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 resultsshow 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 deseaseincidence 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

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

2.2 Othermaterials

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.

2.3.1Epidemiology 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 m2 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 isthe 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 $\sum(a.b)$ isthe 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 Sperman'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.

critetia / **varieties (name and /or code)**	**Leafcolor**	**Petiolecolor**	**Leafform**	**Lobelength (cm)**	**Petioleheigth (cm)**	**Numberlobe**
Pola rouge beul / F 21	dark green	ligth green	lanceolate	15	23	3
Tokbanbwgueive, Dana / F17	dark green	ligth green	lanceolate	14	15	5
Pola noir, court / F21	purple	red	lanceolate	19,5	36	7
Pola noir, long beul/ F21	purple	red	ovoïd	30	39	7
Gladys Dschang	dark green	red	ovoïd	17	22	5

MabongMekoul, Sovokonl	purple	darkred	lanceolate	14	30	7
Brown Stem, Yamben	green	ligthred	ovoïd	12	10	5
Mani Mbong-Sangmelima	green purplish	red	ovoïd	17	25	6
Pola noir long (beul)	dark green	red	ovoïd	16	17	7
Bout, Mpemzok	purple	ligth green	lanceolate	19	22	8
SawadaDigron	purple	darkred	ovoïd	15	21	5
Gambada, Soagol	green purplish	red	lanceolate	19	25	5
Balonkpong, Dana	Ligth green	red	lanceolate	14	15	4
YaraAdinkoé	green	red	ovoïd	14	25	5
Manoic sucré	green purplish	riddish--green	ovoïd	23	31	7
Gambada, Boumadjalé	dark green	red	ovoïd	14	26	5
NabongMekoul, Sovokongll	dark green	red	ovoïd	10	17	3
6 mois, Tiko. Lis	dark green	ligthred	ovoïd	21	27	6
Akourakwa, Mpemzok	green purplish	red	ovoïd	16,5	15	3
Guge 2^{e}	dark green	ligth green	ovoïd	14	11,5	3
2^{e} - 9	green purplish	red	ovoïd	14,7	15	3
Bitoto/ F17	dark green	green	ovoïd	11,5	11	4
Nkol- ossané	dark green	red	cylindrical	26,5	25	7
BalbineMeyosbben	green	red	lanceolate	18	28,5	7
BititiBoumadjalé	green purplish	darkred	lanceolate	22	34	7
Ché 2^{e} / F4	green purplish	red	ovoïd	15,5	25	6
Mdaga 2^{e} – 3	green purplish	darkred	ovoïd	15	32	7
Mraheg2^{e} - 2	dark green	red	Lanceolate	17	21	5
GbeguedaGandoua	green purplish	red	lanceolate	17,5	22,5	6
Moumpé Femelle, Garoua Yara	green purplish	red	lanceolate	19,5	26,5	7
Campo (Mvaa)	green purplish	rede	lanceolate	18	26	4
Badobo- Tikolo	dark green	green	ovoïd	17	27	7
Moan- Moan, NkolOsananga	green purplish	ligth green	lanceolate	14,5	15	3
Mintourou- Mvaa II	dark green	red	lanceolate	16	19	3
Ngambada- Ngambada	dark green	red	lanceolate	14,5	17	4
Gbalonkpong- Gandong	dark green	green	ovoïd	13	16	4 to 6
Pétiole rouge Bafia	green purplish	red	lanceolate	15	23	5 to7
AfoubaDovaye	green purplish	red	lanceolate	18	28	6
Ntanga (le blanc), Mvaa	green purplish	red	ovoïd	19	29	6 to 7
Tougueda – Gbata / F16	dark green	green	lanceolate	14,5	14,5	4 to 6
Pétiole vert – Yambassa						
LiogoAdinkol/F10	purple	green	lanceolate	16	24	5 to 7
Pétiol rouge Yambassa	green purplish	red	lanceolate		21	7
Tuyobo- Bétani/F11	green purplish	riddish-green	ovoïd	13	35,5	7
Gbafdougoa- Bata	green purplish	red	lanceolate	14,5	14,5	3 to 7
RedPétiole- Binoun	purple	green	lanceolate	18	16	5
Fonctionnaire (Mekonkin)	dark green	red	ovoïd	16	26	5
Bokito(green pétiol)	green purplish	red	ovoïd	15	28,2	5 to 6
Ganbada	dark green	ligth green	lancolate	11,5	10	3
Pétiole vert (Bafia)	dark green	green	ovoïd	12	16,5	3
Green pétiolbinoun	purple	green	ovoïd	9	20	7

