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Agro-morphological Assessment of Local Cultivars of Nightshade (*Solanum macrocarpon* L.) in Benin

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Authors' contributions

This work was carried out in collaboration between all authors. Author MS designed the study, managed the field experiments, performed the statistical analysis and wrote the first draft of the manuscript. Author LEA managed the literature review, wrote the protocol and wrote the first draft of the manuscript. Authors VE and FQ managed the analyses of the study and participated in writing the first draft of the manuscript. Author MA managed the literature searches and participated in data analysis. All authors read and approved the final manuscript.

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ABSTRACT

Solanum macrocarpon (L.) commonly known as "Gboma" is a leafy vegetable widely eaten in several countries of West Africa and South America. Despite the importance of gboma in Africa, this plant is still neglected and underutilized. An understanding of the diversity and characteristics of the existing local cultivars would help value this vegetable crop. The present study aims to characterize local cultivars of *S. macrocarpon*. Therefore, 51 local cultivars of *S. macrocarpon* collected from 24 communes of Benin were grown in a randomized alpha lattice design with five (5) incomplete blocks and three (3) replications. Data were collected on 23 variables including 14 quantitative and nine (9) qualitative traits. The results of analysis of variance (ANOVA) revealed a very highly significant difference for all quantitative traits (P <0.001) and showed that there was a significant diversity amongst the collected samples. The hierarchical ascending classification generated a dendrogram which grouped the 51 local cultivars into four (4) different classes. The cultivars of class 2 had the

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highest values for the useful biomass and total biomass. Those in class 4 had the highest values for the leaf length, leaf width, leaf area, fruit length and width. After analysis, it appears that the cultivars of Class 2 and 4 showed the best leaf traits. Thus, local cultivars 13; 42; 19; 47; 39; 4; 12; 1; and 38 may be used as potential parents in future breeding programs and improvement of *S. macrocarpon*.

Keywords: S. macrocarpon; local cultivars; genetic variability; characterization; Benin.

1. INTRODUCTION

In Benin, vegetable production is characterized by a diversity of vegetables grown. Traditional leafy vegetables are largely consumed amongst vegetables after tomato, pepper, onion, and are very common in the food habits of people in Benin [1]. Many vegetables are grown by gardeners in the country. Among these*, Solanum macrocarpon* occupies a prominent place in agricultural holding. It is produced by almost 95% of gardeners [2]. The interest in this leafy vegetable could be explained by the fact that many consumers of all ages like it. Commonly called "Gboma" in one of the local languages of the country, nightshade, *S. macrocarpon* is also eaten in many countries of West Africa such as Togo, Ivory Coast and Nigeria [2,3]. It is found everywhere in non-arid hot zones in Africa and is an important vegetable because of its leaves and fruits [4]. Gboma is rich in protein, fiber, calcium, iron, potassium, magnesium, phosphorus and sodium [5,6]. The leaves and fruits of gboma are sources of nutrients and income for many households [7]. In addition, Gboma is used in traditional medicine for the treatment of several diseases including: Obesity, asthma, skin infections, rheumatism, gastro-esophageal disease, constipation and diabetes [8]. Despite the importance of the species in Africa, this plant is still underutilized.

The characterization of local cultivars of *S. macrocarpon* grown in Benin would be of paramount importance for germplasm conservation, management of plant genetic resources and crop improvement. *S. macrocarpon* has been the subject of several studies in terms of the analysis of cropping systems, disease resistance, and chemical composition of leaves. But it should be noted that very few studies have been carried out on the diversity and characteristics of existing local varieties. What is the diversity within the *S. macrocarpon* in Benin? What is the structure of the genetic diversity of Gboma germplasm in Benin? The response to these research questions will help in understanding the agro-morphological characteristics so as to enhance the potential of this leafy vegetable.

The global objective of this study was to assess *S. macrocarpon* cultivars in Benin.

2. MATERIALS AND METHODS

2.1 Collection Areas and Plant Material

The fruits and seeds were collected from 11 departments including 24 communes in Benin. During the fruits and seeds collection, a survey on local taxonomy of this plant was carried out. The choice of these communes was due to their potential for market gardening and accessibility. After collecting the seeds from 24 communes in Benin, 51 samples of different *S. macrocarpon* cultivars were grown to study the different agro morphological characteristics. Fig. 1 shows the different collection zones of seed samples of local *S. macrocarpon* local cultivars.

2.2 Experimental Design and Collected Data

The experiment was conducted on the experimental site of Africa Rice in Abomey-Calavi. This site extends between 6° 25 'North Latitude and 2° 20' E. Longitude. 51 cultivars (50 + 1 control because all of its characteristics are already known) collected from different areas surveyed were first sown in the nursery. 28 days later, plants were transplanted in five (5) randomized incomplete blocks with 10 treatments per block and the control in each block; thus a total of 11 treatments per block. The 51 local cultivars were laid out in alpha design with 3 replications [9]. Seedlings were transplanted in the trial plot of 0.9 m^2 with 30 cm between rows and 30 cm within rows and were watered daily until harvest. Two weeks before transplanting, poultry manure was applied as basal dressing at a rate of 10 tons / ha. Two weeks after transplanting, urea was applied as maintenance fertilizer at a rate of 0.1 ton / ha. Manual weeding was carried out at three times before harvesting of the leaves. For protection

against pests, the plants are treated with Acaricide of which active substance was Abametin at a dose of 18 g / l. We used also Top Organic with active substance (Azadrachtine; Nimbin; Citronellal; Citronellol) at a dose of 40 ml / 18 l of water.

