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Characterization of Some Traditional Cowpea Varieties Grown by Farmers in the Soudano-Sahelian Zone of Cameroon

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Abstract Cowpea (Vigna unguiculata L. Walp.) is a legume crop grown in the semi-arid regions of Africa. Some farmer's local varieties possess stable traits that could be selected for breeding, but there is lack of information. Eighteen cowpea genotypes from farmer's field were planted in a randomized complete block design with four replications at the experimental farm of the Regional Agricultural Research Centre of Maroua in 2011 for agro-morphological characterization. The data collected were subjected to multivariate analysis using XLSAT2013 and correlations were performed on SAS (Statistical Analysis System) version 9.3. The results revealed that the genotypes were predominantly spreading habit with rough and white seeds. Despite the variability of the genotypes, the results also indicated that they form five distinctive groups in the base of discriminant descriptors. Regarding the interrelationship between the descriptors, the leaf area ($r = -0.58$), days to 50% ($r = -0.79$), days to 95% maturity ($r = -0.77$) and thrips damages ($r = -0.66$) showed a significant negative correlation to the grain yield indicating the need for advising early cowpea maturing varieties where the rainfall cycle is short. In addition, late maturing genotypes are more subject to thrips damages. A significant positive correlation was revealed between the number of the grain per pod and the grain yield ($r = 0.62$), suggesting that this descriptor is the most important yield component for cowpea. Molecular investigation could provide additional information on the genetic basis of these genotypes.

Keywords Genotypes, Agro-morphology, Assessment, Descriptors

1. Introduction

Cowpea (*Vigna unguiculata* Walp) is one of the most legumes widely grown and consumed in the tropical region of Africa ([1],[2]). The dry Savannah regions of the West and Central Africa are the privileged geographic area of cowpea production where more than 80% of farmers are involved in the cultivation[3]. Cowpea production ofCa me r oon is annually estimated at 152 000 tones[4] where more than 80% of it is from the soudano-sahelian region of the northern part of the country[5]. Along with cereals such as sorghum and maize, this crop constitutes the main diet for the local population[6]. Its grain and leaves are rich sources of high-quality protein[7], which provides an excellent supplement to the lower quality cereal or root and tuber protein consumed in much of this region ([8],[9]). Moreover to its role as food, cowpea has become a commercial crop for poor farmers and its fodders are very important for animal feeding[7]. However, cowpea yield is limited by several constraints, some are biotic such as insects, diseases and pest weeds peculiarly *Striga gesneroides* while others are abiotic as erratic rainfall, soil salinity and heat. At the farmer's level, different varieties with a broad genetic back ground are being grown. Many of them possess interesting traits for which genes could be exploited by breeders to integrate in cowpea improvement program. Furthermore, they are well adapted to the local farming system and are able to produce stable yield[10] in the fragile agro - ecologi cal zone of the North Cameroon. Unfortunately, until now few studies have been conducted to provide information on these local promising varieties despite its importance as a key factor for their selection[11]. Thus the objective of this study was to characterize and evaluate the agronomic perfor mance of some local cowpea varieties under the agro - climatic conditions of the North Cameroon. This would provide information that would serve for their selection according to the importance of the traits they may carry to assist the national cowpea breeding program.

