

BIOMETRICAL EVALUATION OF MORPHOLOGICAL TRAITS IN FAMILY CUCURBITACEAE IN LAFIA, NIGERIA

Abstract

Biometrical evaluation is a valuable tool for the study of biosystematics of plant taxa. This study assessed morphological variation and phenetic relationship in the Cucurbitaceae species in Lafia, Nasarawa State, Nigeria. Plant specimens were collected by simple random sampling across the municipality. Wide variations were observed in the morphological characters; *Telfairia occidentalis* had the longest pods (46.3cm) and the longest vines (831.4cm), while *Cucumis sativus* had the shortest vines (162.3cm). All the species had multi-seeded pods; *Lagenaria breviflora* had 734.7 seeds, which was significantly more than the seeds in other species, *Citrullus lanatus* had 438.3 seeds and *Momordica charantia* had the fewest seeds (12.7) per pod. *T. occidentalis* had significantly ($p \leq 0.05$) the heaviest seeds (89.8 g) of the species. *Lagenaria abyssinica* and *L. rufa* had similarity index of 0.9; *Cucumeropsis mannii* and *Citrullus lanatus* had index of 0.89. There is need to widely study the phenetic relationship of Cucurbitaceae to revise the taxonomy of the family.

Keywords: Cucurbitaceae; biometric evaluation; Phenetic relationship; simple random sampling

Introduction

The family Cucurbitaceae with more than 120 genera and 820 plant species is genetically very diverse plant group; they are widely distributed in tropical and subtropical agro-ecologies of Africa and the world (Jeffery, 1990; Ndoro, *et al.*, 2007). Cucurbitaceae contains important species, such as pumpkin, melon, cucumber and squash; the species are much appreciated for their nutritional,

medicinal and aesthetic values; their fruits, leaves, flowers and seeds are comestible (Stefanova *et al.*, 1994; Arua *et al.*, 2010). Cucurbits contain 20 to 35% protein with essential amino acids, such as arginine, aspartate and glutamic acid; 25 to 55% oil that are rich in unsaturated oleic and linoleic acid; minerals such as calcium, iron, magnesium and potassium and vitamins e.g. Vitamin A (Ndoro, *et al.*, 2007; Shrivastava and Roy 2013). Most Cucurbitaceae species are consumed as vegetables in many African cuisines, they are used to purify blood, as diuretic drugs, as remedy for constipation, asthma and arthritis, to aid digestion, boost energy, amend cholesterol level and strengthens immunity and heals wounds.

Classification of the Cucurbitaceae family in Africa have been variously conducted since the 1950s by Hutchinson and Dalziel (1954), Purseglove (1968), Okoli in 1984 and more recently by Agbagwa and Ndukwu (2004), yet the taxonomic categorization of this group has not been exhausted because knowledge gaps still exist. In Nigeria, many rural people mistake soft and orange skin Cucurbits as tomato because of their usage in local sauces. Furthermore, the species *Cucumeropsis mannii* (L.) Naudin is synonymous with *Citrullus colocynthis* (L.) Shrad. while Ogbonna (2013) described the species as *Colocynthis citrullus* L. and the species has several common names, such as colocynth, bitter apple, bitter cucumber and ‘egusi’.

Secondly, there has been intense germplasm erosion resulting from natural phenomena, such as wild fire, flooding, wind and water erosion; and human activities, such as farming, municipal development and unregulated lumbering (IUCN, 2004). The natural and human processes pose selection challenges on the taxa; these pressures threaten the phylogenetic composition of the species (Arua, *et al.*, 2010). Nigeria is particularly noted for deforestation; it has lost much of its forest and many valuable genetic resources to this phenomenon (FAO, 2005; FGN, 2006); therefore, there is urgent need for mitigation. The evaluation of plant diversity to identify groupings sharing close genetic makeup is important for conservation of genetic resources and for utilizing the diversity as breeding materials.

