary between 22 to 29°C and 85 to 90°C, respectively. The average rainfall is between 2500 and 4000 mm/year. Zone V is the humid forest zone with bimodal rainfall, located between 500 and 1000 m of altitude on an area of 22.5 million hectares. It benefits from a "Guinean" type climate with average temperatures of 25°C and a rainfall of 1500-2000 mm/year divided into two distinct seasons. Humidity is constantly high between June and October. Within these two zones, three regions were studied: the southwest, the coast and the center.

### **2.2 Plant material**

The plant material consisted only of symptomatic and asymptomatic cassava plants, local and improved, cultivated in monoculture from farmers' fields in several localities of each study region, and from IRAD and IITA research stations.



Fig.1. Cassava plants: a = symptomatic b = asymptomatic

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## 2.2 Other materials

A number of materials were used for the different investigations. These were a data collection sheet, a length measuring instrument (a graduated ruler), a Samsung digital camera, a course scale for rating the severity of the symptoms.

## 2.3 Characterization of the different varieties in the field

The characterization in the field of the varieties consisted in a visual identification of each variety and not only by noting the morphological characters (color of the leaf, color of the petiole, length of the lobe, shape of the leaflet, number of lobes, height, number of branches), but also by assigning it a name and/or code corresponding either to the locality of origin or according to the morphological characters noted. The cassava variety collection sheet of Sandrine [5] was indispensable in this work.

### 2.3.1 Epidemiology of African mosaic disease

The epidemiology of mosaic in the field consisted in the evaluation of two parameters, namely incidence and severity based on a probable assumption of a visual diagnosis of the symptoms, following a line system for the local accessions (at a rate of 30 plants per line and per variety) and a block system for the improved varieties. The 5-square method was applied [6]. It consists in delimiting in each block, four squares of 10 m<sup>2</sup> on the 4 corners and 1 square in the center of each block. Thirty (30) plants per square were used and an overall average was retained per variety. The symptom severity index scale of Cours was used and consisted of assigning indices to plants showing symptoms of the disease at different stages as follows

0: no symptoms;

1: slight mosaic without deformation or reduction of the size covering less than 1/3 of the leaf surface;

2: mosaic without clear reduction of the size and covering less than half of the leaf surface with sometimes deformation of the leaf;

3: mosaic covering most of the leaf, accompanied by deformation and reduction of the surface;

4: mosaic covering the whole surface, accompanied by severe deformation and dwarfing of the leaf;

5: intensity of 5 is sometimes used and applies when the leaflets are practically reduced to the veins.

Disease expansion (incidence) was evaluated in frequencies of disease occurrence on plants in a row or block and was determined by the formula:  $P = (n / N) \times 100$ [7]. Where P is the frequency of the disease in the line or block; n is the number of diseased plants per line or block; N is the total number of plants sampled per line or block

Disease severity was assessed on leaf areas occupied by disease symptoms and a percentage estimate is assigned to each plant. Thus the severity during development will be given by the formula of Chumakov and Zaharova[7] which is expressed as follows:  $S = \sum (a.b) / N$  Where  $\sum(a.b)$  is the sum of multiplications of the number of diseased plants (a) by the corresponding degree of infection (b) given in percentage; with N as the total number of diseased plants.

A principal component analysis (PCA) and a hierarchical numerical classification (HNC) were respectively carried out to define the links between the epidemiological and morphological variables studied, and to group the varieties into more or less homogeneous classes. For this purpose, two epidemiological parameters (incidence and severity) were chosen for the disease. For morphological parameters, the following variables were chosen: leaf color, petiole color, plant height, number of lobes, number of branches, petiole length, lobe length.

### **2.3.2 Correlation between symptom severity and plant height**

The correlation lines were drawn to check if the increase or not of the severity indexes has an impact on the growth in length of the plant, which will give us an idea on the particularity of each variety towards the disease. From the linear regression equation  $Y = ax + b$  between severity on the abscissa and height on the ordinate, if the correlation coefficient (r) is between 0.8 and 1 the correlation is perfect and positive. If r is between -0.8 and -1 then the correlation is perfect but negative. If  $r < 0.8$  then the correlation is positive but imperfect. If  $r > -0.8$  then the correlation is negative but imperfect, if r is between 5 and 7 then the correlation is said to be average

### **2.3.3 Statistical analysis**

The data were analyzed by the R software which performs the analysis of variances (ANOVA). Duncan's test was used to judge the difference between the means at the 5% threshold. PCA was performed using SPAD software. V55. The degree of association between the different variables was estimated using Spearman's coefficient. Ascending Hierarchical Clustering (AHC) was used to group accessions on the basis of epidemiological variables.

### 3. Results

#### 3.1 Morphological characterization of cassava varieties in different regions

##### Morphological characterization of local varieties in Nkolbisson (central region)

Investigations carried out in the field, based on the probable assumption of a visual diagnosis of morphological characters, reveal the results recorded in Tables 1 and 2. About 86 local varieties and 07 improved varieties were recorded. The average leaf color is dark green, the average number of branches is 3, the average lobe and petiole lengths are 16.46 and 22 cm respectively and the average number of lobes is 5. The tables show the names and morphological characters of the different varieties.

As for the improved varieties, there is no particularity in the color of the leaflets and many other characteristics. Thus, the dominant color of the leaflets is purplish green, the green color dominates at the level of the petiole, the shape of the leaflets is ovoid, the average lengths of the lobes and the petiole are respectively 14,18 and 16,71cm, and the average number of lobe is 4 (Table 2).

**Table 1. Names and morphological characters of the local varieties listed.**

Criteria varieties (name and /or code)	Leafcolor	Petiolecolor	Leafform	Lobelength (cm)	Petioleheight (cm)	Numberlobe
<i>Pola rouge beul / F 21</i>	dark green	light green	lanceolate	15	23	3
<i>Tokbanbwgueive, Dana / F17</i>	dark green	light green	lanceolate	14	15	5
<i>Pola noir, court / F21</i>	purple	red	lanceolate	19,5	36	7
<i>Pola noir, long beul/ F21</i>	purple	red	ovoid	30	39	7
<i>Gladys Dschang</i>	dark green	red	ovoid	17	22	5

<i>MabongMekoul, Sovokonl</i>	purple	darkred	lanceolate	14	30	7
<i>Brown Stem, Yamben</i>	green	lighred	ovoïd	12	10	5
<i>Mani Mbong-Sangmelima</i>	greenpurplish	red	ovoïd	17	25	6
<i>Pola noir long (beul)</i>	dark green	red	ovoïd	16	17	7
<i>Bout, Mpezok</i>	purple	ligh green	lanceolate	19	22	8
<i>SawadaDigron</i>	purple	darkred	ovoïd	15	21	5
<i>Gambada, Soagol</i>	greenpurplish	red	lanceolate	19	25	5
<i>Balonpong, Dana</i>	Ligth green	red	lanceolate	14	15	4
<i>YaraAdinkoé</i>	green	red	ovoïd	14	25	5
<i>Manoïc sucré</i>	greenpurplish	riddish--green	ovoïd	23	31	7
<i>Gambada, Boumadjalé</i>	dark green	red	ovoïd	14	26	5
<i>NabongMekoul, Sovokongll</i>	dark green	red	ovoïd	10	17	3
<i>6 mois, Tiko. Lis</i>	dark green	lighred	ovoïd	21	27	6
<i>Akourakwa, Mpezok</i>	greenpurplish	red	ovoïd	16,5	15	3
<i>Guge 2<sup>e</sup></i>	dark green	ligh green	ovoïd	14	11,5	3
<i>2<sup>e</sup> - 9</i>	greenpurplish	red	ovoïd	14,7	15	3
<i>Bitoto/ F17</i>	dark green	green	ovoïd	11,5	11	4
<i>Nkol- ossané</i>	dark green	red	cylindrical	26,5	25	7
<i>BalbineMeyosbben</i>	green	red	lanceolate	18	28,5	7
<i>BititiBoumadjalé</i>	greenpurplish	darkred	lanceolate	22	34	7
<i>Ché 2<sup>e</sup> / F4</i>	greenpurplish	red	ovoïd	15,5	25	6
<i>Mdaga 2<sup>e</sup> - 3</i>	greenpurplish	darkred	ovoïd	15	32	7
<i>Mraheg2<sup>e</sup> - 2</i>	dark green	red	Lanceolate	17	21	5
<i>GbeguedaGandoua</i>	greenpurplish	red	lanceolate	17,5	22,5	6
<i>Moumpé Femelle, Garoua Yara</i>	greenpurplish	red	lanceolate	19,5	26,5	7
<i>Campo (Mvaa)</i>	greenpurplish	rede	lanceolate	18	26	4
<i>Badobo- Tikolo</i>	dark green	green	ovoïd	17	27	7
<i>Moan- Moan, NkolOssananga</i>	greenpurplish	ligh green	lanceolate	14,5	15	3
<i>Mintourou- Mvaa II</i>	dark green	red	lanceolate	16	19	3
<i>Ngambada- Ngambada</i>	dark green	red	lanceolate	14,5	17	4
<i>Gbalonpong- Gandong</i>	dark green	green	ovoïd	13	16	4 to 6
<i>Pétiole rouge Bafia</i>	greenpurplish	red	lanceolate	15	23	5 to 7
<i>AfoubaDovaye</i>	greenpurplish	red	lanceolate	18	28	6
<i>Ntanga (le blanc), Mvaa</i>	greenpurplish	red	ovoïd	19	29	6 to 7
<i>Tougueda - Gbata / F16</i>	dark green	green	lanceolate	14,5	14,5	4 to 6
<i>Pétiole vert - Yambassa</i>						
<i>LiogoAdinkol/F10</i>	purple	green	lanceolate	16	24	5 to 7
<i>Pétiol rouge Yambassa</i>	greenpurplish	red	lanceolate		21	7
<i>Tuyobo- Bétani/F11</i>	greenpurplish	riddish-green	ovoïd	13	35,5	7
<i>Gbafdougoa- Bata</i>	greenpurplish	red	lanceolate	14,5	14,5	3 to 7
<i>RedPétiole- Binoun</i>	purple	green	lanceolate	18	16	5
<i>Fonctionnaire (Mekonkin)</i>	dark green	red	ovoïd	16	26	5
<i>Bokito(green pétiol)</i>	greenpurplish	red	ovoïd	15	28,2	5 to 6
<i>Gambada</i>	dark green	ligh green	lancolate	11,5	10	3
<i>Pétiole vert (Bafia)</i>	dark green	green	ovoïd	12	16,5	3
<i>Green pétiolbinoun</i>	purple	green	ovoïd	9	20	7