Redpetiole (Bokito)	dark green	riddish- green	ovoïd	17,5	21,5	5
Damouna GRP / B8	green purplish	red	ovoïd	17	25	7
Tymère- kournou / F1	dark green	red	lanceolate	19,5	27	7
Ntani-Koumou/ F1	green	ligth green	lanceolate	16,5	17	3
Ntolo 1er - 20	dark green	green	ovoïd	13	11	3
Yoyolo-Ovangoull /F5	green purplish	red	lanceolate	22,5	34	7
Akourou- Ovangoul	dark green	red	lanceolate	14	15,5	5
Noumpé Mal (Garoua) Yakol/F12	dark green	red	ovoïd	13	15	4 to 5
Aoa-koumou	green purplish	red	lanceolate	14,5	14,5	3
Saa 1er /15	green purplish	green	ovoïd	23	30	5
Mekinda 1er – 14	dark green	riddish-green	ovoïd	17	19,5	5
Manioc Bassa 1er / 9	green purplish	red	ovoïd	14	14	3
AyabBisoa	dark green	red	landeolate	20,5	32	5 to 7
Campo Mvaa	dark green	red	lanceolate	18,5	32	6
Ntolbiko 1er / 6	green purplish	green	ovoïd	16,5	19,5	6
AkourouOvangou	dark green	ligth green	ovoïd	11,5	12	4
EnoumaObokoé	green-purplish	red	lanceolate	17	21	5
MegnongNkolo- Sanaga	green purplish	red	lanceolate	19	23	6
Ntem I- Okoukouda	dark green	green	ovoïd	16,5	23,5	6
Ekwémé 1er -1	dark green	red	lanceolate	17	22,1	5
CampoNkol-Ossam F18	dark green	green	lanceolate	12,5	10,2	3
Mbam 1er – 21	dark green	green	lanceolate	12,5	20,5	5
Ekékam I	dark green	green	ovoïd	14	20,5	6
Ekékam II	dark green	green	ovoïd	10,2	9,5	5
Manioc Bassa	dark green	ligth green	lancolate	16,2	14	6
OwonaEkani	dark green	red	ovoïd	10	16	5
Mbida et Mbani	dark green	red	ovoïd	16	23	5 to 6
Manioc jaune	dark green	ligth green	ovoïd	13,5	17	5
Man Mbong (P.M.N. N)	dark green	green	lanceolate	18,5	20	5
NnomEwondo	green purplish	red	lanceolate	12	16,5	5
Makoumba I	dark green	red	lanceolate	19,5	28,5	5
Ziéyabomedzé/ 001/ NN	dark green	red	lanceolate	23,2	36,5	6
Bitourou M. K. 1	green purplish	dark red	lanceolate	25,8	43	5 to 6
Minbourou (BGL)	dark green	dark red	ovoid	15	15	6
Ntangna-Pétiol rouge (OM)	green purplish	red	lanceolate	14,6	21	5
Makoumba II(S P) Mefomo	green purplish	riddish-green	lanceolate	18,5	14,5	3
Alotbikon (N.O)	dark green	green	lanceolate	13	7	3
AfoboNkozoa	green purplish	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	Lobeheigth (cm	pétiole heigth (cm)	Lobenumber
92 /0326	green purplish	red	ovoïd	16	23	5
0110	green purplish	ligth green	ovoïd	14	12	3
	green	green	lanceolate	16,2	19,5	3

8034						
8061	dark green	green	lanceolate	13,5	16	5
8017	green purplish	green	lanceolate	14,1	18	3
Excel	green purplish	red	ovoïd	13	15,5	3
champion	green purplish	green	ovoïd	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 fromNjombé