The objective of this study was to evaluate the variation in some biometric traits in the Cucurbitaceae family germplasm collection in Lafia, Nigeria.

Materials and methods

Study Area

Eleven species in family Cucurbitaceae were collected in Lafia (8°29'N, 8°31'E); located in the north central and within the Guinea Savannah ecology of Nigeria. It has tropical climate with rainfall of 1311.75cm per annum and mean annual temperature of about 28°C; the rainy season starts from March to October and the dry season (sometimes with little rain) starts from November to February, humidity is of about 80% in the rainy season (Nigerian Meteorological Agency, Lafia 2012). The vegetation of the area is a derived forest type with economic trees clusters cultivated among grasses and shrubs. The common economic trees are citrus (lemon, grapes and oranges), cashew, mango, *Moringa* spp, guava and other tree crops which have replaced most of the natural tree vegetation (Kana, *et al.*, 2014). The landscape is undulating with plain lands and hills measuring up to 300 ft above the sea level.

Specimen collections

The plant specimens were collected by simple random sampling; made by traversing the town, in fields and along the banks of water-bodies. Morphological characterization was identified according to the standard descriptor of Agro-Botanical Institute (ABI), Tapiósztele, Hungary. Multiple measurements of three to five random samples were taken of each trait.

Data analysis

Data collected were subjected to analysis of variance to estimate the differences among the species and significant means were separated using Duncan New Multiple Range Test (DNMRT).

Data collected were also subjected to principal component analysis to identify the most discriminating morphological characters. Dendrograms and genetic similarity among the taxa were

generated by the single linkage algorithm of Bray-Curtis similarity index. The multivariate analyses were computed with Past 3 package (Hammer, *et al.*, 2001).

Results and Discussion

Morphological traits in Cucurbitaceae in Lafia, Nasarawa State, Nigeria

Eleven species were collected in the course of survey in Lafia Nasarawa State, Nigeria, the species were *Cucumeropsis mannii* (L) Naudin., *Citrullus lanatus* (Thunb) Matsum and Nakai, *Cucumis sativus* L, *Cucurbita pepo* L, *Lagenaria abyssinica* (Hook. f) Jeffrey, *L. breviflora* (Benth) Roberty, *L. rufa* (Gilg) Jeffrey, *L. siceraria* (Molina) Standl, *Luffa cylindrica* (L.) M. Roem, *Momordica charantia* (L.) Karela and *Telfairia occidentalis* Hooke. The morphological and yield traits of the species collected in the Cucurbitaceae family in Lafia, Nasarawa State, Nigeria are presented in Table 1. The vine length ranged from 162.3cm in *Cucumis sativa* to 831.4cm in *Telfairia occidentalis*. *Telfairia occidentalis* had significantly ($p \leq 0.05$) the longest vines (831.4cm), followed by *Lagenaria siceraria* (705cm). Length of leaf blades ranged from 2cm in *Momordica charantia* to 14cm in *Telfairia occidentalis*. *M. charantia* had the smallest leaf blades (0.68cm), while, *T. occidentalis* had the largest leaf blades (8.5cm). The length of pods ranged from 5.4cm in *Momordica charantia* to 46.3cm in *Telfairia occidentalis*.

Characteristic of Cucurbitaceae, all the species in the study were multi-seeded; *Lagenaria breviflora* had 734.7 seeds per pod, *Citrullus lanatus* had an average of 438.3 seeds per pod, *L. siceraria* had 328.3 seeds per pod, while *M. charantia* had the least number of seeds per pod (12.7). *M. charantia* had the lightest seeds weight per pod (2.58 g), followed by *Cucumis sativus* (3.92 g), *Telfairia occidentalis* had largest and heaviest seeds per pod (89.7 g). The weight of 30 seeds ranged from 0.5 g in *Cucumis sativa* to 37 g in *Telfairia occidentalis*. The seed weight per pod of *T. occidentalis* (89.8 g) was significantly ($p \leq 0.05$) the heaviest of the species in Lafia, Nigeria.