<i>Redpetiole (Bokito)</i>	dark green	riddish- green	ovoid	17,5	21,5	5
<i>Damouna GRP / B8</i>	greenpurplish	red	ovoid	17	25	7
<i>Tymère- kournou / F1</i>	dark green	red	lanceolate	19,5	27	7
<i>Ntani-Koumou/ F1</i>	green	ligh green	lanceolate	16,5	17	3
<i>Ntolo 1<sup>er</sup> - 20</i>	dark green	green	ovoid	13	11	3
<i>Yoyolo-Ovangoull /F5</i>	greenpurplish	red	lanceolate	22,5	34	7
<i>Akourou- Ovangoul</i>	dark green	red	lanceolate	14	15,5	5
<i>Noumpé Mal (Garoua) Yakol/F12</i>	dark green	red	ovoid	13	15	4 to 5
<i>Aoa-koumou</i>	greenpurplish	red	lanceolate	14,5	14,5	3
<i>Saa 1<sup>er</sup> /15</i>	greenpurplish	green	ovoid	23	30	5
<i>Mekinda 1<sup>er</sup> - 14</i>	dark green	riddish-green	ovoid	17	19,5	5
<i>Manioc Bassa 1<sup>er</sup> /9</i>	greenpurplish	red	ovoid	14	14	3
<i>AyabBisoa</i>	dark green	red	landeolate	20,5	32	5 to 7
<i>Campo Myaa</i>	dark green	red	lanceolate	18,5	32	6
<i>Ntolbiko 1<sup>er</sup> /6</i>	greenpurplish	green	ovoid	16,5	19,5	6
<i>AkourouOvangou</i>	dark green	ligh green	ovoid	11,5	12	4
<i>EnoumaObokoé</i>	green-purplish	red	lanceolate	17	21	5
<i>MegnongNkolo- Sanaga</i>	greenpurplish	red	lanceolate	19	23	6
<i>Ntem I- Okoukouda</i>	dark green	green	ovoid	16,5	23,5	6
<i>Ekwémé 1<sup>er</sup> -1</i>	dark green	red	lanceolate	17	22,1	5
<i>CampoNkol-Ossam F18</i>	dark green	green	lanceolate	12,5	10,2	3
<i>Mbam 1<sup>er</sup> - 21</i>	dark green	green	lanceolate	12,5	20,5	5
<i>Ekékam I</i>	dark green	green	ovoid	14	20,5	6
<i>Ekékam II</i>	dark green	green	ovoid	10,2	9,5	5
<i>Manioc Bassa</i>	dark green	ligh green	lancelate	16,2	14	6
<i>OwonaEkani</i>	dark green	red	ovoid	10	16	5
<i>Mbida et Mbani</i>	dark green	red	ovoid	16	23	5 to 6
<i>Manioc jaune</i>	dark green	ligh green	ovoid	13,5	17	5
<i>Man Mbong ( P.M.N. N)</i>	dark green	green	lanceolate	18,5	20	5
<i>NnomEwondo</i>	greenpurplish	red	lanceolate	12	16,5	5
<i>Makoumba I</i>	dark green	red	lanceolate	19,5	28,5	5
<i>Ziéyabomedzé/ 001/ NN</i>	dark green	red	lanceolate	23,2	36,5	6
<i>Bitourou M. K. 1</i>	greenpurplish	dark red	lanceolate	25,8	43	5 to 6
<i>Minbourou( BGL)</i>	dark green	dark red	ovoid	15	15	6
<i>Ntangna-Pétiol rouge ( OM)</i>	greenpurplish	red	lanceolate	14,6	21	5
<i>MakoumbaII(S P) Mefomo</i>	greenpurplish	riddish-green	lanceolate	18,5	14,5	3
<i>Alotbikon (N.O)</i>	dark green	green	lanceolate	13	7	3
<i>AfoboNkozooa</i>	greenpurplish	riddish-green	lanceolate	17,5	12,5	3

**Table 2. Names and morphological characteristics of improved varieties**

Varieties (name and/ or code)	Leafcolor	Petiolecolor	Leafform	Lobeheight (cm)	pétioleheight (cm)	Lobenumber
92 /0326	greenpurplish	red	ovoid	16	23	5
0110	greenpurplish	ligh green	ovoid	14	12	3
	green	green	lanceolate	16,2	19,5	3

8034						
8061	dark green	green	lanceolate	13,5	16	5
8017	greenpurplish	green	lanceolate	14,1	18	3
Excel	greenpurplish	red	ovoid	13	15,5	3
champion	greenpurplish	green	ovoid	12,5	13	5

### 3.2 Morphological characterization of local varieties from Njombé (littoral region)

Following investigations carried out in the field on the basis of a probable assumption of a visual diagnosis of symptoms and morphological characters, the results are recorded in Tables 3 and 4. 94 local varieties and 07 improved varieties were recorded. The average leaf color is dark green, the average number of branches is 3, the average lobe and petiole lengths are 15 and 21 cm respectively and the average number of lobes is 5. The tables show the names and morphological characteristics of the different varieties

**Table 3. Morphological characteristics of local cassava varieties from Njombé**

criteria varieties	leafcolor	petiolecolor	leafform	lobeheight (cm)	petioleheight (cm)	lobenumber	ramification
<i>Manioc blanc</i>	green	red	lanceolate	17	25	6 to 7	3
<i>Mediviu</i>	dark green	red	lanceolate	16,5	20	5	3
<i>Pas connu 9</i>	green	red	lanceolate	18	28,5	7	0
<i>Manioc lelem-magoteh</i>	dark green	red	lanceolate	17	26,5	7	0
<i>Manioc rouge</i>	dark green	red	lanceolate	17,5	25,5	4 to 7	2
<i>Pas connu 10</i>	green-purplish	red	ovoid	12	13,5	5	3
<i>Manioc rouge</i>	green	red	lanceolate	18	27,5	7	4
<i>Packasing</i>	dark green	red	lanceolate	14	21,5	7	3
<i>Chechem</i>	dark green	red	dark green	18	31	7	0
<i>Maniocsouza</i>	dark green	red	ovoid	12,5	11,5	3	3
<i>Yara</i>	green	red	lanceolate	18,5	33,5	7	3
<i>Mano/Boumocreboe</i>	dark green	red	ovoid	16	29	7	3
<i>Manioc blanc kolo</i>	green	red	lanceolate	26	36	7	3
<i>Biafra non racine</i>	dark green	red	lanceolate	18	3	8 to 9	2
<i>Manioc longtoka</i>	green-purplish	red	ovoid	13	17	7	2
<i>Manioc blanc koutoukoup</i>	green	red	lanceolate	12,5	15	5	3
<i>Manioc rouge fossang</i>	dark green	red	ovoid	17,5	23,5	8 to 9	3
<i>Manioc blanc tendre</i>	dark green	red	lanceolate	12,5	12	3 to 4	4
<i>Moindre moucroitre</i>	dark green	red	lanceolate	11,5	14	5	3
<i>Makwabamapubi</i>	green-purplish	red	lanceolate	15,5	16,5	4 to 5	4
<i>Agriculture</i>	dark green	red	ovoid	17,5	26,5	8	2
<i>Chechumfu</i>	green	darkred	lanceolate	11,2	17	6 à 7	2
<i>Manioc blanc sodico village</i>	dark green	red	lanceolate	15,5	12,5	3	3
<i>Toso local</i>	green-purplish	riddish-green	lanceolate	13,5	18,5	7	3
<i>5 minutes</i>	dark green	green	ovoid	13,5	18,5	5	2
<i>Tsogui</i>	green-	green	ovoid	13,5	14,5	5	3

	purplish						
<i>Ndjeti</i>	green	green	ovoid	12,5	18,4	3 to 5	2
<i>Ndjiguim</i>	green-purplish	green	lanceolate	12,5	9,5	3	4
<i>Manioc sélectionné</i>	green-purplish	green	lanceolate	11,5	9	3 à 5	3
<i>Manioc sélectionné logdikot</i>	green-purplish	green	ovoid	15,5	14,5	3 à 5	2
<i>Manioc sélectionné sokele</i>	green-purplish	riddish-green	lanceolate	15,5	19	7	3
<i>Manioc rouge Biwani pk 32</i>	dark green	green	lanceolate	14,5	20	7	3
<i>Nd</i>	dark green	green	ovoid	9	8	3	
<i>Kolo blanc</i>	dark green	green	ovoid	16,5	23,5	7	4
<i>Manioc rouge lelemmagotech</i>	dark green	green	ovoid	15	14,5	5	2
<i>Manioc sélectionné Dibamba</i>	dark green	green	ovoid	13,5	15	5	3
<i>Pas connu 2</i>	dark green	green	lanceolate	13,5	13,5	3	3
<i>Pas connu 3</i>	green-purplish	green	lanceolate	18,5	30	9	0
<i>Pas connu 5</i>	green	green	lanceolate	19,5	23,5	7	4
<i>Manioc souza</i>	green	green	lanceolate	16	20,3	7	3
<i>82/05/6</i>	green-purplish	green	lanceolate	13	12,5	6	2
<i>Manioc Muyuka</i>	green-purplish	green	ovoid	13,5	16	5 to 6	3
<i>Muyuka jaune</i>	dark green	red	ovoid	10,5	14,5	5	2
<i>manioc rouge lemgah</i>	green	red	ovoid	13,5	18,5	7	3
<i>Manioc sélectionné sokelle</i>	green	red	ovoid	13	14,5	3	2
<i>Bengombebanem</i>	green	red	ovoid	19,5	23,5	7	3
<i>Nakomakoa</i>	dark green	red	ovoid	12,5	15,5	7	0
<i>Local blanc</i>	dark green	riddish-green	ovoid	18,5	24	7	4
<i>Nd</i>	dark green	green	lanceolate	21	31	9	2
<i>Nd</i>	green-purplish	riddish-green	ovoid	14,5	15	7	0
<i>Manioc jaune nkokom</i>	green	green	ovoid	15,5	26	7	3
<i>Muyuka rouge</i>	dark green	green	lanceolate	14	13,5	5	2
<i>Manioc sélectionné Dibamba</i>	dark green	green	lanceolate	18	29,5	7	0
<i>manioc blanc dur</i>	green-purplish	green	ovoid	10	11	7	3
<i>Manioc blanc Nkokom</i>	green	green	ovoid	16	25	7	3
<i>Manioc jaune solé</i>	dark green	green	ovoid	20,5	30	6	2
<i>Manioc blancmougnelel pk 37</i>	dark green	green	ovoid	19	30	9	3
<i>Manioc jaune Dongmba</i>	dark green	green	lanceolate	15	15	5	3
<i>Manioc Bejenq</i>	dark green	green	lanceolate	16,5	19	5	3
<i>Nd</i>	dark green	green	ovoid	16	17	5	2
<i>Nd</i>	dark green	green	ovoid	14	22,5		
<i>Pas connu 6</i>	dark green	green	lanceolate	19	27	9	3
<i>Manioc rouge (1)</i>	dark green	green	lanceolate	20	29	7	2
<i>Manioc agriculture</i>	dark green	green	ovoid	18,5	20	5	3
<i>Manioc yato</i>	green	red	lanceolate	20	31,5	7	0
<i>Manioc noir</i>	green-purplish	red	ovoid	21	33	7	2
<i>Manioc blanc (3)</i>	dark green	red	ovoid	21	31	7	3
<i>Manioc blanc (2)</i>	dark green	red	ovoid	14	17,5	5	3
<i>Manioc blanc</i>	dark green	red	ovoid	16,5	24,5	7	2
<i>Manioc patate</i>	green	red	ovoid	12,5	14	7	3