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2. Material and Methods

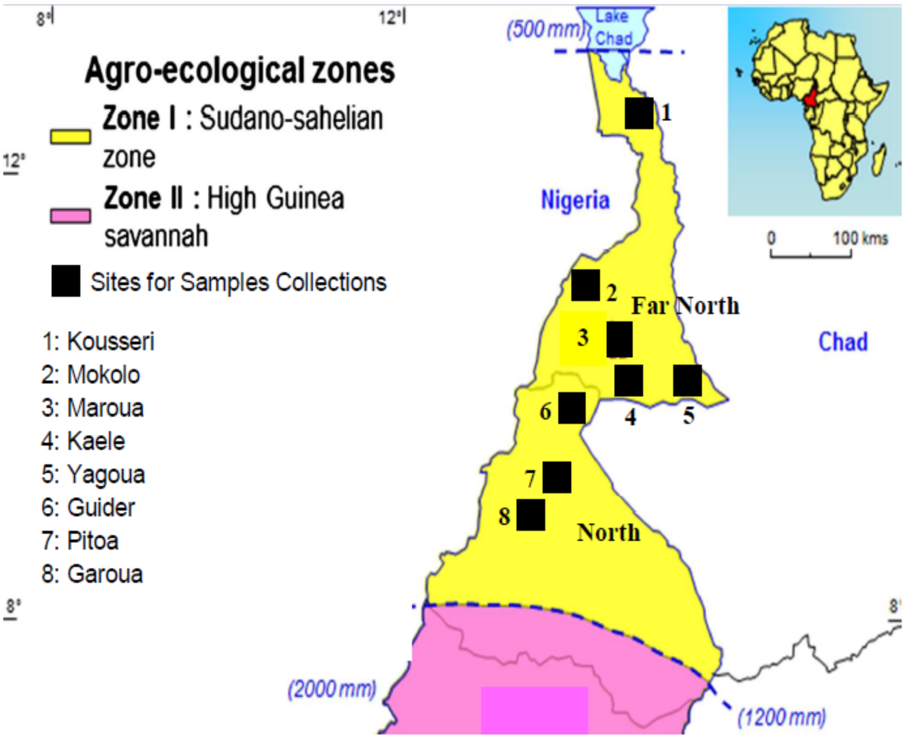

Figure 1. Position of the sites where the cowpea samples were collected

2.1. Experimental Site

The experiment was conducted in 2011 at the experimental farm of the Regional Agricultural Research Centre of Maroua located at Guiring, 7 Km in the north of Maroua, the capital of the far north region of Cameroon. Guiring is located at 900 m altitude (10º 00' to 12º 30'N; 13º 30' to 15 30'E). The soil is mostly sandy-clay[12]. The climate is tropical soudano-sahelian characterized by two annual seasons: a short raining season from 4 months from June to September and 8 months of dry season coverin g October to May. The cumulative annual rainfall is between 800 and 1,000 mm. The temperature varies around 35ºC with a maximum of 40ºC during the month of April[13].

2.2. Biological Material

Thirty varieties were collected from seven most cultivated cowpea areas in the North and the Far North region corresponding to the Soudano-Sahelian zone of Cameroon. Based on the similarities observed in the form, color, size and texture of the grain, the number was reduced to eighteen genotypes as follow: Kousseri (01); Mokolo (01); Maroua (05); Kaele (06) and Yagoua (01) in the far north; and Guider (01); Pitoa (01) and Garoua (01) in the North region (Figure 1 and Table 1).

2.3. Experimental Design

The experiment was conducted, during the raining season in a randomized complete blocks design (RCBD) with four replications where each experimental unit was consisted of a rectangular plot (2.4 m x 5.0 m) of 12 m^2. Cowpea seeds were sow in four lines of 5 m per plot providing 0.20 m between hole in the same line and 0.80 m between lines. Two cowpea seed were sow per hole at a depth of 0.03 m to 0.04 m during the month of August. Plugging was carried out two weeks before planting. Weeding was performed manually when necessary. Delta-methrin was spray three times at the rate of 1l.ha^{-1} to control insects at the budding, flowering and podding stages.

Table 1. List of Traditional Cowpea Genotypes tested

N°	Genotypes	Origins	Regions
1	*Fali*	Garoua	North
2	*Leré*	Guider	North
3	*Blackeye*	Guider	North
4	*Pitoa*	Pitoa	North
5	*Lara*	Kaele	Far North
6	*Vya*	Kaele	Far North
7	*Soufou*	Kaele	Far North
8	*Mendéo*	Kaele	Far North
9	*Mozongo*	Kaele	Far North
10	*Bou*	Kaele	Far North
11	*Kousseri*	Kousseri	Far North
12	*Samira*	Maroua	Far North
13	*Bokolo*	Maroua	Far North
14	*Haddiyan*	Maroua	Far North
15	*Halagaré*	Maroua	Far North
16	*Salak*	Maroua	Far North
17	*Ahel*	Mokolo	Far North
18	*Guéra*	Yagoua	Far North