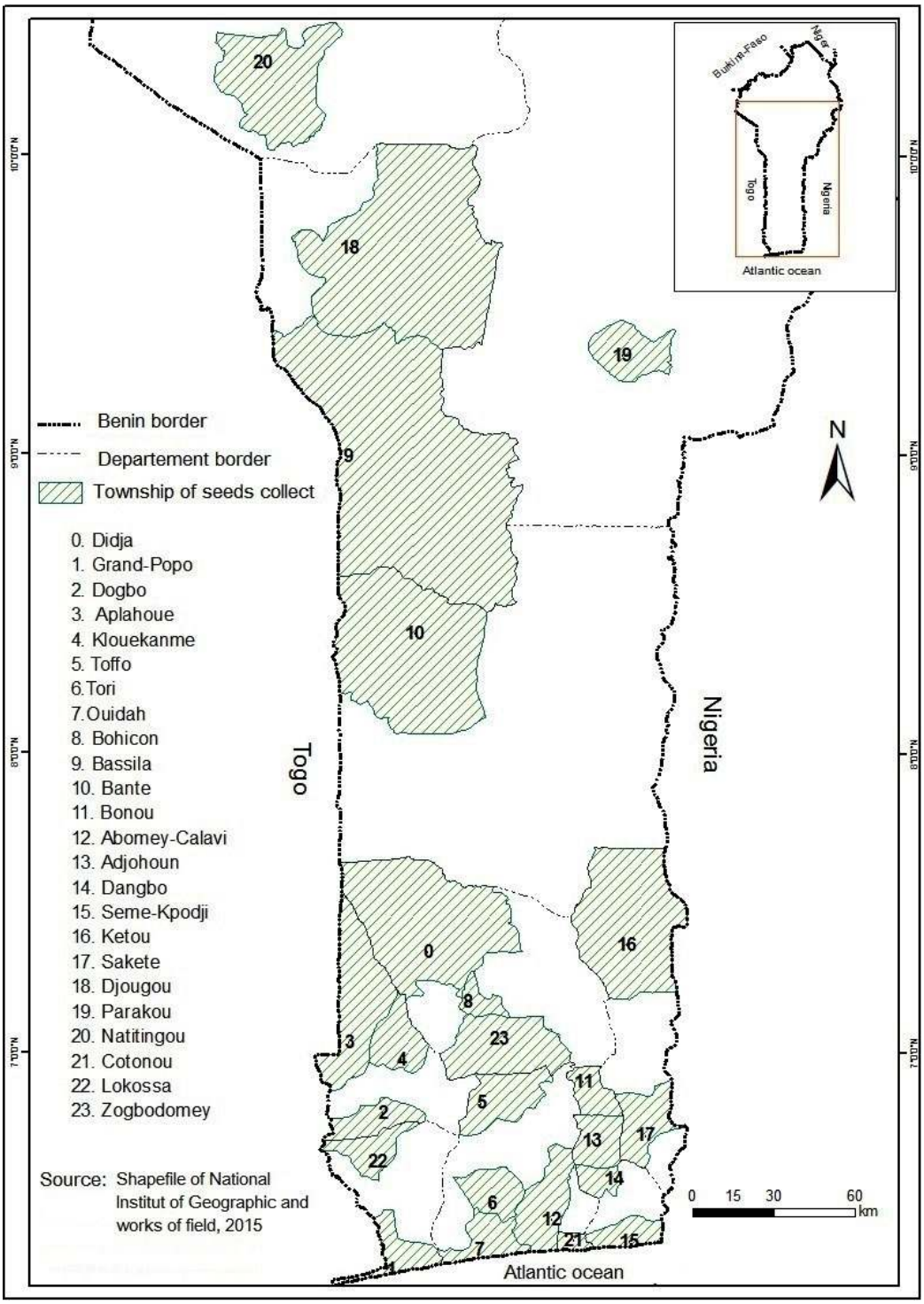

Fig. 1. Different collection zones of seed samples of local *S. macrocarpon* cultivars

2.3 Data Collection

Data were collected from 3 plants / plot, thus, a total of 9 plants per local cultivars for the 3 replications.