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

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

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

Criteria / Varieties	leafcolor	petiolecolor	leafcolor	lobe heigth (cm)	petioleheigth (cm)	lobe number	height (m)
Manioc blanc	dark green	green	lanceolate	15,5	18,5	6 à 7	2,65
Jaune d'or	dark green	green	ovoïd	16	15	4 à 5	1,96
Manioc rouge 2	dark green	green	ovoïd	13,5	16	5 à 6	2,4
Manioc rouge	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 ovoid, 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	lobe heigth (cm)	petioleheigth (cm)	Lobe number	ramification	heigth (m)

varieties								
IITA 1	dark green	green	ovoïd	17	24,5	7	3	2,12
IITA 2	dark green	darkred	ovoïd	20	28,5	7	2	1,87
IITA 3	dark green	green	lancolate	16	19,5	5	2	1,97
IITA 4	dark green	riddish-green	ovoïd	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	petioleheigth (cm)	lobe heigth (cm)	Lobe number
Mambo	dark green	red	lanceolate	24	21	7
Wowo	dark green	darkred	ovoïde lancéolée	21	14	7
Mbufung	green	red	lanceolateovoid	36	17.5	7 to 9
Agric white	dark green	green	ovoïd	19	16.5	7
Anyekweck	purplish-green	darkred	ovoïde	23.5	15.5	7
Agric white (kembong)	dark green	riddish-green	lanceolate	23	17	7
Local red	green-purplish	greenish-red	ovoïd	22	19	7
Eyumojock	green	light red	Cylindricalovoid	36	20.5	6 to 7
96-14-14	Purplish-green	darkred	ovoïd	32	16	7 to 8
Agricred	dark green	light green	lancolate	35	21	7
Strongcanda	light green	greenish-red	lanceolateovoid	39	17	6 to 7
Ntenako	dark green	green	lanceolate	40	21.5	9
Canopy	green	light-green	lanceolateovoid	34	18	7
Nkonéhapi	green	red	lanceolateovoid	30	16.5	7 to 9
Black stem	green-purplish	darkred	lanceolate	47	23	8 to 9
Local white	black green	greenish-red	lanceolateovoid	48	20	8 to 9
Yaoundé Red	light green	darkred	lanceolateovoid	44	19	8 to 9
White stem	dark green	green	ovoïd	33	16.5	8
Local white (Batoké)	black green	riddish-green	ovoïd	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

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
Leafcolor			
dark green	43	43	06
purpilsh	11	0	0

purplish-green	32	19	04
light green	0	28	02
black-green	0	0	03
Lobe form			
Lanceolate	46	39	05
Ovoïd	39	51	06
Cylindrical	1	0	0
Ovoïdcylindrical	0	0	1
Ovoïdlanceolate	0	0	07
Lobe number			
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
Petiolecolor			
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).