2.4. Data Collection

The following data were collected from the plants in the two middle rows of each plot. (i) In the filed level: counting of the number of plant emerged, number of plant harvested, days to 50% flowering, days to 95% maturity, leaf area, the stem colour and the growth habit. From natural field infestation, pest weeds and insects damages were assessed respectively by counting the number of striga per plot at 9 weeks after sowing (WAS) and the use of a visual scoring scale of 1.0 to 5.0 for aphids (*Aphis craccivora*) and thrips (*Megalurothrips sjostedti*) as applied in Jackai and singh[14]. Aphids damages included the curling of leaves, number of aphid colonies seen, presence of sooty mould and cast skins, growth retardation and dead plants. The scoring was done at 2, 4 and 6 weeds after sowing. 1.0 = (0%) resistant; 1.1-1.5 = (1-25%) moderately resistant; 1.6-3.5= (26-50%) moderately susceptible; 3.6- 5.0= (51-100%) very susceptible. Damages from thrips were scored at the critical developmental stages budding (35 DAS), at 50% flowering (55 DAS) and podding stage (70 DAS). Scoring included the brown discoloration and dryness of stipule, leaves or buds and the elongation of peduncles. Genotypes with scores of; 1.0 = (0%) resistant; 1.1-1.5 = (1-25%) moderately resistant; 1.6-3.5= (26-50%) moderately susceptible; 3.6-5.0= (51-100%) very susceptible. (ii) At the lab unit of Maroua research centre, 10 pods were randomly selected per plot and the lengths were measured using a ruler. Then the pods were hand threshed to remove the seeds. The seeds were counted from 10 pods and the mean per pod was determined. After that, seed colour and texture were determined visually. Finally pods and seeds were weighed for each individual plot and the obtained weight was used for yield calculation:

Y= (W/PA)*10 000

Y= Pod or Grain yield (Kg/ha)

W = Pod or Grain weight (Kg)

PA = Plot Area (m^2)

2.5. Data Analysis

Hierarchical cluster analysis of genotypes was made to the component principal component analysis using XLSTAT20 13 based on the means of the agro-physiological parameters and computation of Pearson Correlation was performed by Statistical Analysis System (SAS) version 9.3 to establish interrelationships among the descriptors.

3. Results

3.1. Morphologic Characters of the Cowpea Genotypes

Based on their morphology divers cowpea genotypes have been observed among the farmers cultivated varieties. They can be easily grouped into 3 distinctive groups according to their growth habit: erect, semi-erect and spreading. Moreover, it has been observed that half of the cowpea varieties cultivated by farmers are spreading (50%). In addition it was observed that genotypes can be ranged into 3 groups depending on the color of their stem: light-green (50%), purple (33.3%) and green (16.6%). Nevertheless the genotypes tested didn't appear to be different in term of seeds color and texture regardless of location of origin. They were overall white (94.4%) and rough (100%) with only one exception from the location of Kousseri where the variety collected (Kousseri) has shown red seeds (Table 2).

Table 2. Characterization of Different Genotypes According to their Growth Habit, Stem Colour, Seed Colour and Seed Texture

N°	Genotypes	Growth Habit	Stem Colour	Seed Colour	Seed Texture
1	Bokolo	Erect	Green	White	Rough
2	Mendéo	Erect	purple	White	Rough
3	Mozongo	Erect	purple	White	Rough
4	Samari	Semi-erect	Light green	White	Rough
5	Haddiyan	Semi-erect	Light green	White	Rough
6	Blackeye	Semi-erect	Light green	White	Rough
7	Soufou	Semi-erect	purple	White	Rough
8	Salak	Semi-erect	purple	White	Rough
9	Vya	Semi-erect	purple	White	Rough
10	Lara	Spreading	Light green	White	Rough
11	Léré	Spreading	Light green	White	Rough
12	Kousseri	Spreading	Light green	Red	Rough
13	Guéra	Spreading	Green	White	Rough
14	Pitoa	Spreading	purple	White	Rough
15	Halagaré	Spreading	Light green	White	Rough
16	Bou	Spreading	Light green	White	Rough
17	Ahel	Spreading	Green	White	Rough
18	Fali	Spreading	Light green	White	Rough