Twenty-three traits including 14 quantitative and 9 qualitative traits were collected on the plants during foliation, flowering and fruiting. The 14 quantitative variables include: number of leaves / plant (Nbr leav / P), leaf length (Lft leng), leaf width (Lft W), leaf area (lft ar), useful biomass (Use Bio), total biomass (Bio Ttl), days to first flowering (Flw day 1), days to 50% flowering (Flw day 50:), fruit length (frt leng), fruit width (frt W), number of fruits / plant (Nb fr / P), stem diameter (Grt stm), number of branches per plant (Nbr br / P), plant height (Plt heig). The 9 qualitative variables were: leaf appearance (lft Asp), pubescence of the leaf (Prs hair) leaf spinosity (Prs thorn), leaf color (lft color), leaf shape (Shap lft), stem color (stem color), the color of immature fruit (color frt-I), color of mature fruit (color frt-II), appearance of the fruit (color frt-II).). The color chart was used to determine various leaves color, stems color, immature and mature fruits color relative to each cultivar.

2.4 Methods of Statistical Analysis

For quantitative variables, a multivariate analysis of variance (MANOVA) was performed on the control to verify the uniformity of the plots. Descriptive statistics and analysis of variance (ANOVA) were used to assess the difference between cultivars (cultivar diversity). Connections between the various variables were determined using correlation coefficients. The classification of cultivars and analysis of the organization of the variability were performed using the Principal Component Analysis (PCA) and Ascending Hierarchical Classification (AHC). All these analyses were performed with R software Version 3.2.2 [10].

For qualitative variables, frequency analysis was performed to assess the proportion of cultivars in relation to different modalities. The frequency analysis of different qualitative modalities was done with Microsoft Excel 2010 software.

3. RESULTS

3.1 Variation in Local Taxonomy and Traits among Cultivars

In Benin, several local names varying according to socio-ethnic groups were used to designate the nightshade. The name “gboman” is used as prefix followed by adjectives describing the morphological traits of leaves, according to their usage and origin (Table 1).

3.2 Quantitative Variables

Multivariate analysis of variance (MANOVA) performed on the controls show no significant difference between blocks ($P = 0.7045$), indicating uniformity amongst plots of different blocks.

Mean values, standard deviations; minimum and maximum of quantitative traits of 51 cultivars are presented in Table 2.

The analysis of variance (ANOVA) based on linear mixed model shows a very highly significant difference for all quantitative traits ($P < 0.001$).

The observed diversity was related to flowers, leaves, fruits and stem but the greatest diversity was found in the leaf and fruit traits.

It was observed that the leaves revealed morphological variations (Fig. 2) through their size (length, width, leaf area). Cultivar 26 had the minimum value for leaf length and width (6.3 cm and 14.83 cm, respectively) while the cultivar 49 shows the maximum (31.82 cm and 44.32 cm). Cultivar 26 having the smallest leaf dimensions demonstrated the smallest leaf area unlike cultivar 49 which had the longest and widest leaves but not the highest leaf area (698.62 cm^2). Cultivar 13 showed the highest leaf area (781.98 cm^2). This could be explained by leaf shape (level of limb cut) which was 7 (pronounced) in cultivar 49 and 5 (intermediate) in cultivar 13.

The fruits showed diversity based on their roundness, colors (immature and mature) and their appearance. Fruit size varies from 16.93 mm to 82.19 mm.

Of the 51 local cultivars collected cultivar 48 and especially cultivars 10 and 26 revealed distinctive characteristics in relation to the color of fruit; fruit size and shape of leaves. Cultivar 48 revealed fruit size three times greater than all other cultivars (Fig. 3, fruit with number 48). Cultivars 10 and 26 (Fig. 3, fruits with numbers 10 and 26) demonstrated the largest number of leaves and the smallest fruits and the only ones with mature red fruits. For example, the average width and the average number of leaves of cultivars 10 and 26 were equal to (13.28 cm and 552 leaves)

while those of all other cultivars were equal to (36.36 cm and 53 leaves).

3.3 Qualitative Variables

The quantitative variables also illustrated different modalities, which showed a wide diversity within cultivars collected. The shape (appearance of leaves, level of limb cut), the colors and the presence or absence of thorns were the most diverse variables. The appearance of the surface of the limb varied and showed three different modalities namely 13.72% were waffled, 43.13% were semi-waffled and 43.13% were smooth. The different colors observed were: dark green (RHS137A 54.90%); green (RHS137C 43.13%) and green light (RHS144A, 1.96%). the presence of thorns was 13.72% and the remaining without thorns, the presence of hairs on the leaves was 9.80% while the remaining was without hairs. 94.11% plants showed green stems and only 5.89% plants revealed purple stem. We noted that the greatest variations were found in the leaves and fruits.