TABLE 1: Variation in morphological and yield traits of some species in the family Cucurbitaceae in Lafia, Nasarawa State, Nigeria

Plants Species	Length of vine (cm)	length of leaves (cm)	Width of leaves (cm)	Weight of oven-dried leaves (g)	Length of pod (cm)	Diameter of pod (cm)	Number of seeds per pod	Seed weight per pod (g)	Weight of 30 seeds (g)
1. <i>Cucumeropsis mannii</i> (L) Naudin.	241.1 ^e	12.1 ^{ab}	1.44 ^{ef}	0.512 ^b	11.3 ^c	11.9 ^{bc}	316.7 ^c	43.17 ^c	3.04 ^{bc}
2. <i>Citrullus lanatus</i> (Thunb) Matsum and Nakai	248.1 ^e	10.9 ^{ab}	6.66 ^{bc}	0.584 ^b	23.7 ^b	15.7 ^b	438.3 ^{bc}	21.60 ^d	1.60 ^d
3. <i>Cucumis sativus</i> L	162.3 ^f	7.62 ^c	5.92 ^c	0.475 ^b	24.9 ^b	6.7 ^c	238.0 ^{cd}	3.92 ^f	0.53 ^f
4. <i>Cucurbita pepo</i> L	337.2 ^d	13.6 ^a	4.9 ^d	1.830 ^a	16.1 ^{bc}	14.9 ^b	274.0 ^{cd}	23.28 ^d	2.52 ^{cd}
5. <i>Lagenaria abyssinica</i> (Hook. f) Jeffrey	324.9 ^d	11.7 ^{ab}	5.24 ^{cd}	0.409 ^b	14.1 ^c	4.7 ^c	140.3 ^d	12.63 ^e	2.68 ^{bc}
6. <i>Lagenaria breviflora</i> (Benth) Roberty	245.1 ^e	8.0 ^{bc}	6.7 ^{bc}	0.502 ^b	11.4 ^c	9.2 ^{bc}	734.7 ^a	26.27 ^d	1.35 ^d
7. <i>Lagenaria rufa</i> (Gilg) Jeffrey	246.3 ^e	8.4 ^{bc}	5.74 ^{cd}	0.521 ^b	6.5 ^d	5.6 ^c	148.0 ^d	10.23 ^e	1.84 ^d
8. <i>Lagenarias siceraria</i> (Molina) Standl	705.7 ^{ab}	13.2 ^a	7.6 ^{bc}	1.192 ^a	22.6 ^b	6.6 ^c	328.3 ^c	55.62 ^{bc}	4.44 ^{bc}
9. <i>Luffa cylindrica</i> (L.) M. Roem	525.6 ^c	10.86 ^{ab}	2.36 ^e	1.377 ^a	14.0 ^c	7.0 ^c	128.3 ^e	9.42 ^e	2.33 ^{cd}
10. <i>Momordica charantia</i> (L.) Karela	347.2 ^d	2.02 ^d	0.68 ^f	0.047 ^b	5.4 ^d	2.5 ^d	12.7 ^f	2.58 ^f	3.87 ^{bc}
11. <i>Telfaria occidentalis</i> Hooke	831.4 ^a	14.0 ^a	8.5 ^{ab}	1.314 ^a	46.3 ^a	21.5 ^a	110.3 ^e	89.76 ^a	37.11 ^a

Key: Means with the same letters in the same column are not significantly different at 5 % probability (DNMRT)

Variation in the Cucurbitaceae species in Lafia, Nigeria

The Bray-Curtis single linkage cluster measuring the similarity among the species is presented in Figure 1. The similarity indices ranged from 0.75 to 0.99, *Lagenaria abyssinica* (G5) and *L. rufa* (G7) had similarity index of 0.9; *Cucumeropsis mannii* (G1) and *Citrullus lanatus* (G2) had index of approximately 0.87; G1 and G2 had similarity index of 0.87 with *Cucurbita pepo* (G4). *Lagenarias siceraria* (G8) and *Telfaria occidentalis* (G11) were clustered together and separated from the other species. *Momordica charantia* (G10) was morphologically distinct; it was isolated into a separate cluster, from the other species.