<i>Manioc sélectionné sikoum</i>	green-purplish	red	ovoïd	20	32	7	2
<i>Biafra racine Bwoni</i>	green	red	ovoïd	9,5	15,5	5	3
<i>Perchechim</i>	green	red	ovoïd	17	25	7	2
<i>Pas connu 4</i>	green	red	ovoïd	16	27,5	7	2
<i>Pas connu 7</i>	green	red	ovoïd	9,5	14	5	3
<i>Pas connu 8</i>	green-purplish	red	ovoïd	13,5	16,5	5	2
<i>Manioc sélectionné logbadjeck</i>	green	darkred	ovoïd	22,5	37	7	3
<i>Ndolambua</i>	green	red	ovoïd	11,5	14,5	5	3
<i>Manioc patate Bakenga</i>	green	red	ovoïd	11,5	15,5	5	2
<i>Manioc rouge fossang</i>	green	red	ovoïd	15,2	14,5	3	3
<i>Nlefokep</i>	dark green	red	ovoïd	17,5	27	4 to 7	3
<i>Manioc rouge Bakenga</i>	green	red	ovoïd	14	13,5	3	3
<i>manioc blanc(1)</i>	green-purplish	red	lanceolate	15	22	6	3
<i>8017</i>	dark green	green	lanceolate	15	20	5	2
<i>Namelong</i>	dark green	green	ovoïd	18,5	23,5	6	3
<i>Chechemkulah</i>	green	green	ovoïd	13,5	14	3	3
<i>Manioc</i>	green	reddish-green	lanceolate	15	22	7	2
<i>Manioc patate Fonjwang</i>	green	green	lanceolate	13	18	5	3
<i>Manioc rouge Njiwom</i>	green	reddish-green	ovoïd	13	21	7	3
<i>Manioc blanc clone</i>	green-purplish	green	ovoïd	18,5	24	7	3

Criteria	leafcolor	petiolecolor	leafcolor	lobeheight (cm)	petioleheight (cm)	lobenumber	height (m)
<i>Manioc blanc</i>	dark green	green	lanceolate	15,5	18,5	6 à 7	2,65
<i>Jaune d'or</i>	dark green	green	ovoïd	16	15	4 à 5	1,96
<i>Manioc rouge 2</i>	dark green	green	ovoïd	13,5	16	5 à 6	2,4
<i>Manioc rouge</i>	green-purplish	green	ovoïd	11	17	7	1,86

The so-called improved varieties of Njombé have variable characteristics depending on the cultivar. For all varieties the color of the leaves is dark green, the dominant color of the petiole is green and the dominant shape of the leaflet is ovoïd, while the other parameters (length of the lobe, petiole, number of lobes, height of the plants and branching) changed according to the cultivars (Table 4).

**Table 4. Morphological characteristics of the improved varieties of Njombé**

Criteria	Leafcolor	Petiolecolor	Leafform	lobeheight (cm)	petioleheight (cm)	Lobe number	ramification	height (m)
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varieties								
<i>IITA 1</i>	dark green	green	ovoid	17	24,5	7	3	2,12
<i>IITA 2</i>	dark green	darkred	ovoid	20	28,5	7	2	1,87
<i>IITA 3</i>	dark green	green	lanceolate	16	19,5	5	2	1,97
<i>IITA 4</i>	dark green	riddish-green	ovoid	16	29	9	2	1,03

### 3.3. Characterization of Ekona cultivars (Southwest region)

The results of the characterization of the different varieties after the investigations carried out in the field on the basis of a visual observation of the morphological characters are consigned in table V.19 local varieties only were listed. The average leaf color is dark green, the average number of branches is 3, the average lobe length is 17 cm, the average petiole length is 32 cm and the average number of lobes is 8 (Table 5).

**Table 5. Morphological characteristics of local cassava varieties in Ekona**

criteria varieties	Leafcolor	Petiolecolor	Leafform	petioleheight (cm)	lobeheight (cm)	Lobe number
<i>Mambo</i>	dark green	red	lanceolate	24	21	7
<i>Wowo</i>	dark green	darkred	ovoïde lancéolée	21	14	7
<i>Mbufung</i>	green	red	lanceolateovoid	36	17.5	7 to 9
<i>Agric white</i>	dark green	green	ovoïde	19	16.5	7
<i>Anyekweck</i>	purplish-green	darkred	ovoïde	23.5	15.5	7
<i>Agric white (kembong)</i>	dark green	riddish-green	lanceolate	23	17	7
<i>Local red</i>	green-purplish	greenish-red	ovoïde	22	19	7
<i>Eyumojoek 96-14-14</i>	green	lightred	Cylindricalovoid	36	20.5	6 to 7
	Purplish-green	darkred	ovoïde	32	16	7 to 8
<i>Agricred</i>	dark green	light green	lanceolate	35	21	7
<i>Strongcanda</i>	light green	greenish-red	lanceolateovoid	39	17	6 to 7
<i>Ntenako</i>	dark green	green	lanceolate	40	21.5	9
<i>Canopy</i>	green	light-green	lanceolateovoid	34	18	7
<i>Nkonéhapi</i>	green	red	lanceolateovoid	30	16.5	7 to 9
<i>Black stem</i>	green-purplish	darkred	lanceolate	47	23	8 to 9
<i>Local white</i>	black green	greenish-red	lanceolateovoid	48	20	8 to 9
<i>Yaoundé Red</i>	light green	darkred	lanceolateovoid	44	19	8 to 9
<i>White stem</i>	dark green	green	ovoïde	33	16.5	8
<i>Local white (Batoké)</i>	black green	riddish-green	ovoïde	30	17	7

### 3.4 Results related to morphological characteristics of cassava leaves

The dark green color of the leaves is the most represented in the varieties of the center and the littoral (50%) and (47.77%) respectively against 40% in the varieties of the southwest. The purple color of the leaves is totally absent in the coastal and southwestern varieties, while in

**Comment [CG3]:** Modify to morphological characteristics of cassava leaves

the central region it is found in a proportion of 12%. The light green color of the leaves is more represented in the coast and practically non-existent in the center and southwest. Black green (dark) is also absent in the central and coastal varieties, although it is present in the southwest. As for the color of the petiole, the red color is the most dominant and is found in the coastal varieties (50%) followed by the center (49.4%) and almost non-existent in the Southwest (11%). The green color of the petiole is more represented in the coastal region (41.7%), followed by the central region (21.1%) and very low in the southwestern region (17%). The other colors, namely purple, reddish green and light green, are very poorly represented in all three regions (Table 6).

As for the number of lobes, which is a purely quantitative characteristic and is highly valued by farmers in the sense that the higher the number of lobes in a variety, the more it increases the biomass. The varieties of the south-west stood out with the number of 8 lobes while in the varieties of the coast and the center the number of 5 lobes per leaf is represented (Fig. 2).



Fig.2. Representation of the different numbers of lobes

**Table 6. Percentage distribution of local cassava varieties for leaf morphological characteristics by region of investigation**

regions criteria	Centre	Littoral	Sud-Ouest
<b>Leafcolor</b>			
dark green	43	43	06
purpilsh	11	0	0

purplish-green	32	19	04
light green	0	28	02
black-green	0	0	03
<b>Lobe form</b>			
Lanceolate	46	39	05
Ovoid	39	51	06
Cylindrical	1	0	0
Ovoidcylindrical	0	0	1
Ovoidlanceolate	0	0	07
<b>Lobe number</b>			
02	0	0	0
03	17	07	0
04	07	04	0
05	26	23	0
06	17	07	02
07	17	37	10
08	0	2	04
09	9	05	03
<b>Petiolecolor</b>			
red	43	45	02
green	18	38	03
light green	10	0	02
riddish-green	08	08	05
purple	06	0	05

### 3.5 Incidence and severity of cassava mosaic in the littoral region (njombé)

In this work, the symptom severity index (SSI) of Cours used to study the severity of the disease reveals that the severity varies according to the varieties in their diversity. Moreover, 42.22% of the plants are infected and show severity indices that vary from 2 to 5 corresponding to 25% - 100%. With regard to the incidence of mosaic in the locality of Njombe, the results show that all the varieties studied proved to be susceptible to African mosaic with nuances and, presented variable incidences according to the varieties. Overall, 63.8% of the varieties showed a percentage of attack lower than 50% while 36.2% of varieties showed a percentage of attack between 50 and 100% (Table 7).

Comment [CG4]: Removespace

**Table 7. Percentage of incidence of the different varieties according to the number of people**

interval	effectif	Pourcentage (%)
0 - 50	58	63,8 %
50 - 100	33	36,2 %

Total	91	100 %
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In other words, incidence values ranged from 7.22% to 78.53% with an average of 40.16%. Varieties such as red cassava fossang, red cassava Lemgah, Mediviu and 5 minutes had very low values of 7.22%; 10.66%; 7.23% and 9.46% respectively. On the other hand, varieties such as Chechemhulah, cassava potato, yellow cassava solé and red cassava lelemmagotech presented the highest incidence values namely: 64.39; 78.53%; 70.63%; 70.85% respectively (Table 8).