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 %

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

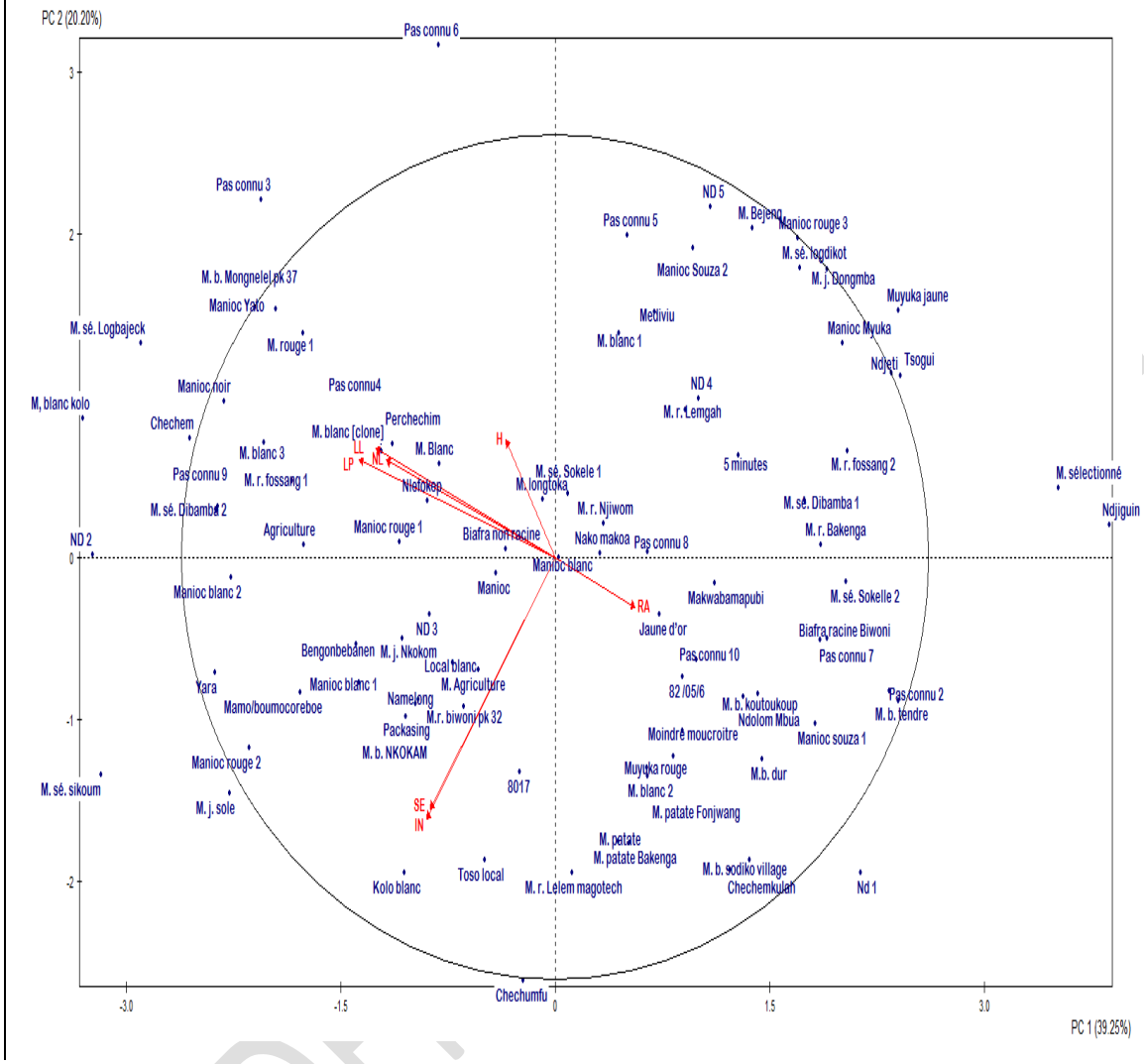
varieties	**severity**	**incidence**
Manioc blanc	46,13 ± 8,09 abcd	55,33 ± 13,61 abcdef
Manioc souza	25,00 ± 7,00 bcdefg	51,55 ± 15,87abcdef
yara	33,06 ± 15,62 abcdefg	63,68 ± 24,21 abcde
Mamo/boumou	49,11 ± 12,54 abc	61,00 ± 21,28 abbcdef
Manioc blanc kolo	30,90 ± 4,74 abcdefg	58,08 ± 19,18 abcdef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