In the production of interspecific hybrids, crossing is achievable by genetic closeness; closely related species cross more easily than distantly related ones. One of the basic assumptions in numerical taxonomy is that similarity in biometrical evaluation is a measure of their genetic similarity (Sneath and Sokal, 1973), by this assumption, interspecific and possibly intergeneric hybridization can be achieved in taxa in the same clusters in this study. Rakha *et al.* (2012) reported successful crosses between *Cucurbita moschata*, *C. ficifolia* and *C. martinii* (as male parents) with *C. pepo*. Yu *et al.* (2015) also crossed cucumber (*Cucumis sativus*) with its wild relative (*C. hystrix*) to improve shade tolerance in cultivated cucumber. Oloyede-Kamiyo and Akoroda (2014) crossed different sexes of *Cucumis sativus* (pickling, poinsett and burpless tasty) to generate interspecific hybrids. Intergeneric hybridization was achieved in Brassicaceae species with some success (Kaneko and Bang, 2014), however, chromosome doubling is needed in advance, to enhance crossability.

The scatter plot of the principal component analysis (Figure 2) presents *T. occidentalis* (G11) and *Lagenaria siceraria* (G8) in the first quadrant, *Lagenaria breviflora* (G6) and *Citrullus lanatus* (G2) in the second quadrant; *Cucumeropsis mannii* (G1), *Cucurbita pepo* (G4), *Cucumis sativus* (G3) and *Lagenaria rufa* (G7) in the third quadrant and *Lagenaria abyssinica* (G5), *Luffa cylindrica* (G9) and *Momordica charantia* (G10) in the fourth quadrant. The

occurrence of taxa in the same quadrant is indicative of the phenetic relationship between them. This is evident from Rahman *et al.* (2013) who used morphometric analysis to identified phenetic similarities in eleven *Senna* species in Bangladesh.

Table 2 presents the principal components (PC) matrix for morphological traits in the family Cucurbitaceae in Lafia, Nigeria. Eight of the principal component (PC) had Eigen-values greater than 1. Sixty-four per cent of the variation in the morphological traits was explained by the first principal component (PC1); and 34% was explained by the second principal component (PC2), the dissimilarity PC1 and PC2 were created by the variation in vine length and number of seeds per pod. The variation in PC3 was loaded on weight of seeds per pod and weight of 30 seeds.

There were positive correlations between most morphological traits of the Cucurbitaceae species in Lafia, Nigeria (Table 3). For example, the weight of 30 seeds had highly significant and strong correlation with seed weight per pod ($p = 0.813$, $r = 0.001$), but medium correlation with pod diameter ($p = 0.662$, $r = 0.001$). Similarly, highly significant and strong correlation between seed weight per pod and length of pod ($p = 0.741$, $r = 0.001$) and diameter of pod ($p = 0.707$, $r = 0.001$). The length of pod had significant and medium correlation with width of leaves ($p = 0.67$, $r = 0.05$). Traits with high positive and strong or medium correlation show that as one trait increases, the other increases correspondingly, this indicates that both traits can be improved simultaneously; consequently, weight of seeds, pod diameter and pod length are agronomic traits that can be improved at the same time in a breeding programme in the Cucurbitaceae species.