Table 1. Gboma local names according to each socio-ethnic group in the collection zones

Phytogeographic regions	Vernacular names	Significance
Guinean	Gboman Togan	Gboman with large leaves (Minan)
	Gboman Kougan	Gboman with large leaves (Adja)
	Gboman gbadjagbadja	Gboman with large leaves (Fon)
	Gboman hounnon	Thorny Gboman (Fon)
	Gboman founon	Hairy Gboman (Fon)
	Gboman amanmounon	Gboman with yellow stripe fruit (Fon)
	Gboman wiwi	Gboman with green-dark leaves and violet stem
	Gboman wéwé	Gboman with green-light leaves and green stem (Fon)
	Gboman aman kpèvi	Gboman with small leaves
	Gboman tovi	Gboman with small leaves (Minan)
	Gboman accra	Gboman from Accra (Minan ; Adja ; Fon)
	Gboman Oreille d'éléphant	Gboman of which leaves are similar to elephant ears (in all ethnic groups)
	Gboman kpinman	Gboman of which leaves are similar to the leaves of papaya (Fon)
Sudano-Guinean	Igboman	Gboman (Idatcha ; Nago)
	Agbangbangnonra	Gboman (Yoom ; Lokpa)
Soudanese	Sansou	Gboman (Bariba)
	Gboman bi	Gboman with green-dark leaves (Deendi)
	Gboman kparè	Gboman with green-light leaves (Deendi)
	Tikati	Gboman (Otamari)

Table 2. Descriptive statistics of quantitative parameters

N°	Variables	Means	CV	Min	Max
1	(Flw day1)	52.88	0.11	42.33	64.33
2	Flw day50:	57.35	0.11	45.33	70.33
3	Nbr leav P	73.21	1.49	31.22	790.11
4	Lft leng (cm)	35.63	0.15	14.83	44.32
5	Lft W (cm)	20.18	0.22	6.3	31.82
6	Ttl Bio (g)	623.46	0.36	211.33	1454.55
7	Use Bio (g)	243.71	0.38	51.62	605.66
8	lft ar : (cm^2)	394.75	0.36	46.69	781.98
9	Plt heig (cm)	50.12	0.15	34	67.94
10	Grt stm (mm)	15.88	0.09	13.11	20.55
11	Nbr br/P:	9.68	0.23	6.11	19.66
12	Frt leng (mm)	41.06	0.22	12.37	83.57
13	frt W : (mm)	54.72	0.19	16.93	82.19
14	Nb fr /P	13.08	2.00	1	154.77

Fig. 2. Morphological diversity of *S. macrocarpon* leaves, the numbers on the leaves represent the coding numbers of the cultivars from which they derived

Fig. 3. Diversity of shapes and colors of *S. macrocarpon* fruits

At immaturity, 27.45% of fruits were white and 72.55% were green. At maturity, 31.37% of fruits were brown; 58.82% yellow, 3.93% yellow striped green; and 5.88% were red in color. For their appearance, 60.78% of fruits were smooth and 39.22% were rough.

3.4 Correlations between Variables

It was observed a positive correlation between the days to flowering, leaf length (r = 0.243); stem diameter (r = 0.319) and a negative correlation between total biomass (r = -0.381); plant height (r = -0.332) and number of fruits per plant (Table 3). The number of leaves per plant was positively correlated with plant height (r = 0.203); the number of branches per plant (r = 0.348); the number of fruits per plant (r = 0.934); and negatively correlated with: leaf length (r = -0.632); leaf width (r = -0.563); leaf area (r = -0.472); fruit length (r = -0.577) and fruit width (r = -0.659).

Leaf length and leaf width were positively correlated with leaf area (r = 0.771; 0.902) and negatively correlated with the number of fruits per plant (r = -0.676; -0.565). It should be noted that the highest correlation coefficients were observed between leaf width and leaf area (r = 0.9021) between the number of leaves per plant and the number of fruits per plant (r = 0.9345).

3.5 Analysis of Close Relationships amongst Cultivars

The adjusted averages of variables obtained by analysis of variance were used to perform principal component analysis (PCA) to identify similarities or dissimilarities among different cultivars.

The cumulative percentages of variance of the correlation matrix of eigenvalues permit to retain the first two factorial axes which account for over 56% of the variation. The correlation circle of the variables on the axes (cloud of variables) shows that the variables number of fruits per plant and number of leaves per plant were negatively correlated to axis 1, while fruit length and width, leaf length, width, and area were positively correlated with this axis. Number of days from planting to first flowering, days to 50% flowering, was negatively correlated with axis 2 while the total biomass and useful biomass were positively correlated with this axis (Fig. 4).

The projection of local cultivars on axes 1 and 2 (Fig. 5) shows that cultivars (10, 26) were taken into account by the negative side of axis 1, cultivars (20, 39, 38 , 49, 13, 1, 12, 47, 42, 25, 37, 30, 51) were still positively taken into account by this axis. Regarding axis 2, the local cultivars (11, 32, 6, 14, 15, 9, 3, 8, 16, 24, 34, 4, 18, 19, 40, 46, 17 , 33, 35, 7, 48.) were taken into account by the negative side of this axis as opposed to cultivars (2, 22, 36, 28, 45, 29, 31, 21, 27, 43, 50, 23, 23, 41, 44 and 5) which were positively considered.

The distribution of individuals in classes is presented in the dendrogram (Fig. 6).

Four classes were observed from the coefficient of determination R - Square = 0.50

Class 1 includes cultivars 10 and 26. Class 2 is composed of cultivars 22, 36, 28, 2, 31, 29, 45, 41, 43, 5, 44, 21, 27, 23. Class 3 consisted of Cultivars 19, 46, 11, 6, 15, 32, 14, 9, 40, 35, 4, 18, 17, 34, 16, 24, 8, 33, 3. Class 4 was made of cultivars 48, 42, 47, 7, 12, 1, 20, 39, 38, 13, 49, 30, 50, 51, 37, 25.