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

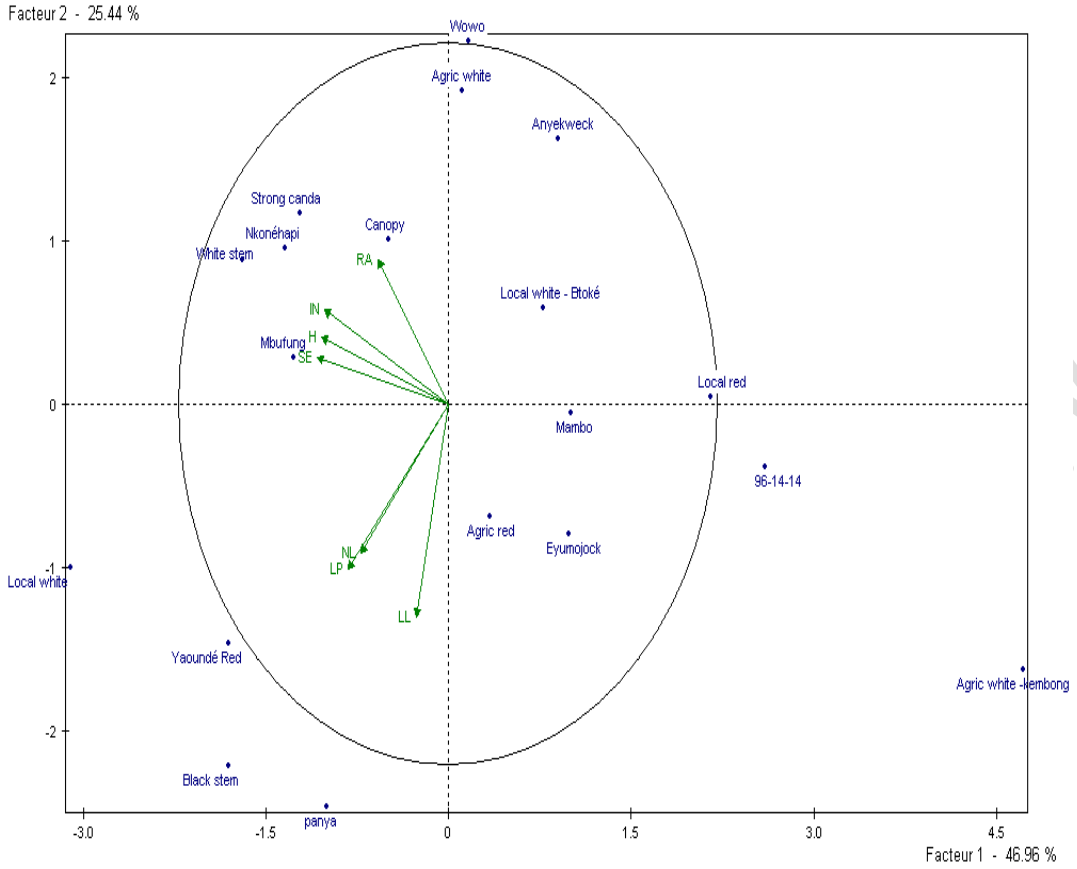
Table 9. Incidence and severity of cassava mosaic in Ekona (South West Region)