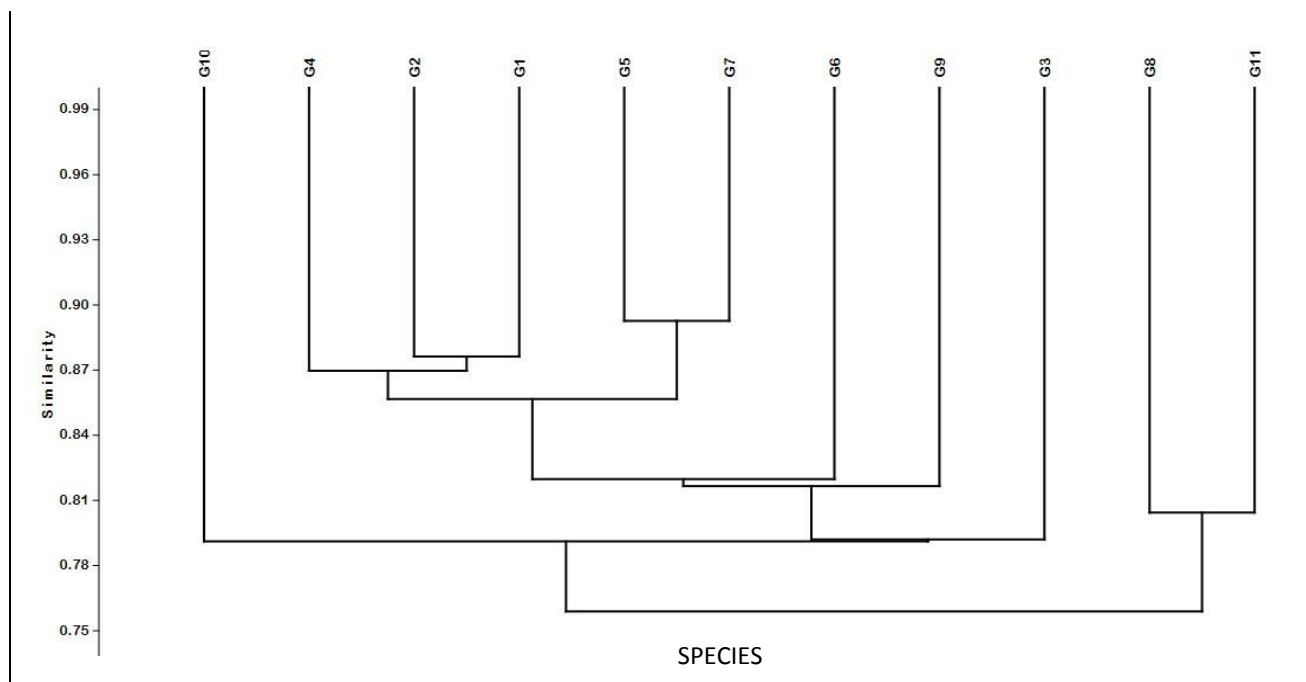


Figure 1. Bray-Curtis similarity indices of species in the family Cucurbitaceae in Lafia, Nigeria

Key: *Cucumeropsis mannii* (G1); *Citrullus lanatus* (G2); *Cucumis sativus* (G3); *Cucurbita pepo* (G4); *Lagenaria abyssinica* (G5); *Lagenaria breviflora* (G6); *Lagenaria rufa* (G7); *Lagenarias siceraria* (G8); *Luffa cylindrica* (G9); *Momordica charantia* (G10); *Telfaria occidentalis* (G11).