**Table 8. Incidence and severity of cassava mosaic in the locality of njombé**

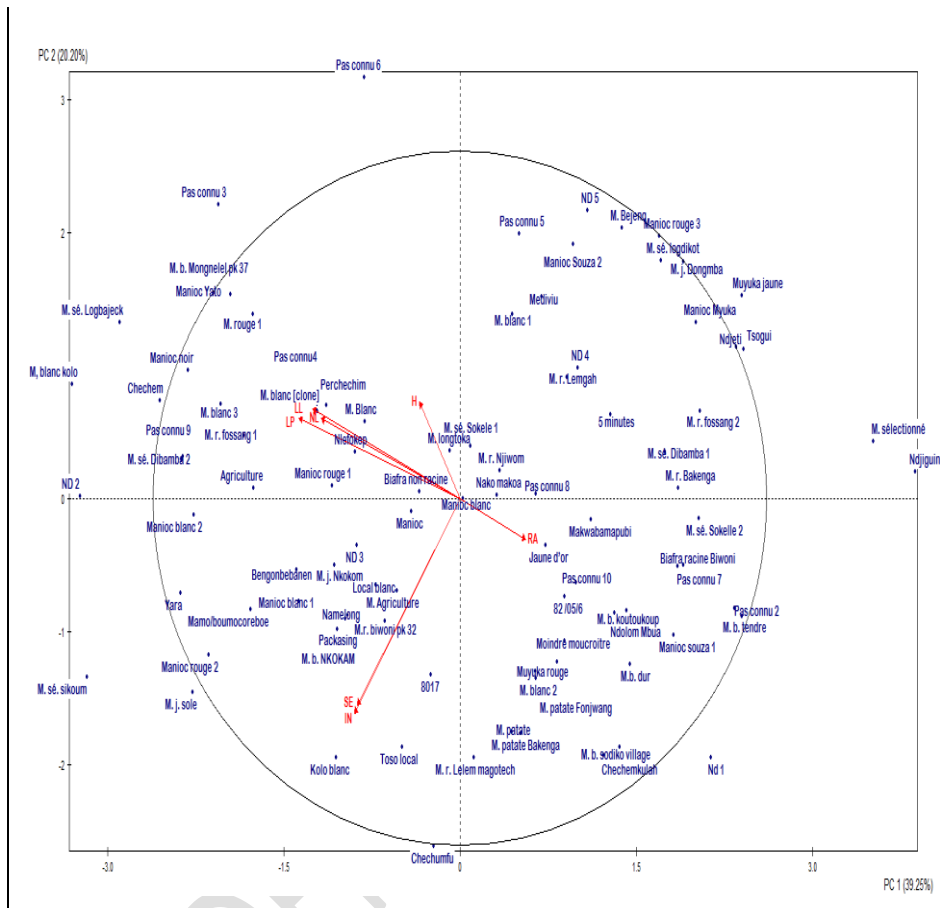
varieties	severity	incidence
<i>Manioc blanc</i>	46,13 ± 8,09 abcd	55,33 ± 13,61 abcdef
<i>Manioc souza</i>	25,00 ± 7,00 bcdefg	51,55 ± 15,87 abcdef
<i>yara</i>	33,06 ± 15,62 abcdefg	63,68 ± 24,21 abcde
<i>Mamo/boumou</i>	49,11 ± 12,54 abc	61,00 ± 21,28 abcdef
<i>Manioc blanc kolo</i>	30,90 ± 4,74 abcdefg	58,08 ± 19,18 abcdef
<i>Biafra non racine</i>	18,33 ± 8,02 abcdefg	47,80 ± 23,22 abcdef
<i>Manioc longtoka</i>	31,33 ± 10,96 abcdefg	31,57 ± 9,22 abcdef
<i>Manioc blanc koutoukoup</i>	22,66 ± 8,50 abcdefg	35,00 ± 15,00 abcdef
<i>Manioc rouge fossang</i>	30,66 ± 10,69 abcdefg	56,17 ± 14,27 abcdef
<i>Manioc blanc tendre</i>	15,66 ± 4,50 cdefg	31,38 ± 17,73 abcdef
<i>Moindre moucroitre</i>	43,00 ± 20,66 abcdef	23,44 ± 8,91 abcdef
<i>makwabamapubi</i>	19,66 ± 8,18 bcdefg	22,90 ± 11,19 bcdef
<i>agriculture</i>	19,00 ± 10,01 bcdefg	54,50 ± 27,17 abcdef
<i>chetchumfu</i>	42,80 ± 21,91 abcdef	62,70 ± 28,69 abcdef
<i>Manioc blanc sodiko village</i>	24,66 ± 12,58 bcdefg	61,40 ± 22,77 abcdef
<i>Toso local</i>	45,26 ± 13,56 abcde	53,97 ± 24,60 abcdef
<i>5 minutes</i>	19,00 ± 6,55 bcdefg	9,46 ± 7,52 ef
<i>Tsogui</i>	10,96 ± 8,77 fg	15,66 ± 4,5 bcdef
<i>ndjeti</i>	12,00 ± 4,35 efg	16,66 ± 6,11 bcdef
<i>ndjiguin</i>	10,00 ± 2,00 fg	20,00 ± 5,00 bcdef
<i>Manioc sélectionné</i>	13,66 ± 5,13 defg	22,33 ± 6,80 bcdef
<i>mediviu</i>	19,33 ± 4,04 bcdefg	7,23 ± 3,02 f
<i>Pas connu 9</i>	33,00 ± 5,56 abcdefg	49,76 ± 17,73 abcdef
<i>Manioc sélectionné logdikot</i>	14,66 ± 5,03 defg	24,00 ± 6,55 abcdef
<i>Manioc sélectionné sokélé</i>	20,66 ± 6,02 bcdefg	32,00 ± 17,08 abcdef
<i>Manioc rouge biwoni pk 32</i>	27,00 ± 15,13 bcdefg	50,64 ± 23,96 abcdef
<i>Nd1</i>	20,33 ± 5,85 bcdefg	63,00 ± 27,05 abcde
<i>Kolo blanc</i>	33,63 ± 15,65 abcdefg	63,66 ± 26,31 abcde
<i>Manioc rouge lelemmagotech</i>	30,33 ± 13,10 abcdefg	70,85 ± 23,09 ab
<i>Manioc sélectionné dibamba</i>	15,60 ± 4,50 cdefg	13,42 ± 4,06 def
<i>Pas connu 2</i>	18,66 ± 7,09 bcdefg	33,83 ± 8,60 abcdef
<i>Pas connu 3</i>	16,66 ± 3,51 cdefg	16,33 ± 6,65 bcdef
<i>Pas connu 5</i>	19,33 ± 9,71 bcdefg	33,33 ± 12,01 abcdef
<i>Manioc blanc 2</i>	39,00 ± 8,18 abcdefg	69,88 ± 21,98 abc
<i>82/05/6</i>	34,66 ± 15,01 abcdefg	19,86 ± 8,80 bcdef
<i>Manioc muyuka</i>	20,00 ± 9,16 bcdefg	34,33 ± 10,50 abcdef
<i>Muyuka jaune</i>	14,00 ± 6,00 defg	22,33 ± 8,02 bcdef
<i>Manioc rouge lemgah</i>	19,00 ± 6,55 bcdefg	10,66 ± 4,04 ef
<i>Manioc sélectionné sokellé 2</i>	20,33 ± 7,50 bcdefg	27,66 ± 6,80 abcdef
<i>bengonbebanen</i>	24,70 ± 8,18 bcdefg	62,23 ± 23,85 abcdef
<i>Nakomakoa</i>	34,50 ± 6,06 abcdefg	18,00 ± 3,60 bcdef
<i>Local blanc</i>	18,66 ± 7,63 bcdefg	57,9 ± 21,76 abcdef
<i>Nd2</i>	27,32 ± 8,02 bcdefg	69,23 ± 24,43 abc

<i>Manioc rouge 1</i>	31,33 ± 10,01 abcdefg	54,51 ± 12,56 abcdef
<i>Nd3</i>	33,35 ± 15,72 abcdefg	40,11 ± 16,27 abcdef
<i>Manioc jaune nkokam</i>	36,49 ± 10,74 abcdefg	38,08 ± 19,07 abcdef
<i>Muyuka rouge</i>	20,02 ± 7,06 bcdefg	66,33 ± 25,69 abcd
<i>Manioc sélectionné dibamba</i>	35,61 ± 11,63 abcdefg	41,61 ± 12,97 abcdef
<i>Manioc blanc dur</i>	23,09 ± 10,00 bcdefg	40,00 ± 11,13 abcdef
<i>Manioc blanc nkokam</i>	25,71 ± 10,34 bcdefg	63,16 ± 26,5 abcde
<i>Manioc jaune solé</i>	34,00 ± 16,52 abcdefg	70,60 ± 28,62 abc
<i>Manioc blanc mongnelel pk 37</i>	19,00 ± 3,60 bcdefg	39,30 ± 10,50 abcdef
<i>Manioc jaune dongmba</i>	14,66 ± 4,16 defg	16,66 ± 5,50 defg
<i>Manioc benjeng</i>	14,33 ± 4,04 defg	25,00 ± 7,00 abcdef
<i>Pas connu 10</i>	30,66 ± 4,93 abcdefg	47,76 ± 16,41 abcdef
<i>Nd4</i>	20,00 ± 5,00 bcdefg	11,11 ± 3,47 def
<i>Nd5</i>	8,60 ± 7,20 g	15,33 ± 5,68 cdef
<i>Manioc rouge 1</i>	19,00 ± 8,18 bcdefg	30,22 ± 12,42 abcdef
<i>Manioc agriculture</i>	35,00 ± 8,88 abcdefg	56,40 ± 21,53 abcdef
<i>Manioc yato</i>	18,33 ± 6,50 bcdefg	27,12 ± 8,73 abcdef
<i>Manioc noir</i>	24,33 ± 6,02 bcdefg	52,82 ± 16,33 abcdef
<i>Manioc blanc 3</i>	24,66 ± 5,55 bcdefg	57,80 ± 20,05 abcdef
<i>Manioc blanc 2</i>	24,60 ± 7,07 bcdefg	58,49 ± 19,91 abcdef
<i>Manioc blanc</i>	16,00 ± 4,58 cdefg	44,63 ± 15,50 abcdef
<i>Manioc rouge</i>	61,66 ± 20,20 a	45,66 ± 15,63 abcdef
<i>Manioc patate</i>	31,17 ± 4,59 abcdefg	78,53 ± 8,29 a
<i>Manioc sélectionné sikoum</i>	46,16 ± 18,34 abcd	35,66 ± 8,62 abcdef
<i>Biafra racine biwoni</i>	18,66 ± 8,62 bcdefg	25,20 ± 10,35 abcdef
<i>perchechim</i>	25,76 ± 11,32 bcdefg	38,03 ± 8,22 abcdef
<i>Pas connu 4</i>	23,33 ± 6,05 bcdefg	42,37 ± 11,72 abcdef
<i>Pas connu 7</i>	19,75 ± 6,52 bcdefg	37,53 ± 7,60 abcdef
<i>Pas connu 8</i>	16,45 ± 6,42 cdefg	46,64 ± 12,19 abcdef
<i>Manioc sélectionné logbajeck</i>	25,10 ± 7,77 bcdefg	47,44 ± 13,34 abcdef
<i>Ndolombua</i>	24,33 ± 6,65 bcdefg	42,37 ± 13,00 abcdef
<i>Manioc patate bakenga</i>	33,53 ± 11,21 abcdefg	58,41 ± 23,03 abcdef
<i>Manioc rouge fossang</i>	16,00 ± 4,00 cdefg	7,22 ± 3,53 f
<i>packasing</i>	51,28 ± 21,03 ab	40,11 ± 18,16 abcdef
<i>nlefokep</i>	24,88 ± 6,19 bcdefg	48,70 ± 15,11 abcdef
<i>Manioc rouge bakenga</i>	23,63 ± 7,32 bcdefg	18,09 ± 9,13 bcdef
<i>Manioc blanc 1</i>	19,66 ± 5,50 bcdefg	13,09 ± 2,70 def
<i>8017</i>	38,30 ± 9,50 abcdefg	18,00 ± 2,04 bcdef
<i>chechemkulah</i>	35,66 ± 5,85 abcdefg	64,33 ± 13,61 abcde
<i>Manioc</i>	29,00 ± 3,60 abcdefg	50,84 ± 7,69 abcdef
<i>Manioc patate fonjwang</i>	22,00 ± 4,35 bcdefg	64,11 ± 20,23 abcde
<i>Manioc rouge njiwom</i>	19,00 ± 3,60 bcdefg	44,13 ± 6,22 abcdef
<i>chechem</i>	31,33 ± 10,96 abcdefg	54,90 ± 22,22 abcdef
<i>Manioc blanc clone</i>	25,66 ± 7,76 bcdefg	46,31 ± 11,45 abcdef
<i>Manioc blanc 01</i>	20,33 ± 5,03 bcdefg	38,20 ± 7,59 abcdef
<i>Jaune d'or</i>	25,00 ± 7,00 bcdefg	38,33 ± 9,01 abcdef
<i>Manioc rouge 2</i>	31,33 ± 4,04 abcdefg	44,66 ± 4,04 abcdef

#### Distribution of variables on the first two axes of the PCA

The PCA constructed on the 6 variables relating to mosaic infestation (severity and incidence) and morphological characters (height, petiole length, lobe length, number of lobes) shows a good representation of the variables through the correlation circle. There is a good rate of information restitution on total variability on the F1; F2 plane (59.39%) and an almost heterogeneous spread along the axes F1 which contains 30.20% of information relating to

morphological characters of local cassava varieties and F2 20.19% of information on African cassava mosaic infestation.



Distribution of variables on axes 1 and 2 of the principal component

LL= lobe length; LP = petiole length; NL = number of lobes; SE = severity; IN = incidence; RA = branching; H = height; M = cassava; j = yellow; r = red; b = white.