Fig. 6 shows the dendrogram classifying 51 local cultivars of *S. macrocarpon* in 04 different classes.

The analysis of the averages of quantitative variables and frequency variables and the values of qualitative variables was performed to identify the main traits characteristic of the cultivars of each class (Table 4).

4. DISCUSSION

The surveys conducted during the collection of *S. macrocarpon* fruits and seeds showed that in Benin, traditional leafy vegetables in general and gboma in particular are consumed and are highly appreciated by the rural and urban populations. Unlike the populations of some African countries who consume the fruits of gboma, the Beninese consumes only the leaves. The same observations were made by [11] who reported that the leaves of this species are most used in Benin and Ghana.

The high significance of the variance analysis tests for quantitative variables and the different modalities of qualitative characteristics show that each of these variables can be used to discriminate the local cultivars and there is a great diversity in the samples collected. The studies of [12] at Pantaloo in Europe, [13] in

Ghana, [14] in Spain and [15] in Nigeria showed high diversity within *S. macrocarpon*, which represents an opportunity for future breeding programs in order to improve the species.

Significant correlations existing between variables permit the use of some traits to predict others. For example, a late flowering allows obtaining taller plants with well-developed leaves and with huge total biomass. The appearance of flowers requires enough nutrients and the nutrients mobilized by the plant are used for the production of flowers, which penalize the leaves during their development. Therefore, the more the plant is slow to flower the more leaves develop in size and number.

Plants with small leaves had fruits of small dimensions but were characterized by big size and high number of fruits and branches. The longest and widest leaves had a large leaf area and a reduced number of fruits. This also represents an advantage for the selection as the traits having a positive correlation could be selected simultaneously.

According to [16], the domestication of *S. dasyphyllum* from which originated *S. macrocarpon* resulted in selection against the presence of hair and thorns. During this experimentation, the spontaneous appearance of thorns on some plants was observed. The seeds from the same fruit produced plants without

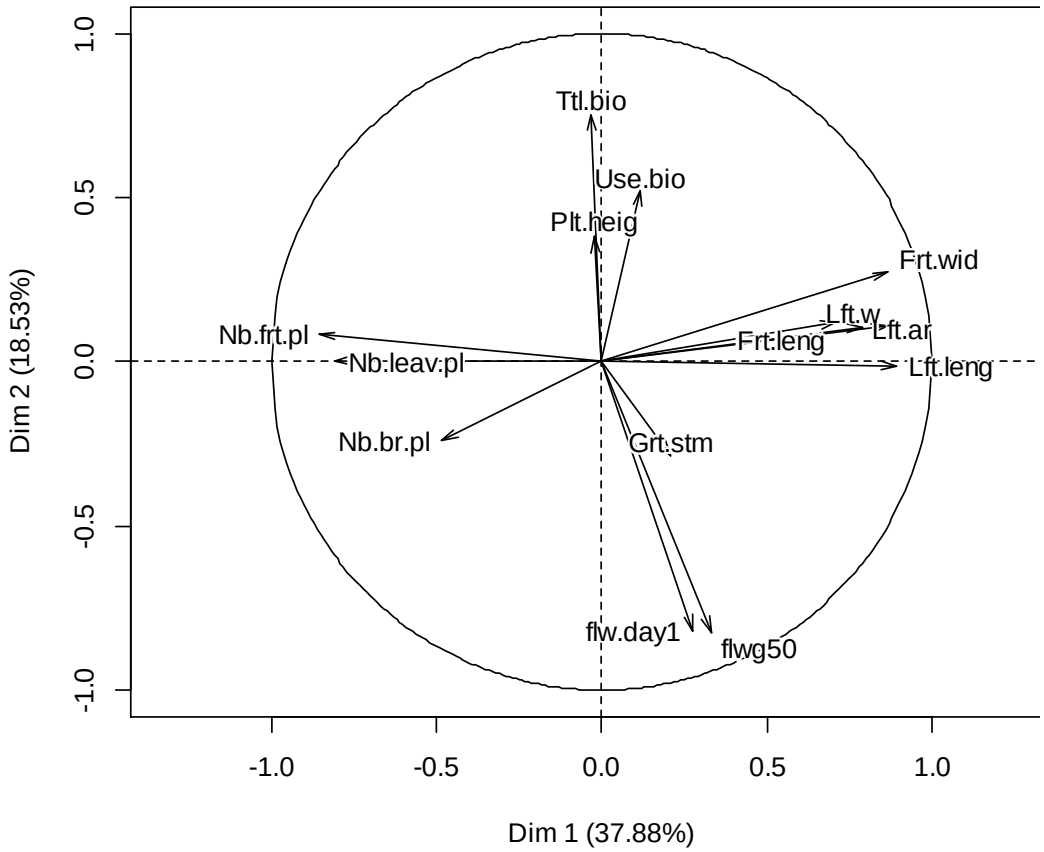

Fig. 4. Correlation circle formed by planes 1 and 2 (cloud of variables)