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

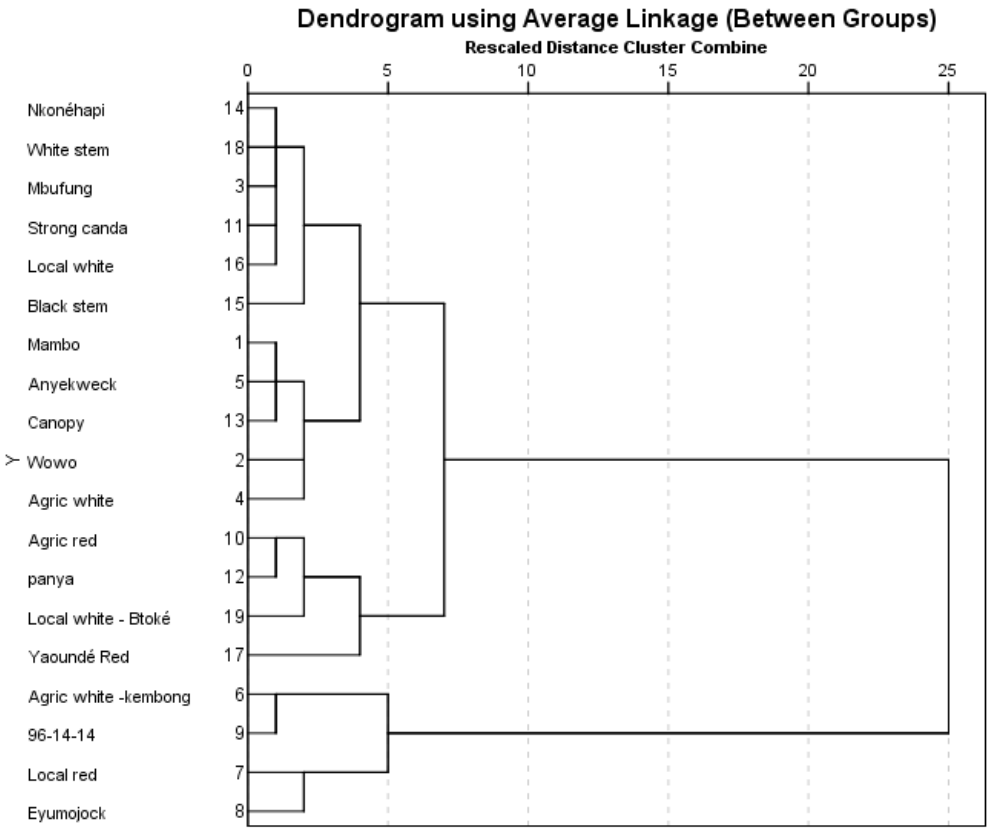


LL = lobe length; LP = petiole length; NL = number of lobes; SE = severity; IN = incidence; RA = branching; H = height.

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



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

3.7Incidence 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 ± 25.70); pétiole rouge yambassa (60.33 ± 28.83); Mintourou-Mvaa (63.93 ± 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±0.20); Petiole rouge Bafia (12.00 ± 8.18) (Table 10).