### 3.6 Incidence and severity of cassava mosaic in the southwestern region of Cameroon (Ekona)

Statistical analysis shows that varieties are grouped into six clusters namely a; ab;abc; bcd; cd and d. This reveals a significant difference between groups and implicitly between varieties. Thus, the incidence varied from 0 to 66.33%, Agric white (kembong) and 96-14-14 varieties the showed zero incidence which means total absence of disease while mambo, mbufung, stongcanda, canopy, local white varieties showed high incidence 66.00%; 61.66; 64%; 33%

and 66.33% respectively highlighting the high propensity of the disease on said varieties (Table 9). Like the incidence, the severity varies according to the groups and the different varieties. It varies from 0 to 47% the varieties Agric white (kembong) and 96-14-14 present a null severity with the values of 0 translating the absence of disease while the varieties White stem, Local white, Yaoundé red, wowo and mbufung presented degrees of severity of 47, 33% 46,03% 45,33% 39,40 and 39,33% respectively, corresponding to the index of gravity 3 (table 9).

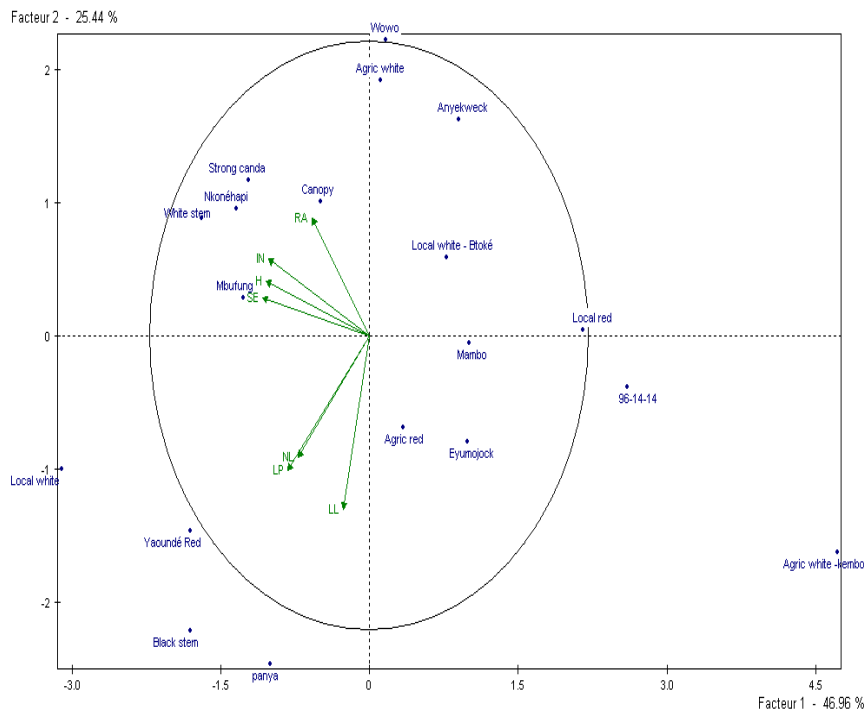
**Table 9. Incidence and severity of cassava mosaic in Ekona (South West Region)**

varieties	Incidence	severity
<i>Mambo</i>	65,00 ± 18,02 cd	24,66 ± 5,50 bc
<i>wowo</i>	45,00 ± 22,91 bcd	39,40 ± 16,82 bc
<i>mbufung</i>	61,66 ± 27,53 cd	39,33 ± 16,77 bc
<i>Agric white</i>	56,00 ± 29,46 bcd	37,83 ± 18,93 bc
<i>Anyekweck</i>	57,56 ± 22,67 bcd	26,16 ± 5,39 bc
<i>Agric white (kembong)</i>	0,00 ± 0,00 a	0,00 ± 0,00 a
<i>Local red</i>	17,06 ± 6,32 ab	19,00 ± 6,56 ab
<i>Eyumojoek</i>	23,00 ± 6,08 abc	25,00 ± 5,00 bc
<i>96-14-14</i>	0,00 ± 0,00 a	0,00 ± 0,00 a
<i>Agricred</i>	44,66 ± 19,55 bcd	35,00 ± 11,71 bc
<i>Strongcanda</i>	64,33 ± 26,15 cd	41,00 ± 9,64 bc
<i>Panya</i>	55,00 ± 18,02 bcd	41,00 ± 6,55 bc
<i>Canopy</i>	63,16 ± 23,77 cd	24,16 ± 4,80 bc
<i>Nkonehapi</i>	52,33 ± 29,68 bcd	36,90 ± 19,91 bc
<i>Black stem</i>	56,00 ± 29,71 bcd	31,00 ± 9,00 bc
<i>Local white</i>	66,33 ± 23,18 d	46,03 ± 12,31 c
<i>Yaoundé red</i>	49,86 ± 14,90 bcd	45,33 ± 16,80 c
<i>White stem</i>	59,33 ± 34,26 cd	47,33 ± 20,23 c
<i>Local white (Btoké)</i>	34,01 ± 17,72 abcd	24,00 ± 6,55 bc

#### Distribution of variables on the first two axes of the PCA

The PCA constructed on the 6 variables relating to the development of parameters (severity and incidence) of viral mosaic and morphological characters (height, petiole length, lobe length, number of lobes) indicates a good representation of the variables through the correlation circle, a good rate of information restitution on the total variability on the F1 ; F2 (72.4%) and an almost heterogeneous spread along the axes, with F1 containing 46.96% information on the 86 local cassava varieties and F2 25.44% information on infestation and morphological characteristics of African cassava mosaic.

**Image1: Distribution of variables on axes 1 and 2 of the principal component**



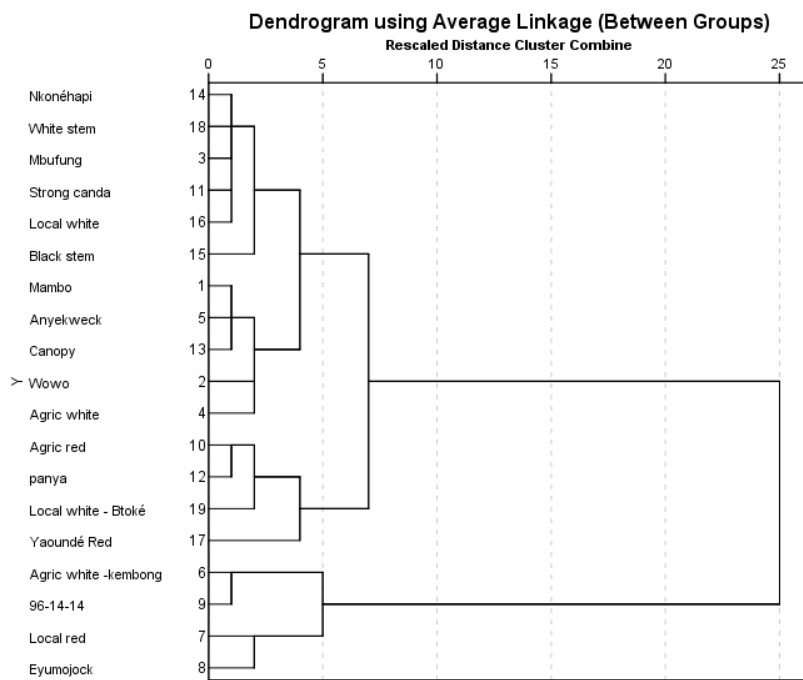
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LL = lobe length; LP = petiole length; NL = number of lobes; SE = severity; IN = incidence; RA = branching; H = height.

To better appreciate the agromorphological diversity of cassava varieties in the study area, a hierarchical ascending classification (PCA) was used to produce a dendrogram that groups varieties into statistically homogeneous classes on the basis of the epidemiological and agromorphological parameters assessed. From the genotypic configuration, axes 1 and 2 show the closeness between certain varieties which are located at the same level on the first axis of the PCA and which consequently present a very strong similarity with the latter.

The different variables (severity, incidence and morphological parameters) were used to discriminate the varieties and classify them into 4 distinct groups using the R software procedure.

**Image 2 :Dendrogram using average linkage**



**Comment [CG6]:** Should not be screen shoot, it is not visible

Matching dendrogram between cassava genotypes screened on the basis of mosaic development and morphological criteria

### 3.7 Incidence and severity of African cassava mosaic in the central region of Cameroon (Yaoundé)

In the Central region, results show that the disease was present on all varieties but to different and variable degrees; severity indices 4 and 5 showing the most susceptible plants to the disease. A range of plants presenting the above-mentioned indices was recorded, such as green petiole-Binoun ( $67.00 \pm 25.70$ ); pétiole rouge yambassa ( $60.33 \pm 28.83$ ); Mintourou-Mvaa ( $63.93 \pm 24.80$ ) (Table 10). On the other hand, very low values with a corresponding severity level of 1 were also recorded, indicating tolerance to mosaic. This is the case for Nkolossane /18 ( $3.83 \pm 0.20$ ); Petiole rouge Bafia ( $12.00 \pm 8.18$ ) (Table 10).

**Table 10. Incidence and severity of mosaic according to varieties**

varieties	incidence	severity
<i>pola rouge. beul</i>	60,00 ± 24,55 abcde	39,33 ± 16,80 abcde
<i>Tokbanwgueive, D/17</i>	32,88 ± 15,66 abcde	31,20 ± 14,26 abcde
<i>pola noir court/F21</i>	16,85 ± 11,36 abcde	37,00 ± 15,71 abcde
<i>pola noir long beul</i>	52,76 ± 21,90 abcde	37,00 ± 15,71 abcde
<i>Gladys Dschang</i>	73,00 ± 28,88 abcde	46,33 ± 18,44 abcde
<i>MabongMekoul, Sovokon</i>	38,33 ± 17,55 abcde	28,66 ± 13,05 abcde
<i>Brown Stem, Yaben</i>	69,84 ± 27,74 abcde	41,73 ± 17,13 abcde
<i>Mani mbong-Sangmelima</i>	12,06 ± 10,85 de	37,00 ± 15,71 abcde
<i>pola noir long beul 2</i>	81,66 ± 31,75 abcd	59,60 ± 23,68 abc
<i>Bout, Mpemzok</i>	56,66 ± 24,28 abcde	30,33 ± 23,57 abcde
<i>SawadaDigron</i>	71,00 ± 29,54 abcde	38,53 ± 17,78 abcde
<i>Gambada, Soaga</i>	47,00 ± 19,67 abcde	41,33 ± 16,80 abcde
<i>Balonkpong</i>	82,33 ± 30,59 abc	36,33 ± 16,50 abcde
<i>Yara Adinkoé</i>	24,48 ± 13,15 abcde	28,00 ± 14,10 abcde
<i>Manioc sucré</i>	57,42 ± 24,90 abcde	51,00 ± 20,66 abcd
<i>Gambada, Boumadjalé</i>	28,71 ± 14,78 abcde	20,66 ± 10,01 bcde
<i>NabongMekoul, Sovokong II</i>	46,66 ± 20,20 abcde	41,00 ± 17,34 abcde
<i>6 mois, Tiko, lis 2</i>	56,00 ± 21,28 abcde	42,06 ± 18,22 abcde
<i>Akourakwa, Mpemzok</i>	71,00 ± 29,54 abcde	28,66 ± 14,64 abcde
<i>Guge 2</i>	30,00 ± 15,00 abcde	31,46 ± 13,68 abcde
<i>2 - 9(2)</i>	5,16 ± 0,51 e	3,83 ± 0,22 e
<i>Bitoto/F17 (2)</i>	23,81 ± 12,68 abcde	20,66 ± 10,01 bcde
<i>Nkol- Ossané/18</i>	3,51 ± 0,51 e	3,83 ± 0,20 e
<i>BalbineMeyosbben</i>	24,81 ± 11,22 abcde	20,33 ± 10,50 bcde
<i>BitiBoumadjalé</i>	24,14 ± 12,22 abcde	29,40 ± 7,21 abcde
<i>Ché 2 /F2 (2)</i>	13,33 ± 10,40 cde	20,33 ± 10,50 bcde
<i>Madaga 2 - (2)</i>	22,33 ± 11,67 abcde	29,00 ± 12,52 abcde
<i>Mraheg 2-2(2)</i>	30,00 ± 15,00 abcde	20,66 ± 10,01 bcde
<i>GbeguedaGandoua</i>	65,33 ± 39,11 abcde	26,60 ± 12,21 abcde
<i>Moumpé Fe Garoua yara</i>	48,33 ± 17,55 abcde	27,00 ± 12,52 abcde
<i>Campo (Mvaa) 2</i>	45,00 ± 22,91 abcde	24,00 ± 11,00 abcde
<i>Badobo-Tikolo</i>	65,66 ± 38,55 abcde	34,93 ± 14,85 abcde
<i>Moan-Moan, nkol</i>	60,44 ± 24,91 abcde	42,40 ± 17,67 abcde
<i>Mintourou-Mvaa</i>	70,66 ± 30,10 abcde	63,93 ± 24,80 ab
<i>Ngambada-Ngambada</i>	63,33 ± 25,65 abcde	26,93 ± 13,26 abcde
<i>Gbalonkpong (1)</i>	38,00 ± 18,08 abcde	37,00 ± 15,71 abcde
<i>PétioleRouge Bafia (1)</i>	25,33 ± 14,50 abcde	12,00 ± 8,18 de
<i>AfoubaDovaye</i>	14,40 ± 10,45 bcde	20,00 ± 11,00 cde
<i>Ntangna, Mvaa</i>	83,33 ± 42,52 ab	20,66 ± 10,01 bcde
<i>Tougueda-</i>	51,09 ± 24,63 abcde	24,66 ± 11,50 abcde