3.2. Evaluation of Agronomic and Physiological Traits

3.2.1. Grouping of Variables

Table 3. Principal Component Analysis of the different Agro - physiological Descriptors

	Eigenvectors		
	PC1	PC2	PC3
Eigenvalue	7.725	1.301	1.013
Variability (%)	64.379	10.840	8.441
Cumulative %	64.379	75.219	83.660

The principal component analysis grouped the 12 parameters: number of plant emerged (NPEM), number of plant harvested (NPHR), leaf area of plant (LAP), days to 50% flowering (FL50), days to 95% pod maturity (MAT95), number of grain per pod (NGPD), pod length (PDL), number of striga emerged (NStriga), Thrips damages score (ThripD), Aphids damages score (AphidD), pod yield (PYD) and grain yield (GYD) into various components with the first three explaining 83.66% of the variation (Table 3).

Table 4. Eigen Vectors and Values for the three Principal Component axes

Descriptors	Eigenvectors		
	PC1	PC2	PC3
Number of Plant Emerged	0.286	0.375	0.290
Number of Plant Harvested	0.282	0.333	0.226
Leaf Area of Plant (cm^2)	0.322	0.137	-0.151
Days to 50% Flowering	0.348	-0.135	0.002
Days to 95% Pod Maturity	0.332	-0.251	-0.086
Number of Grain per Pod	-0.338	0.038	0.036
Pod Length (cm)	-0.276	-0.047	0.001
Number of Striga Emerged	0.192	0.061	0.684
Thrips Damages	0.336	-0.047	-0.176
Aphids Damages	-0.004	0.754	-0.429
Pod Yield (Kg/ha)	-0.234	0.155	0.360
Grain Yield (Kg/ha)	-0.331	0.216	0.145

Tables 3 and 4 revealed that the principal component 1 (PC1) associated with the leaf area of plant, days to 50% flowering, days to 95% pod maturity, number of grain per pod, pod length thrips damages and grain yield accounted for 64.38% of the total variation. PC2 consisting mainly of number of plant emerged, number of plant harvested and Aphids damages accounted for 10.84% of the total variation while PC3 associated with the number of striga emerged and the pod yield explained 8.44% of the total variation.

3.2.2. Grouping and Characterization of Genotypes

Based on the hierarchical cluster analysis and the cutting of the dendogram at 6.0% the results revealed that the eighteen cowpea genotypes formed five distinctive groups (Figure 2) displaying 34.39% dissimilarity within group and 65.65% between groups from optimal classification. Each of the group showed clear specifics traits for which the performances differed from those of the other groups (Table 5). Group 1 (G1) is constituted by *Halagari, Samira, Ahel* and *Fali*. These are mainly long cycle genotypes having days to 50% flowering around 75 days, days to 95% pod maturity was observed around 90 days. The genotypes of this group are also characterized by large leaves (16.28cm^2), they were found as the most susceptible to thrips damages showing a score of 4.69 and lowest pod and grain yield (1521.86 kg/ha and 136.56 kg/ha).