Table 10.Incidence and severity of mosaic according to varieties

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

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

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

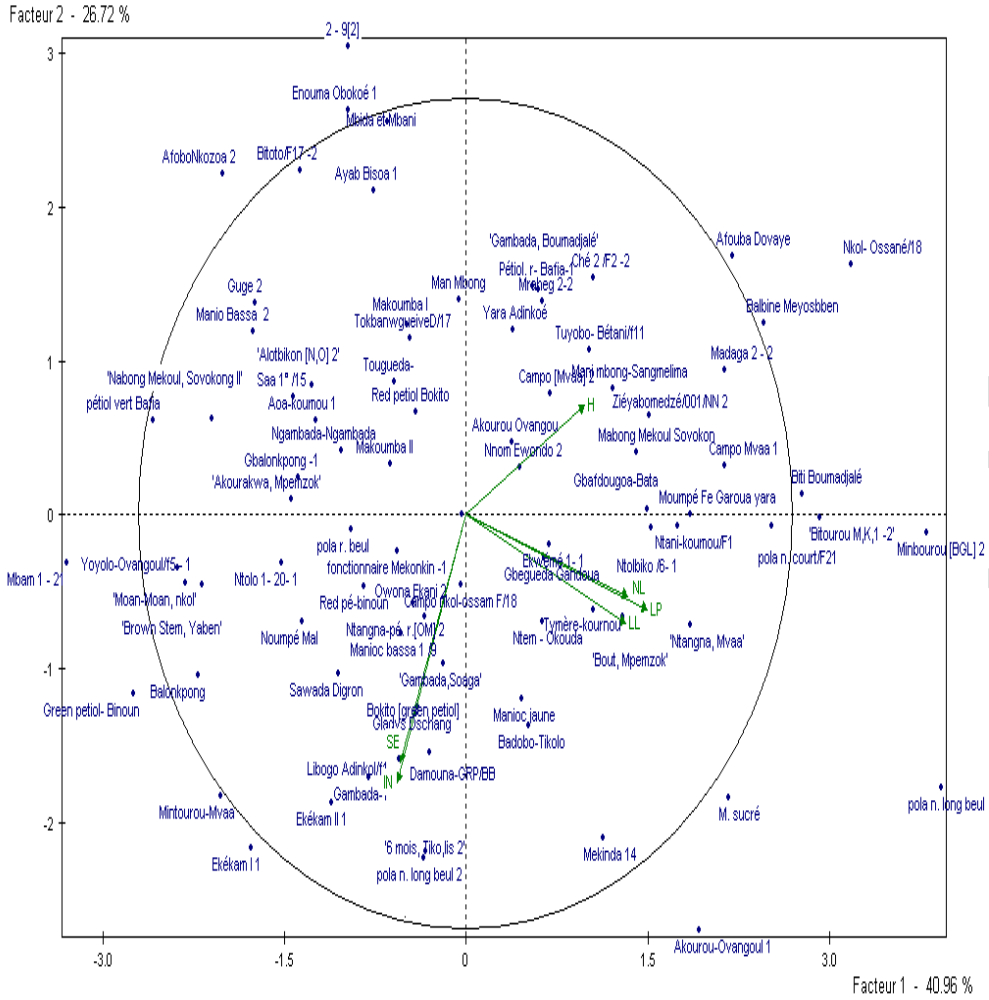


Image 3 Distribution of variables on the first two PCA axes

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

Campo Mvaa(1)	1	Stronglycorrelated
Ntolbiko/6(1)	0,9	Stronglycorrelated
AkouraOvangou	0,7	Weaklycorrelated
EnoumaObokoé (1)	0,7	Weaklycorrelated
MegnongNkols	0,8	Stronglycorrelated
Ntem-okouda (1)	0,8	Stronglycorrelated
Ekwémé 1-1(1)	0,8	Stronglycorrelated
Camponkol-ossam F/18(1)	0,9	Stronglycorrelated
Mbam 1-21 (1)	1	Stronglycorrelated
Ekékam I (1)	0,9	Stronglycorrelated
Ekékam II (1)	0,8	Stronglycorrelated
Manioc Bassa (2)	0,7	Weaklycorrelated
Mbida et Mbani	0,9	Stronglycorrelated
OwonaEkani (2)	/	
Manioc jaune	0,9	Stronglycorrelated
Man Mbong	0,9	Stronglycorrelated
EnomEwondo (2)	0,9	Stronglycorrelated
Makoumba I	0,5	Weaklycorrelated
Ziéyabomedzé/001/NN(2)	0,8	Stronglycorrelated
Bitourou M,k,1(2)	0,8	Stronglycorrelated
Mimbourou (BGL) (2)	0,8	Stronglycorrelated
Ntangna-petiol rouge (0M) (2)	0,8	Stronglycorrelated
Makoumba II	0,9	Stronglycorrelated
Alotbikon (N, 0) (2)	0,9	Stronglycorrelated
Afobonkozoa (2)	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
Mambo	0,5	Weaklycorrelated
Wowo	0,8	Stronglycorrelated
Mbufung	0,5	Weaklycorrelated
Agric white	0,5	Weaklycorrelated
Anyekweck	0,9	Stronglycorrelated
Agric white (kembong)	1	Stronglycorrelated
Local red	0,8	Stronglycorrelated
Eyumojock	0,3	No correlated
96-14-14	1	Stronglycorrelated
Agricred	0,7	Weaklycorrelated
Strongcanda	1	Stonglycorrelated
Panya	1	Stronglycorrelated
Canopy	0,9	Stronglycorrelated
Nkonéhapi	0,9	Stronglycorrelated
Black stem	0,5	Weaklycorrelated
Loacalwhite	0,4	No correlated
Yaoundéred	0,5	Weaklycorrelated
White stem	1	Stronglycorrelated

Local white (Btoké)	0,5	Weaklycorrelated

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 sélectionnédibamba (r = 0.5). No correlation was obtained for certain varieties such as Makwa bamapubi (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
Manioc blanc	0,8	Stronglycorrelated
Mediviu	0,8	Stronglycorrelated
Pas connu 9	0,5	Stronglycorrelated
Manioc blanc 1	1	Stronglycorrelated
Manioc rouge	1	Stronglycorrelated
Pas connu 10	0,5	Weaklrycorrelated
Manioc rouge 1	1	Stronglycorrelated
Packasing	0,5	Weaklycorrelated
Chechem	0,5	Weaklycorrelated
Manioc souza	0,5	Weaklycorrelated
Yara	1	Stronglycorrelated
Mano/boumocoreboe	1	Stronglycorrelated
Manioc blanc kolo	1	Stronglycorrelated
Biafra non racine	0,8	Stronglycorrelated
Manioc longtoka	0,8	Stronglycorrelated
Manioc blanc koutoukoup	0,5	Weaklycorrelated
Manioc rouge Fossang	0,5	Weaklycorrelated
Manioc blanc tendre	0,5	Weaklycorrelated
Moindre moucroitre	0,5	Weaklycorrelated
Makwabamapubi	0	No correlated
Agriculture	0,5	Weaklrcorrelated
Chechumfu	1	Stronglycorrelated
Manioc blanc sodiko village	1	Stronglycorrelated
Toso local	1	Stronglycorrelated
5 minutes	0,2	No correlated
Tsogui	0,9	Stronglycorrelated
Ndjeti	1	Stronglycorrelated
Ndjiguin	0,9	Stronglycorrelated
Manioc sélectionné	0,8	Stronglycorrelated
Manioc sélectionné logdikot	0,4	No correlated
Manioc sélectionné sokélé	0,5	Weaklycorrelated
Manioc rouge biwoni pk 32	0,9	Stronglycorrelated
ND	1	Stronglycorrelated
Kolo blanc	1	Stronglycorrelated
Manioc rouge lelemmagotech	0,5	Weaklycorrelated

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

4.Discussion

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, 8061and 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 similarwork.