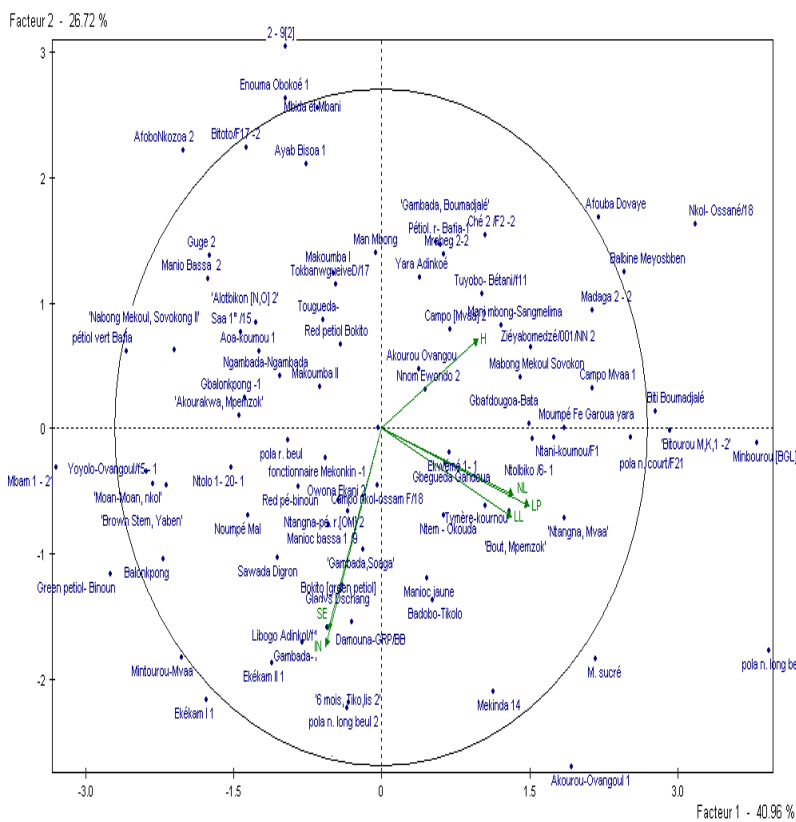
<i>LibogoAdinkol/f1</i>	78,33 ± 37,52 abcde	44,33 ± 20,10 abcde
<i>Pétiole rouge Yambassa (1)</i>	80,66 ± 33,48 abcd	60,33 ± 26,83 abc
<i>Tuyobo- Bétani/f11(1)</i>	25,33 ± 14,50 abcde	20,33 ± 10,50 bcde
<i>Gbaïdougoua-Bata</i>	40,90 ± 18,00 abcde	31,46 ± 13,68 abcde
<i>Red petiole-binoun</i>	57,00 ± 23,73 abcde	53,33 ± 21,77 abcd
<i>fonctionnaireMekonkin (1)</i>	61,66 ± 28,43 abcde	30,26 ± 12,73 abcde
<i>Bokito (green petiol)</i>	82,66 ± 30,02 abc	33,66 ± 14,10 abcde
<i>Gambada(1)</i>	81,00 ± 32,90 abcd	36,00 ± 17,34 abcde
<i>pétiole vert Bafia</i>	63,33 ± 25,65 abcde	32,00 ± 14,10 abcde
<i>Green petiol- Binoun</i>	51,36 ± 21,68 abcde	67,00 ± 25,70 a
<i>Red petiolBokito</i>	45,00 ± 22,91 abcde	26,33 ± 13,57 abcde
<i>Damouna-GRP/BB</i>	71,00 ± 29,54 abcde	55,26 ± 22,56 abcd
<i>Tymère-kournou</i>	74,16 ± 34,49 abcde	25,73 ± 12,32 abcde
<i>Ntani-koumou/F1(1)</i>	41,29 ± 19,90 abcde	27,33 ± 15,17 abcde
<i>Ntolo 1- 20(1)</i>	65,33 ± 30,66 abcde	36,33 ± 16,80 abcde
<i>Yoyolo-Ovangoul/f5(1)</i>	73,86 ± 30,27 abcde	46,33 ± 20,18 abcde
<i>Akourou-Ovangoul(1)</i>	80,00 ± 34,64 abcd	48,00 ± 20,66 abcd
<i>Noumpé Mal</i>	78,33 ± 29,29 abcd	36,66 ± 16,26 abcde
<i>Aoa-koumou(1)</i>	52,00 ± 27,87 abcde	22,80 ± 11,60 bcde
<i>Saa 1° /15 (1)</i>	55,00 ± 22,91 abcde	31,46 ± 13,68 abcde
<i>Mekinda 14 (1)</i>	78,66 ± 36,95 abcd	44,33 ± 20,10 abcde
<i>Manioc bassa 1 /9(1)</i>	62,33 ± 27,31 abcde	40,40 ± 19,33 abcde
<i>AyabBisoa (1)</i>	23,14 ± 13,63 abcde	27,66 ± 14,64 abcde
<i>Campo Myaa (1)</i>	41,29 ± 19,90 abcde	20,00 ± 11,00 cde
<i>Ntolbiko /6(1)</i>	56,66 ± 24,28 abcde	20,00 ± 11,00 cde
<i>AkourouOvangou</i>	41,62 ± 19,37 abcde	27,66 ± 14,64 abcde
<i>EnoumaObokoé (1)</i>	15,07 ± 9,68 bcde	20,00 ± 11,00 cde
<i>Megnongnkolo S</i>	53,22 ± 23,09 abcde	31,46 ± 15,28 abcde
<i>Ntem - Okouda (1)</i>	81,66 ± 31,75 abcd	20,33 ± 10,50 bcde
<i>Ekwémé 1- 1(1)</i>	47,00 ± 19,67 abcde	40,33 ± 18,44 abcde
<i>Campo nkol-ossam F/18(1)</i>	73,22 ± 31,40 abcde	30,00 ± 14,10 abcde
<i>Mbam 1 - 21(1)</i>	80,00 ± 34,64 abcd	24,33 ± 12,01 abcde
<i>EkékamI(1)</i>	81,66 ± 31,75 abcd	58,46 ± 25,25 abc
<i>Ekékam II (1)</i>	79,33 ± 35,79 abcd	46,33 ± 20,10 abcde
<i>Manio Bassa (2)</i>	50,88 ± 22,00 abcde	24,00 ± 12,52 abcde
<i>OwonaEkani(2)</i>	86,00 ± 37,98 a	29,46 ± 13,68 abcde
<i>Mbida et Mbani</i>	5,20 ± 8,66 e	20,66 ± 10,01 bcde
<i>Manioc jaune</i>	75,16 ± 32,78 abcd	38,86 ± 17,23 abcde
<i>Man Mbong</i>	20,50 ± 12,46 abcde	36,66 ± 16,25 abcde
<i>Nnom Ewondo(2)</i>	51,06 ± 23,45 abcde	28,33 ± 15,71 abcde
<i>Makoumba I</i>	44,66 ± 23,45 abcde	25,06 ± 13,36 abcde
<i>Ziéyabomedzé/001/NN(2)</i>	36,00 ± 17,29 abcde	25,06 ± 13,36 abcde
<i>BitourouM,K,1(2)</i>	40,50 ± 20,07 abcde	22,20 ± 11,91 bcde

<i>Minbourou (BGL)(2)</i>	26,00 ± 13,52 abcde	24,00 ± 12,52 abcde
<i>Ntangna-pétiole rouge (OM)(2)</i>	75,83 ± 31,65 abcd	42,66 ± 17,89 abcde
<i>Makoumba II</i>	55,00 ± 27,04 abcde	20,00 ± 11,00 cde
<i>Alotbikon (N,O) (2)</i>	36,00 ± 17,29 abcde	24,33 ± 12,01 abcde
<i>AfoboNkozoa(2)</i>	25,33 ± 14,50 abcde	19,66 ± 11,50 cde

### 3.8 Distribution of variables on the first two PCA axes

The PCA constructed on the 6 variables relating to mosaic infestation (severity and incidence) and morphological characters (height, petiole length, lobe length, number of lobes) shows good representation of the variables through the correlation circle, a good rate of information restitution on total variability on the F1 ; F2 (67.68%) and an almost heterogeneous spread along the axes F1 containing 40.96% information on morphological characteristics of local cassava varieties and F2 26.72% information on infestation of varieties by African cassava mosaic.

UNDER PEER REVIEW



**Comment [CG7]:** Should not be screen shoot, it is not visible, needs to be centered

Image 3 Distribution of variables on the first two PCA axes

LL= lobe length; LP = petiole length; NL = number of lobes; SE= severity; IN = incidence; RA = branching; Height

### Correlations between symptom severity and plant length growth at different study sites

#### 3.9 Correlations obtained with Nkolbisson varieties (central Cameroon region)

The correlation coefficients obtained with the Nkolbisson varieties present several cases; The first case is that of positive and perfect correlations such as GlwadysDschang ( $r = 0.9$ ), Bout Mpemzok ( $r = 1$ ), Mamimbong-sangmelima ( $r = 0.9$ ), 6 moisTiko,lis 2 ( $r = 0.9$ ), Pétiole rouge yambassa (1) ( $r = 0.8$ ), EnomEwondo (2) ( $r = 0.9$ ), etc. The second case is that of weak and positive correlations obtained with Pola rouge beul ( $r = 0.6$ ), Guge2 ( $r = 0.7$ ), AkouraOvangou ( $r = 0.7$ ), Bokito (green petiol) ( $r = 0.5$ ), etc. The third case is that of non-existent correlations obtained with varieties such as Owona Ekani (2) ( $r = 0$ ), Mabongmekoulsovokon ( $r = 0.3$ ), and 2-9(2) ( $r = 0.4$ ) (Table 11).