Legend:

(Flwday1)	*Number of days until the development of the first flower*	*lft ar :*	*Leaf area*
Flwday50:	*50% flowering*	*Plt heig:*	*Plant height*
Nbrleav P:	*Number of leaves per plant*	*Grt stm:*	*Plant diameter*
Lft leng	*Leaf length*	*Nbr br/P:*	*Number of branches per plant*
Lft W :	*Leaf width*	*frt leng:*	*Fruit length*
Ttl Bio:	*Total biomass*	*frt W:*	*Fruit width*
Use Bio:	*Useful biomass*	*Nb fr /P:*	*Number of fruits per plant*

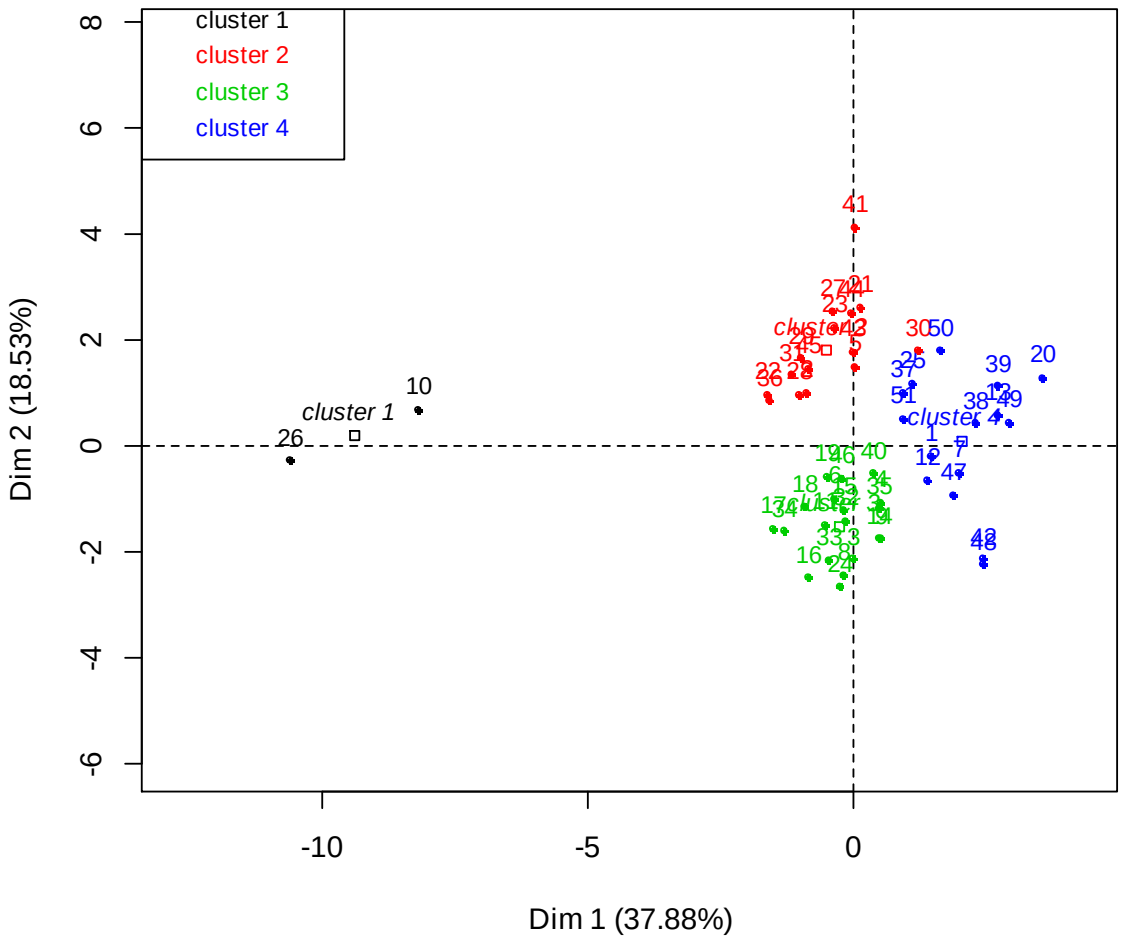

Fig. 5. Projection of cultivars in axes 1 and 2

thorns and some thorny plants. The same observations were made by producers during the collection of cultivars in the field. [17] stated that the presence of thorns on the leaves of some plants is due to the heterozygosity and it was demonstrated through obtaining 60% of plants with thorny leaves and 40% of plants with leaves without thorns after the multiplication of seeds from fruits of the same cultivar called "*Katende UGL, S. macrocarpon*".

Class 1 with two individuals (10 and 26) presenting different characteristics from other individuals and isolated from other groups leads us to doubt the membership of these two cultivars to the group of cultivars to the species *S. macrocarpon*. These works did not allowed us to formally identify these individuals as belonging to two different species namely *S. melongena and S. aethiopicum* for cultivars 10 and 26. The cultivar 48 possesses some traits close to *S. melongena*.