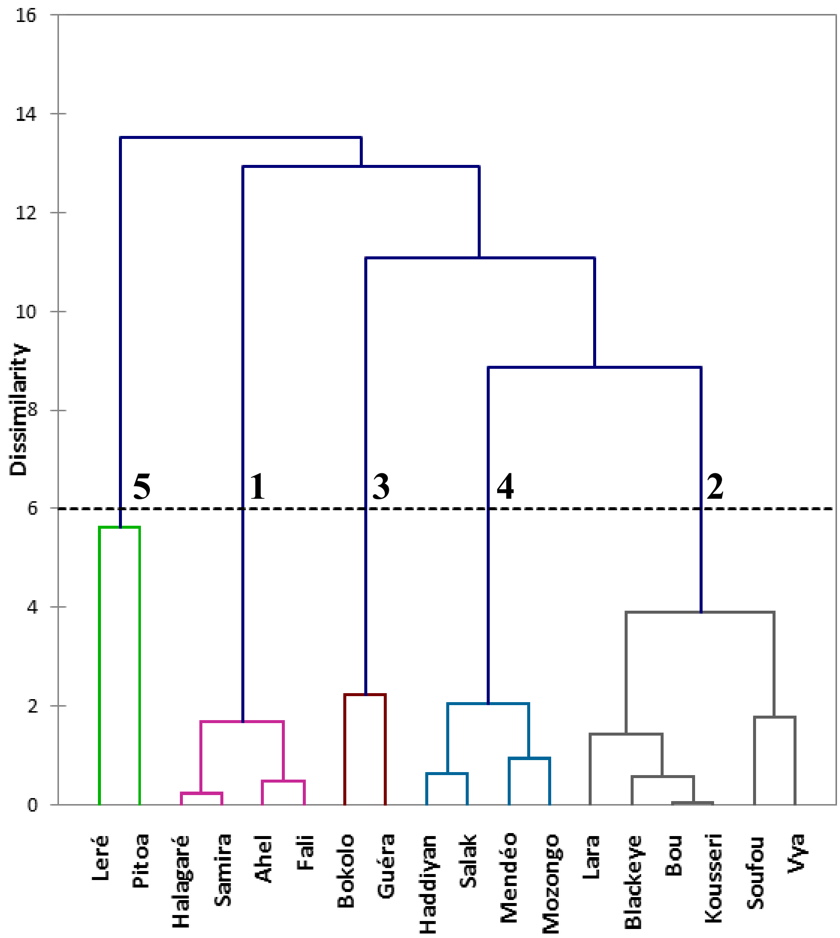

Figure 2. Hierarchical clustering of genotypes based on the agro-physiological descriptors

Table 5. Means values of the descriptors per group of genotype

Descriptors	Group of Genotypes				
	G1	G2	G3	G4	G5
NPEM	30.125	23.458	28.500	20.000	**33.500**
NPHR	27.875	21.208	26.500	18.313	**28.000**
FL50	**75.188**	51.583	48.625	46.563	58.875
MAT95	**90.250**	73.250	68.250	68.563	76.750
NGPD	4.188	9.333	8.125	**10.188**	9.125
NStriga	32.313	14.167	10.625	18.188	**59.375**
ThripsD	**4.688**	3.250	3.000	2.500	3.500
AphidsD	1.783	1.853	**2.060**	1.658	1.780
LAP (cm^2)	**16.280**	11.275	12.325	9.730	11.680
PDL (cm)	6.910	**12.738**	8.625	12.433	12.445
PYD (Kg/ha)	1521.875	2993.055	9250.000	**9585.938**	4500.000
GYD (Kg/ha)	136.563	1013.888	1330.750	**1343.750**	984.375

Bulk indicates the highest value observed for each descriptor

Table 6. Pearson Correlation Coefficients among Descriptors

	Pearson Correlation Coefficients										
	NPEM	NPHR	LAP	FL50	MAT95	NGPD	PDL	ThripsD	AphidsD	NStriga	PYD
NPHR	0.82781*	1									
LAP	0.40459	0.48748	1								
FL50	0.42294	0.5026*	0.71865*	1							
MAT95	0.31866	0.41359	0.75022*	0.91434*	1						
NGPD	-0.32947	-0.50285*	-0.59396*	-0.58121*	-0.52803*	1					
PDL	-0.16802	-0.35442	-0.27282	-0.179	-0.06206	0.74728*	1				
ThripsD	0.34314	0.31647	0.6229*	0.7211*	0.77814*	-0.51484*	-0.15142	1			
AphidsD	0.05086	0.1301	0.11395	-0.03926	-0.07823	-0.24044	-0.40873	-0.07298	1		
NStriga	0.32241	0.28052	0.28973	0.37218	0.39419	-0.10767	0.00793	0.2351	-0.00228	1	
PYD	-0.13835	-0.11897	-0.31119	-0.32505	-0.33725	0.35466	0.02022	-0.55799*	0.02041	-0.07349	1
GYD	-0.28012	-0.41593	-0.58548*	-0.79655*	-0.77755*	0.62599*	0.23366	-0.66641*	0.0314	-0.15498	0.48169