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.

Reference

1. FAO: Food security in the world. Rome: FAO, (2006).

2. Hacqueman, Jocelyne. World hunger and agricultural and food policies: assessment and perspectives. NOR. p.35. (2008).

3. Bakayoko, S., et al., Yield of fresh tubers and dry matter contents of seventy new varieties of cassava (Manihot esculenta Crantz) grown in the center of the Ivory Coast. Journal of Animal and Plant Sciences. 2012, vol. 14.2, pp. 1961-1977, (2012).

4. Diancoumba, Doulaye. Updated diagnosis of the cassava sector for a value chain analysis (CVA). PDA. S. L.: PDA, 25 p. (2008).

5. Manusset, S., 2006. Proposal for a key to identifying cassava varieties among different cultural groups in French Guiana. Antropo, 11, 61-73. www.didac.ehu.es/antropo.

6. Zinga I., Nguimalet C.R., Lakouetene D.P., Konate G., Kosh Komba E. and Semballa S. 2008. The effects of the African cassava mosaic in the Central African Republic. Geo-Trop,2008, 32:47-60.

7. Chumakov A.E., Zaharova I.I., 1990. Influence and statistics of disease development. In: Disease damage to agricultural crops. Agroprome Edition, Moscow. Pp5-60.

8. Nweke F.I., Dixon A.G.O., Samedidu., Folayan S.A. 1994: Cassava varietal needs of farmers and the potential for production Growth in Africa-Collarative study of cassava in Africa (working paper No 10).

9. Emperaire L., Gilda S. M., Fleury M., Robert T., Mckey D., Pujol B. Comparative approach to the genetic diversity and morphological diversity of cassavas in the Amazon (Brazil and the Guianas). Proceedings of the BRG 4: 247-267, (2003).

10. Asare P.A., Galyuon I.K.A., Sarfo J.K. and Tattech J.P, 2011. Morphological and molecular Based diversity studies of some cassava (manihot esculenta Crantz).Germplasm in Ghana. African Journal of Biotechnology,10,13900-239htt:/dx.doi.org/10.5897/AJB11.929

11. Agre A.P., Dansi A., Rabbi I.Y., Battachargee R., Dansi M., Melaku G., Augusto B., Sanni A., Akouegninou A. and Akpagana K., 2015. AgromorphologicalCharactezation of Elite cassava cultivars collected in Benin. International Journal of current research Biosciences and Plant Biology, 2.1-14.

12. Aremu C.O. Adebayo, M.A., Ariyo O.J. and Adewade B.B. Classification of genetic diversity and choice of parents for hybridization in cowpea Vigna unguiculta (L) Walp for humid savanna ecology. African J. of Biotech.; 6 (20): 2333-2339. (2007).

13. Howeler, R.H., Oates C.G., Allem A.C. Strategic Environmental Assessment: An Assessment of the impact of Cassava Production and Processing on the Environment and Biodiversity. The Global Cassava Development Strategy Validation Forum, April 26 -28, (2000).

14. Ambang Z., Akoa A., Bekolo, J. Nantia, Lti. Nyobe., Ongono Y.S.B., Tolerance of some cassava cultivars (Manihot esculenta Crantz) and the wild species (Manihot glaziovii) to African viral mosaic and cassava Sigatoka. Tropicultura.25(3): 140-145, (2007)
15. Seal S. E., vanden Bosch F., Jeger M. J., Factors Influencing Begomovirus Evolution and Their Increasing Global Significance: Implications for Sustainable Control. Critical Reviews in Plant Sciences 25: 23 - 46, (2006).