Nevertheless, based on the work of [18], the fruits of cultivar 48 are closer to *S. melongena* and the fruits of cultivars 10 and 26 are close to *S. aethiopicum*.

According to our work, fruit morphological traits of cultivars 10 and 26 are similar to those described by [14] and [19]. It has been reported by these authors that the fruits of the two plants are similar to those of *S. aethiopicum*. The morphological variability observed between different classes may be due to genotypic differences and / or environmental factors. For example, the cultivars with same local names and even considered as the same ecotypes collected from different agro-ecological zones expressed different morphological traits during the experiment.

Table 3. Correlation matrix between quantitative variables

	Flwday 1	Flwday50	Nbr leav.P	Lft leng	Lft W	BioT	BioU	Lft ar	Plt heig	Grt stm	Nbr br.P	Frt leng	Frt W	Nb fr.P
Flwday 1	1													
Flwday50	**0.902****	1												
Nbr leav.P	-0.128	-0.224*	1											
Lft leng	0.243*	0.278*	-0.632**	1										
Lft W	0.122	0.198	-0.563**	0.804**	1									
Ttl Bio	-0.381**	-0.418**	0.070	-0.074	-0.008	1								
Use Bio	-0.119	-0.144	-0.059	0.076	0.131	0.705**	1							
Lft ar	0.123	0.199	-0.472**	0.771**	**0.902****	-0.006	0.234*	1						
Plt heig	-0.332**	-0.288*	0.203*	0.169	0.114	0.116	0.029	0.143	1					
Grt stm	0.319**	0.325**	0.090	0.403*	0.205*	-0.159	0.016	0.235*	0.295*	1				
Nbr br.P	0.075	0.103	0.348**	-0.441*	-0.383**	-0.103	0.003	-0.281*	-0.020	-0.096	1			
Frt leng	0.148	0.127	-0.577**	0.493*	0.534**	0.147	0.003	0.333**	-0.104	-0.082	-0.296*	1		
Frt W	0.017	0.053	-0.659**	0.723**	0.735**	0.143	0.161	0.657**	0.134	0.071	-0.403**	0.783**	1	
Nb fr.P	-0.254*	-0.304**	**0.934****	-0.676**	-0.565**	0.088	-0.063	-0.501**	0.258*	-0.012	0.379**	-0.620**	-0.705**	1