*: Significant at 0.05 level of probability; NPEM: Number of Plant Emerged; NPHR: Number of Plant Harvested; LAP: Leaf Area; FL50: Days to 50% Flowering; MAT95: Days to 95% Pod Maturity; NGPD: Number Grain per Pod; PDL: Pod Length; ThripsD: Thrips Damages; AphidsD: Aphids Damages; NRAM: Number of Ramifications; NStriga: Number of Striga; PYD: Pod Yield; GYD: Grain Yield

Group 2 (G2) is composed of *Lara, Blackeye, Bou* and *Kousseri*. According to the results, these genotypes are mostly characterised by their long pods (12.74cm). The grain yield was observed around 1013.88 kg/ha. In group 3 (G3) made up of *Bokolo* and *Guera*, the study indicated that they were the most susceptible to the devastative effect of the cowpea pest insect, *Aphis craccivora* leading to a score value of 2.06. However, despite their susceptibility to the impact of this insect, the grain yield (1330.75 kg/ha) was close to the highest performance observed for all the groups. They also exhibited short growth cycle revealed by about 48 days after sowing for 50% flowering and a mean value of 68 days after sowing for days to 95% pod maturity. Group 4 (G4) was noted as the one constituted with members that produce high pod and grain yield (9585.94kg/ha and 1343.75kg/ha) and high number of grain per pod (10). Furthermore, it was found that they were basically early maturing varieties such *Haddiyam, Salak, Mendeo* and *Mozongo* which showed days to 50% flowering of 46 days after sowing and attained 95% pod maturity 68 days after sowing. According to the findings of this experiment, these varieties displayed poor germination rate, the number of plant emerged (20 plants) and the number of plant harvested (18 plants) were low compared to the result recorded from in the other group. The last group 5 (G5) is formed by two cowpea varieties *Léré* and *Pitoa* which showed high values regarding the number of plant emerged (33.5) and the number of plant harvested (28.00). These two varieties were found to be highly susceptible and they allowed high rate germination of the parasitic pest weed of cowpea, *Striga gesneroides*. A mean value of 59 striga plants was recorded during their growing cycle of their representing the highest value observed from this parameter.

3.2.3. Analysis of Interrelationship among the Descriptors

From the results obtained in table 6, it was observed that grain yield was significantly correlated to some physiologic al parameters such the leaf area (r = -0.58), days to 50% flowering (r = -0.79), days to 95% pod maturity (r = -0.77) and to a yield component illustrated by the number of grain per pod. In the same way, additional correlations were found between the grain yield and both the pod length and the pod yield where coefficients of correlation were r = 0.23 and r = 0.48 respectively. Further observations of the same table has shown that strong negative correlation (r = -0.66) was found between the damages caused by Thrips on cowpea plants and the potential final grain yield. The same figure was noted also in the case of *Striga gesneroides* which affected negatively both the pod and the grain yield. It has been also noted that the effect of Thrips attack was significantly correlated to three physiological traits of the plant such as the leaf area (r = 0.62), the days to 50% flowering (r = 0.72) and 95% maturity (r = 0.77) indicating that the impact of this insect is more severe when the variety have long growth cycle. The latter two parameters were found to be correlated to the first one which is the leaf area with r = 0.71 and r = 0.75 respectively. In the other hand, positive correlation was observed between the pod length and the number of grain per plant.