**Table 11. Correlations between symptom severity and length growth of nkolbisson varieties (central region)**

varieties	Coefficient de corrélation	observation
<i>Pola rouge beul</i>	0,6	Weaklycorrelated
<i>TokbanwgueiveD/17</i>	0,7	Weaklycorrelated
<i>Pola noir court/F21</i>	0,5	Weaklycorrelated
<i>Pola noir long beul</i>	0,5	Weaklycorrelated
<i>Glwagys Dschang</i>	0,9	Stronglycorrelated
<i>Mabongmekoulsovokon</i>	0,3	No correlated
<i>Brown stem yaben</i>	0,9	Stronglycorrelated
<i>Mamimbong-sangmelima</i>	0,9	Stronglycorrelated
<i>Pola noir long beul2</i>	0,9	Stronglycorrelated
<i>Bout M pemzok</i>	1	Stronglycorrelated
<i>SawadaDigron</i>	0,9	Stronglycorrelated
<i>Gambadasoaga</i>	0,8	Stronglycorrelated
<i>Balonkpong</i>	0,8	Stronglycorrelated
<i>YaraAdinkoé</i>	0,9	Stronglycorrelated
<i>Manioc sucré</i>	1	Stronglycorrelated
<i>GambadaBoumadjalé</i>	1	Stronglycorrelated
<i>Nabongmekoul, sovokong II</i>	1	Stronglycorrelated
<i>6 mois Tiko, lis 2</i>	0,9	Stronglycorrelated
<i>Akourakwa,mpemzok</i>	0,8	Stronglycorrelated
<i>Guge2</i>	0,7	Weaklycorrelated
<i>2-9(2)</i>	0,4	No correlated
<i>Bitoto/F17(2)</i>	0,9	Stronglycorrelated
<i>Nkol-ossané/18</i>	1	Stronglycorrelated
<i>BalbineMeyosbben</i>	0,8	Stronglycorrelated
<i>BitiBoumadjalé</i>	0,8	Stronglycorrelated
<i>Ché2/F2 (2)</i>	0,1	No correlated
<i>Madaga2-(2)</i>	0,8	Stronglycorrelated
<i>Mraheg 2-2(2)</i>	0,8	Stronglycorrelated
<i>GbeguedaGandoua</i>	0,9	Stronglycorrelated
<i>Moumpé femelle Garoua yara</i>	0,6	Weaklycorrelated
<i>Campo (Mvaa)2</i>	0,9	Stronglycorrelated
<i>Badobo-Tikolo</i>	0,8	Stronglycorrelated
<i>Mintourou-mvaa</i>	0,8	Stronglycorrelated
<i>Ngambada-Ngambada</i>	0,8	Stronglycorrelated
<i>Gbalonkpong(1)</i>	0,7	Weaklycorrelated
<i>Pétiole rouge-Bafia (1)</i>	0,5	Weaklycorrelated
<i>AfoubaDovaye</i>	0,9	Stronglycorrelated
<i>Ntangna,Mvaa</i>	0,8	Stronglycorrelated
<i>Tougueda</i>	1	Stronglycorrelated
<i>LibogoAdinkol/F1</i>	0,8	Stronglycorrelated
<i>Pétiole rouge yambassa(1)</i>	0,8	Stronglycorrelated
<i>Gbafdougoua-bata</i>	0,9	Stronglycorrelated
<i>Tuyobo-betani/F11(1)</i>	0,9	Stronglycorrelated
<i>Redpetiole-binoun</i>	0,9	Stronglycorrelated
<i>Fonctionnaire Mekoukin(1)</i>	0,9	Stronglycorrelated
<i>Bokito(green petiol)</i>	0,5	Weaklycorrelated
<i>Gambada (1)</i>	0,9	Stronglycorrelated
<i>Pétiole vert Bafia</i>	0,5	Weaklycorrelated
<i>Green petiolbinoun</i>	0,8	Stronglycorrelated
<i>Redpetiolbokito</i>	0,8	Stronglycorrelated
<i>Damouna- GRP/BB</i>	0,8	Stronglycorrelated
<i>Tymere-Kournou</i>	0,7	Weaklycorrelated
<i>Ntani-koumou/F1(1)</i>	0,8	Stronglycorrelated
<i>Ntolo1-20(1)</i>	0,8	Stronglycorrelated
<i>Yoyolo-Ovangoul/F5(1)</i>	0,8	Stronglycorrelated
<i>Akourou-Ovangoul(1)</i>	0,8	Stronglycorrelated
<i>Noumpé Mal</i>	0,9	Stronglycorrelated
<i>Aoa-koumou(1)</i>	0,9	Stronglycorrelated
<i>Saa1°/15(1)</i>	0,9	Stronglycorrelated
<i>Mekinda 14(1)</i>	0,7	Weaklycorrelated
<i>Manioc bassa1/9(2)</i>	1	Stronglycorrelated
<i>AyabBisaa</i>	0,7	Weaklycorrelated

<i>Campo Myaa(1)</i>	1	Stronglycorrelated
<i>Ntolbiko/6(1)</i>	0,9	Stronglycorrelated
<i>AkouraOvangou</i>	0,7	Weaklycorrelated
<i>EnoumaObokoé (1)</i>	0,7	Weaklycorrelated
<i>MegnongNkols</i>	0,8	Stronglycorrelated
<i>Ntem-okouda (1)</i>	0,8	Stronglycorrelated
<i>Ekwémé 1-1(1)</i>	0,8	Stronglycorrelated
<i>Camponkol-ossam F/18(1)</i>	0,9	Stronglycorrelated
<i>Mbam 1-21 (1)</i>	1	Stronglycorrelated
<i>Ekékam I (1)</i>	0,9	Stronglycorrelated
<i>Ekékam II (1)</i>	0,8	Stronglycorrelated
<i>Manioc Bassa (2)</i>	0,7	Weaklycorrelated
<i>Mbida et Mbani</i>	0,9	Stronglycorrelated
<i>OwonaEkani (2)</i>	/	
<i>Manioc jaune</i>	0,9	Stronglycorrelated
<i>Man Mbong</i>	0,9	Stronglycorrelated
<i>EnomEwondo (2)</i>	0,9	Stronglycorrelated
<i>Makoumba I</i>	0,5	Weaklycorrelated
<i>Ziéyabomedzé/001/NN(2)</i>	0,8	Stronglycorrelated
<i>BitourouM,k,1(2)</i>	0,8	Stronglycorrelated
<i>Mimbourou (BGL) (2)</i>	0,8	Stronglycorrelated
<i>Ntangna-pétiol rouge (0M) (2)</i>	0,8	Stronglycorrelated
<i>Makoumba II</i>	0,9	Stronglycorrelated
<i>Alotbikon (N, 0) (2)</i>	0,9	Stronglycorrelated
<i>Afobonkozooa (2)</i>	0,8	Stronglycorrelated

### 3.10 Correlations obtained with Ekona varieties (South West region)

The study of the linear correlation between symptom severity and length development of Ekona varieties revealed a strong positive and significant correlation with varieties such as Canopy ( $r = 0.9$ ), White stem ( $r = 1$ ), Anyekweck ( $r = 0.9$ ), Strong canda ( $r = 1$ ) etc. However, we obtained weak correlations with cultivars such as Mambo ( $r = 0.5$ , White stem ( $r = 0.5$ ), Strong canda ( $r = 1$ ) etc. However we obtained low correlations with cultivars like Mambo ( $r = 0.5$ ), Agric red ( $r = 0.7$ ). However, we also have a lack of correlation with varieties like Eyumojock ( $r = 0.3$ ), Local white ( $r = 0.4$ ) (Table 12).

**Table 12. Correlation between symptom severity and length growth of Ekona varieties (Southwest region)**

Variétés	Coefficient de corrélation(r)	Observation
<i>Mambo</i>	0,5	Weaklycorrelated
<i>Wowo</i>	0,8	Stronglycorrelated
<i>Mbufung</i>	0,5	Weaklycorrelated
<i>Agric white</i>	0,5	Weaklycorrelated
<i>Anyekweck</i>	0,9	Stronglycorrelated
<i>Agric white (kembong)</i>	1	Stronglycorrelated
<i>Local red</i>	0,8	Stronglycorrelated
<i>Eyumojock</i>	0,3	No correlated
<i>96-14-14</i>	1	Stronglycorrelated
<i>Agricred</i>	0,7	Weaklycorrelated
<i>Strongcanda</i>	1	Stronglycorrelated
<i>Panya</i>	1	Stronglycorrelated
<i>Canopy</i>	0,9	Stronglycorrelated
<i>Nkonéhapi</i>	0,9	Stronglycorrelated
<i>Black stem</i>	0,5	Weaklycorrelated
<i>Loacalwhite</i>	0,4	No correlated
<i>Yaoundéred</i>	0,5	Weaklycorrelated
<i>White stem</i>	1	Stronglycorrelated

Local white (Btoké)	0,5	Weaklycorrelated
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### 3.11 Correlations obtained with the varieties of Njombé (littoral region)

The correlation coefficients obtained with the Njombé varieties show strong correlations with increasing slopes with most of the varieties such as Red Manioc ( $r = 1$ ), White Manioc ( $r = 0.8$ ), White Manioc sodiko village ( $r = 1$ ), etc. Weak correlations were obtained with the varieties Manioc rouge Fossang ( $r = 0.5$ ), Manioc sélectionné dibamba ( $r = 0.5$ ). No correlation was obtained for certain varieties such as Makwabamapubi ( $r = 0$ ), Manioc rouge Njiwom ( $r = 0.2$ ); the coefficient being zero (Table 13).