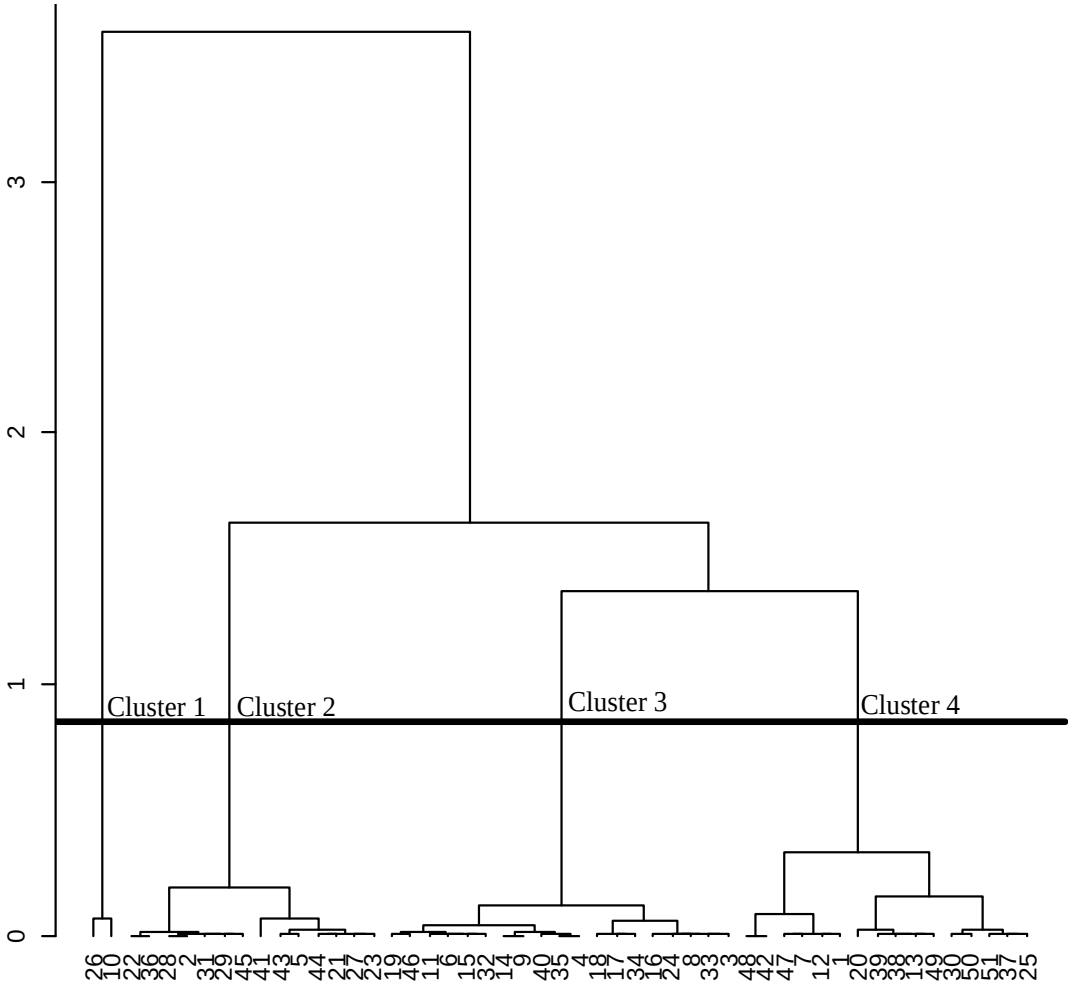

Fig. 6. Dendrogram showing the relationship among the 51 local cultivars of *S. macrocarpon* in Benin

The morphological differences observed show that these cultivars are genetically different or under selection pressure or environmental factors. The same assumption was made by [17] and [13]. Also, according to [20] and [21], morphological, agronomic, crosses, fertility of F1 parameters are insufficient for proper classification of eggplant because there is a morphological variability in the genus *Solanum* and a possibility of crosses between different related species.

Distinctions are much more accurate based on molecular methods and chemical studies such as protein content [22]. [15], confirm this assertion by suggesting a rigorous classification of eggplant cultivars collected throughout the world by a molecular approach and advises the use of RAPD markers as fast technique to reveal the intraspecific and interspecific polymorphism of eggplants. Other authors also proposed the same approach [23-26]. Molecular characterization by the use of SNP method (Single Nucleotide Polymorphism) and sequencing are reliable methods to identify the polymorphism of cultivars and identify the genes responsible for desirable traits for inter and intra specific crosses so as to obtain cultivars that meet the expectations of consumers and producers.

In Benin, *S. macrocarpon* is most used owing to its leaves and the first criterion searched for in this species by consumers and producers is the width and length of the leaves. Of the 23 variables, those that are of paramount

Table 4. Main traits characteristics of each class

Class	Characteristics
C_1	Class containing 02 cultivars of big height with early flowering producing enough smooth leaves and very small fruits. Immature fruits were green and turning red when mature. Cultivars 10 and 26 formed a distinct class when compared to 03 other classes.
C_2	The cultivars of this class were characterized by high biomass but a small diameter and a small number of branches per plant. Over 60% of the plants had green-dark leaves with serrated edges. We observed the presence of thorn and hairs on the leaves of some plants (13.13%). At immature state, 66.66% of fruits were green and yellow when mature. 33.33% were white when immature and brown when mature.
C_3	Late flowering; small plants producing low total biomass. The leaves of this class were not wide and over 50% of the plants had green leaves; semi-waffled with serrated edges and green stems. 9.52% of the plants had thorny leaves and 4.76% had hairy leaves and the remaining without hair and thorns. 71.42% of immature fruits were green and 28.58% were white. Once mature, 66.66% showed a smooth uniform yellow color; 33.34% yellow stripped.
C_4	These cultivars had a large collar diameter with less fruit and leaves. The leaves of this class were the widest and the longest with a large leaf area. Over 50% of plants had green and semi-waffled leaves with serrated edge, 15.38% of plants had thorny and hairy leaves. Over 50% of fruits were green at immaturity and turned yellow when mature.

importance for producers and consumers were analyzed in order to highlight the cultivars that express the best traits. From the results, the cultivars of class 2 and 4 had the best desirable traits. The cultivars of class 4 were very tall plants with the widest and longest leaves; a large leaf area and were of green-dark color. Those of class 2 demonstrated a large number of leaves per plant and a significant useful biomass. The local cultivars 13, 49, 42, 19, 47, 39, 4, 20, 25, 37, 30, 12, 1, and 38 had the traits of interest namely; long and wide leaves; green-dark color; highest plant height; large leaf area and could therefore be used as potential parents for future breeding programs of *S. macrocarpon* in Benin.

5. CONCLUSION

This study allowed us to identify a few trends on the structuring of agro-morphological diversity of *S. macrocarpon*. From the results obtained, it appears that there is great variability within the collection which was grouped into 4 distinct classes through digital classification method. Moreover, cultivars of class 2 and 3 showed main traits (high biomass, late flowering, plants with green leaves, semi-waffled with serrated edges and green stems) which can be used in future breeding programs.

From the data of the present study, we conclude that the characterization of *S. macrocarpon* requires first and foremost: a good knowledge of the species, then the two closely related species *S. aethiopicum* and *S. melongena*, wild relative species belonging to the genus *Solanum* which closely related to *Solanum macrocarpon* by morphological traits. Further molecular characterization is needed to see whether the observed variability is due to environmental factors or cultivars are genetically different. Beyond the morphological markers used in this study, the use of molecular markers is strongly recommended to confirm or refute our findings.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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