4. Discussion

According to the International Board for Plant Genetic Resources[15] descriptors, there are seven main growth habits in cowpea. From the study conducted on eighteen farmers local genotypes, three of these habits were identified. Most of them were spreading, other were semi-spreading type while the latter group with few genotypes have erect habit. These results are consistent with the findings of[16]. The small group number identified compared to the existing number of groups habit described by[15] could be explained by the fact that the sample size of this study is largely smaller than the one used by[15] which is made of various cowpea genotypes from the world. The stem colour of the cowpea collected was variables corroborating with the work conducted by[17]. It varies from green to purple and with a predominant colour of light green similar to the results obtained by[18]. With regard to seed, only two colours were found red and white with most of them being white. Although cowpea presents generally various seeds colour, only two of them where revealed in the case of the present study. This could means that farmers of the north Cameroon mostly preferred white and red cowpea. However, it should be noted that cowpea varieties with red are only grown in Kousseri specifically in the Lake Chad zone during the off season. The seed texture was globally rough deviating from the results of the experiment conducted by[19] where in addition, smooth cowpea seed group was mentioned. This could still depend on the preference of any farmer community. From the principal component analysis, PC1 associated with the leaf area of plant, days to 50% flowering, days to 95% pod maturity, number of grain per pod, pod length, thrips damages and grain yield accounted for 64.38% of the total variation. This mains that, the listed descriptors are the most effective characters for distinguishing among the eighteen traditional cowpea varieties sampled and PC1 is one of the most important features in the selection of these characters. Thus it could be a useful tool to help breeder for selection. However,[20] observed that onset of flowering in local cowpea may be ascribed to the photoperiod control which also depend on the latitude, the origin of the germplasm and the variation in day and night temperatures. In addition to PC1, PC2 and PC3 contributed for 10.84% and 8.44% respectively to the total variation of 83.66% reflecting large differences among the genotypes. Despite the diversity observed, the application of hierarchical clustering analysis based on the principal component analysed showed the eighteen genotypes form five discriminant groups. Each of the group has its peculiar characters that could be used for the description of the group. Group 1 (G1) was formed by late maturing varieties which have difficulty to complete their cycle properly because of the short length of the raining season in semi-arid zone of Cameroun where the rainfall is also erratic. They spent more energy in the vegetative growth such as development of large leaves in disadvantage of pod and grain production leading to low yield as observed in this study. The vegetative development is also in the benefit of pest insect such thrips which is one of the most economical damageable pests of cowpea. Except one genotype, all the varieties of the group are from the same region of the far north. Group 2 (G2) possess long pod length as an exclusive character, resulting in good pod and grain production. Pod length is one the most important yield components. Groups 3 (G3) and 4 (G4) are both constituted mainly with early maturing varieties. However the genotypes of G3 are susceptible to insects attack specially Aphids. Nevertheless it seemed to have less impact on the final yield as the result of the earliness of the genotypes to rapidly complete their cycle. Genotypes of G4 are higher yielding varieties resulting from the potential they have to produce large number of grains per pod and the shortness of their growth cycle. This is consistent with findings from which highlighted that good seed yields require varieties with short flowering periods to enable them divert energy into pod and seed development[21]. Furthermore it is stated that, the earlier a variety sets flowers, the earlier it matured[22]. In addition early maturity is recognised as a relatively important agronomic characteristic in plant breeding program[23]. Despite de good number per plant at the germination and harvesting period observed within the genotypes in groups, their grain yield was low. This could be explained mainly by their affinity to allow high rate germination *Striga gesneriodes*, which is a parasitic weed pest that takes nutrients directly from the plants. Base on the interrelationship among the descriptors, the number of plant emerged was highly correlated to the number of plant at harvesting meaning that the more vigour is the seed the more likely the resulted plant will complete its growth cycle withstanding both the abiotic and the biotic factors. As pointed earlier, early flowering genotypes are early maturing, this is illustrated by the higher coefficient of correlation (r = 0.91) similar to the findings of[17] who concluded that, days to flowering has an influence on days to maturity. However there were negative significant correlation among these descriptors and the grain yield. This confirms the statements of[24] and[25] that genotypes which flowered early produce d many pods and such genotypes maximize the favourable day length to initiate flowering and fruiting. Furthermore this observation suggests that the plants which take more time on vegetative stage have fewer yields in semi-arid conditions of production[26]. Also, Thrips damages were negatively and highly correlated to the grain yield logically implies that the more susceptible to thrips damages the less is the yield of the genotype. In the same way, genotypes with large leaves area put less energy in grain production revealed by the negative and significant coefficient of correlation (r = - 0.58).

5. Conclusions

The characterization and assessment of the eighteen genotypes has provided phenotypic information on the farmer traditional cowpea varieties. The study revealed that the majority of the genotypes cultivated by farmers have spreading habit and they are predominantly white and rough seeds. Despite their various diversity and origin, they can be classified into five main groups based on some agro - physiological descriptors. The leaf area of plant, days to 50% flowering, days to 95% pod maturity, number of grain per pod, pod length thrips damages and grain yield are the most discriminant factors that could be used for the selection of these farmer's traditional varieties. Further investigation establishing the molecular basis of these groups could provide useful information on these genotypes.

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