**Table 13. Correlation between symptom severity and length growth of varieties in Njombé (Littoral region)**

Variétés	Coefficient de corrélation(r)	Observation
<i>Manioc blanc</i>	0,8	Stronglycorrelated
<i>Mediviu</i>	0,8	Stronglycorrelated
<i>Pas connu 9</i>	0,5	Stronglycorrelated
<i>Manioc blanc 1</i>	1	Stronglycorrelated
<i>Manioc rouge</i>	1	Stronglycorrelated
<i>Pas connu 10</i>	0,5	Weaklycorrelated
<i>Manioc rouge 1</i>	1	Stronglycorrelated
<i>Packasing</i>	0,5	Weaklycorrelated
<i>Chechem</i>	0,5	Weaklycorrelated
<i>Manioc souza</i>	0,5	Weaklycorrelated
<i>Yara</i>	1	Stronglycorrelated
<i>Mano/boumocreboe</i>	1	Stronglycorrelated
<i>Manioc blanc kolo</i>	1	Stronglycorrelated
<i>Biafra non racine</i>	0,8	Stronglycorrelated
<i>Manioc longtoka</i>	0,8	Stronglycorrelated
<i>Manioc blanc koutoukoup</i>	0,5	Weaklycorrelated
<i>Manioc rouge Fossang</i>	0,5	Weaklycorrelated
<i>Manioc blanc tendre</i>	0,5	Weaklycorrelated
<i>Moindre moucroitre</i>	0,5	Weaklycorrelated
<i>Makwabamapubi</i>	0	No correlated
<i>Agriculture</i>	0,5	Weaklycorrelated
<i>Chechumfu</i>	1	Stronglycorrelated
<i>Manioc blanc sodiko village</i>	1	Stronglycorrelated
<i>Toso local</i>	1	Stronglycorrelated
<i>5 minutes</i>	0,2	No correlated
<i>Tsogui</i>	0,9	Stronglycorrelated
<i>Ndjeti</i>	1	Stronglycorrelated
<i>Ndjiguin</i>	0,9	Stronglycorrelated
<i>Manioc sélectionné</i>	0,8	Stronglycorrelated
<i>Manioc sélectionné logdikot</i>	0,4	No correlated
<i>Manioc sélectionné sokélé</i>	0,5	Weaklycorrelated
<i>Manioc rouge bivoni pk 32</i>	0,9	Stronglycorrelated
<i>ND</i>	1	Stronglycorrelated
<i>Kolo blanc</i>	1	Stronglycorrelated
<i>Manioc rouge lelemmagotech</i>	0,5	Weaklycorrelated

<i>Manioc sélectionné dibamba</i>	0,5	Weaklycorrelated
<i>Pas connu 2</i>	1	Stronglycorrelated
<i>Pas connu 3</i>	1	Stronglycorrelated
<i>Pas connu 5</i>	0,5	Weaklycorrelated
<i>Manioc souza</i>	0,8	Stronglycorrelated
<i>82/05/6</i>	0,6	Weaklycorrelated
<i>Manioc Muyuka</i>	0,5	Weaglycorrelated
<i>Muyuka jaune</i>	0,5	Weaklycorrelated
<i>Manioc rouge lemgah</i>	0,5	Weaklycorrelated
<i>Manioc sélectionnéDibamba 1</i>	1	Stronglycorrelated
<i>Bengombehanem</i>	/	/
<i>Nakomakoa</i>	0,5	Weaklycorrelated
<i>Local blanc</i>	1	Stronglycorrelated
<i>Nd</i>	0,3	No correlated
<i>Nd</i>	1	Stronglycorrelated
<i>Manioc jaune Nkokom</i>	1	Stronglycorrelated
<i>Muyuka rouge</i>	0,9	Stronglycorrelated
<i>Manioc sélectionnédibamba 2</i>	0,2	No correlated
<i>Manioc blanc dur</i>	0,6	Weaklycorrelated
<i>Manioc blanc nkokam</i>	1	Stronglycorrelated
<i>Manioc jaune sole</i>	1	Stronglycorrelated
<i>Manioc blanc Mongnelel pk 37</i>	0,5	Weaklycorrelated
<i>Manioc jaune Dongmba</i>	0,5	Weaklycorrelated
<i>Manioc Bejenq</i>	0,3	No correlated
<i>Nd</i>	0,9	Stronglycorrelated
<i>Nd</i>	0,8	Stronglycorrelated
<i>Pas connu 6</i>	0,6	Weaklycorrelated
<i>Manioc rouge 1</i>	0,9	Stronglycorrelated
<i>Manioc agriculture</i>	0,1	No correlated
<i>Manioc Yato</i>	0,9	Stronglycorrelated
<i>Manioc noir</i>	0,9	Stronglycorrelated
<i>Manioc blanc 3</i>	0,9	Stronglycorrelated
<i>Manioc blanc 2</i>	0,3	No correlated
<i>Manioc blanc</i>	0,6	Weaklycorrelated
<i>Manioc patate</i>	0,2	No correlated
<i>Manioc sélectionné sikoum</i>	0,6	Weaklycorrelated
<i>Biafra racine Biwoni</i>	0,6	Weaklycorrelated
<i>Perchechim</i>	0,2	No correlated
<i>Pas connu 4</i>	0,7	Weaklycorrelated
<i>Pas connu 7</i>	0,3	No correlated
<i>Pas connu 8</i>	1	Stronglycorrelated
<i>Manioc logbajeck</i>	0,9	Stronglycorrelated
<i>NdolomMbua</i>	0,5	Weaklycorrelated
<i>Manioc patate bakemga</i>	0,9	Stronglycorrelated
<i>Manioc rouge Fossang</i>	0,9	Stronglycorrelated
<i>Nlefokep</i>	0,8	Stronglycorrelated
<i>Manioc rouge Bakenga</i>	0,9	Stronglycorrelated
<i>Manioc blanc 1</i>	0,2	No correlated
<i>8017</i>	0,9	Stronglycorrelated
<i>Namelong</i>	0,9	Stronglycorrelated
<i>Chechemkulah</i>	0,8	Stronglycorrelated
<i>Manioc</i>	1	Stronglycorrelated
<i>Manioc patate Fonjwang</i>	1	Stronglycorrelated
<i>Manioc rouge Njiwom</i>	0,2	No correlated
<i>Manioc blanc (clone)</i>	0,9	Stronglycorrelated

#### 4. Discussion

**Comment [CG8]:** The resultsshouldbediscussed more relative to currentworks in thisfield of study

The characterization, collection and evaluation of local cultivars is a basic strategic priority or raw material for plant breeding and genetic improvement programs. The development and use of this diversity of local cultivars by farmers will contribute to increasing national production. This work initiated for cassava in two agro-ecological zones of Cameroon is being carried out on collections from farmers' fields in several localities of each study region and improved collections maintained in research stations, namely IRAD and IITA. At the end of the inventory of the different varieties, the results show a great diversity of plant material that can be explained by the ecological potential, the enthusiasm of the populations for this crop and the environmental conditions. This result is similar to that of [8], for whom morphological characteristics such as height, leaf shape and size, and organ color can vary with climate, soil and altitude, since, in the absence of molecular markers, the use of morphological descriptors remains the most widely used method for studying the diversity of varieties. With regard to the descriptors used in the collection, it was found that the potential morphological diversity is comparable between the areas of investigation and the groups. Moreover, there is relatively little differentiation in the morphological range between varieties. This result is similar to that of [9] who in a similar analysis showed that there is no significant difference in the morphological space occupied by each set of varieties from a given location. It appears from this work that, of all the regions investigated, the dominant color of the leaves is dark green. This result could be explained by the low virulence of the strains which would have depressed the metabolism of the plants and consequently the pigmentation. This result is contrary to the work of [8] who, in his investigations, showed that cassava genotypes with young purple leaves predominate in central and eastern Africa. Regarding the different lobe shapes, there was an alternation between lanceolate and ovoid forms. Regarding the number of lobes, the figure of 8 lobes compared to 5 lobes obtained in the central and coastal regions was recorded. This result could be explained by the genetic properties of each variety, which confirms the work of Graner. This is an advantage for the marketing and consumption of the leaves. The color of the leaves seems to be the most representative trait by the populations in the choice of local varieties because in all the regions surveyed, the green color was the most dominant. This result is similar to those of [10]; [11], who in their investigations showed that populations use leaf and petiole color to identify varieties.

The results of this study also show the ability of the varieties to branch, as the average number of branches is higher than 3 per variety. This character confers to the plant the capacity to open out and to bloom. This result confirms that of Médard, who in his study proved that the varieties of manioc not presenting ramifications do not bloom normally.

At the end of the inventory of varieties carried out in the different study regions, it was found that the central and coastal regions recorded high numbers of local varieties (86 and 96 respectively), compared to the southwest, which had very low numbers (19). This result could be explained by the dietary habits of the different populations in the sense that the more a crop is prized, the more it is cultivated by the populations concerned. In addition, this could also be explained by climatic conditions, as the higher the rainfall, the more frequent the diseases (mosaic) and consequently the lower the yield, thus discouraging farmers from growing this crop. Similarly, our study shows that: the regional diversity of varieties generally corresponds to the needs of the populations. Several factors have an influence on the choice of varieties. However, we recorded a low rate of regional differentiation. In each region, varieties have specific characteristics but some are identical in other regions. The variability of cultivars would be linked to the experience of communities in cassava production. The large number (19) of varieties obtained in Ekona in southwestern Cameroon compared to other regions could also be explained by the fact that this region is a cocoa production basin, which is more widespread, and demonstrates why inadequate attention is paid to cassava, explaining the low experience of the populations in its cultivation.

The evaluation of the epidemiological parameters according to the varieties allowed to highlight the effect of the varietal resistance on the dynamics of the mosaic epidemics in the field. Indeed, the analysis of the incidence and severity of mosaic in different localities according to varieties showed that some local and improved varieties such as :Mintourou-Mvaa, Green petiole Binoun, red petiole Yambassa, 8017, 8061 and 0110 are affected by the disease. As soon as mosaic began to appear 6 months after planting, in different areas, several varieties showed incidences of more than 50%. These varieties would favour the rapid development of disease epidemics and would therefore be susceptible to cassava mosaic. While varieties such as Nkolossané/18, Ché 2/F2(2), Biafra non root, soft white cassava, ndjiguin, which were less affected by the disease, were tolerant and showed severity levels ranging from 1 to 1.5. This resistance would be attributed to the presence of secondary metabolites such as phenols. These results are similar to those of [12] and [13], who revealed that plants develop during their evolution natural properties to resist crop pests thanks to the biocides they produce. In the same sense, varieties such as Nkolossané/18, 2-9(2), Champion, 8034, 92/0326 would have developed the capacity to mobilize resistance mechanisms in response to infections due to mosaic viruses. All these substances would have an impact on reducing the progression of infections in the field in tolerant varieties, in contrast to susceptible varieties that would favor the speed of infections. This diversity of resistant plants

would have a panel of molecules that would limit the progression of infections in the plant reducing losses in the field.

The incidence study revealed the presence of the disease on cassava plants of different varieties, despite the variation in values between genotypes. These results testify to the endemic nature of this pathology in the agro-ecological zone concerned, as already highlighted by [14]. This result could be explained by the fact that genetic properties render accessions either susceptible or tolerant to the disease, and also by the fact that cuttings would have retained internal infections before being planted, as growers use cuttings from their old fields. The disease was more widespread in the Ekona and Nkolbisson regions, with percentages of 63% and 60% respectively. In Njombé, the incidence was 49.74%. This result can be explained by the climatic conditions in the study areas at the time of the experiments. The highest degree of severity was obtained in the center (2) compared with degree (1) obtained in Njombé and Ekona. This result can be explained by the fact that the investigations were carried out in the central region at the end of the rainy season, confirming the findings of [15] in similar work.

## 5. Conclusion

The work, whose objective was to make a varietal characterization in the field and an epidemiological study, reveals the significant existence of a diversity of varieties in the expected zones. The morphological traits recorded show a low rate of regional differentiation. In each region, the varieties have specific characteristics but some are identical in other regions. Epidemiology carried out independently of regions revealed two categories of varieties (susceptible, tolerant). Varieties with interesting morphological traits and tolerance to mosaic will be an asset not only for molecular studies but also for geneticists and could be included in the catalog of cassava varieties.

**Comment [CG9]:** The conclusion should touch main summaries of the discussion

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