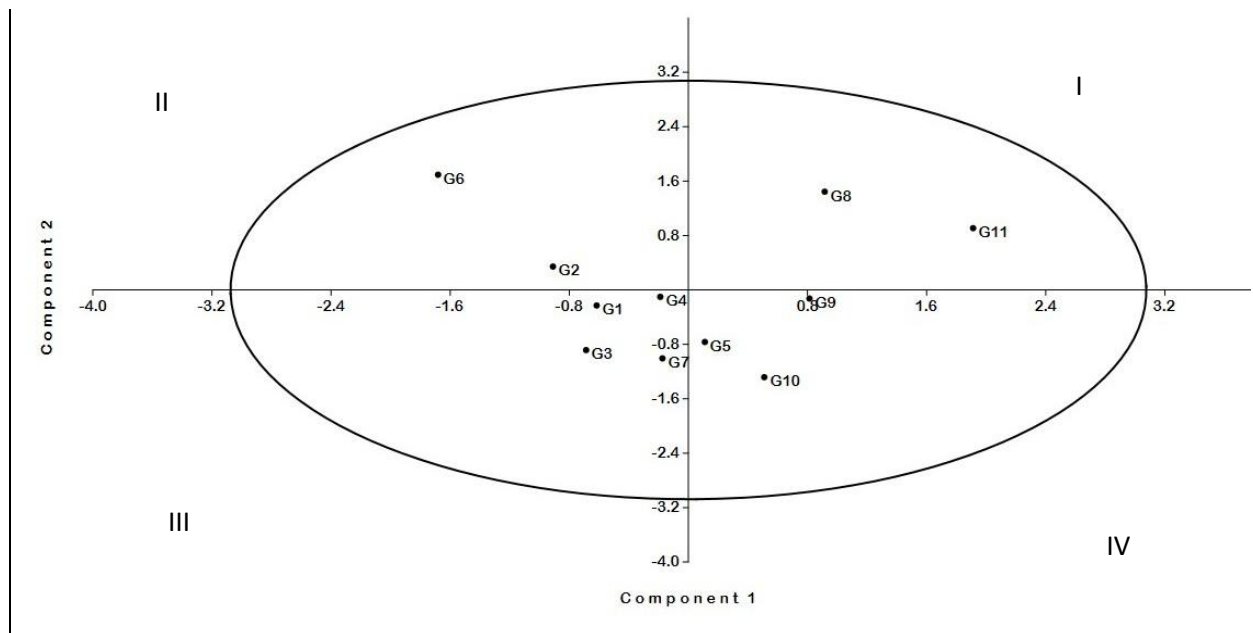


Figure 2. Scatter plot of the Principal component analysis showing 95% ellipsis

Table 2. Principal component matrix for morphological characters in Cucurbitaceae in Lafia, Nigeria

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8
Length of vine (cm)	0.792	0.599	-0.117	0.0104	-0.002	0.012	-0.005	0.003
length of leaves (cm)	0.004	0.010	0.068	-0.003	0.505	0.344	0.592	-0.515
Width of leaves (cm)	0.001	0.009	0.036	0.146	0.064	-0.183	0.663	0.707
Weight of dried leaves (g)	0.001	0.001	-0.001	0.010	0.050	0.090	0.031	0.004
Length of pod (cm)	0.024	0.029	0.346	0.807	0.286	-0.309	-0.194	-0.108
Diameter of pod (cm)	0.0039	0.015	0.225	0.193	0.067	0.834	-0.242	0.384
Number of seeds per pod	-0.607	0.793	-0.043	0.013	-0.015	0.002	0.000	-0.009
Seed weight per pod (g)	0.057	0.100	0.834	-0.484	0.137	-0.171	-0.064	0.060
Weight of 30 seeds (g)	0.031	0.019	0.334	0.234	-0.795	0.139	0.330	-0.267
Eigen value	55788.1	29870.8	293.634	57.843	17.533	10.4883	3.20597	1.2308
Variance %	64.838	34.716	0.3412	0.0672	0.0204	0.0122	0.0037	0.0014

Table 3. Correlation matrix between morphological traits of Cucurbitaceae in Lafia, Nigeria

	VL (cm)	LL (cm)	LW (cm)	WL (g)	PL (cm)	PD (cm)	SP	SW (g)
LL (cm)	0.475							
LW (cm)	0.354*	0.467**						
WL (g)	0.572*	0.729*	0.291					
PL (cm)	0.632*	0.541	0.671*	0.430				
PD (cm)	0.359*	0.634*	0.450	0.528	0.732			
SP	-0.297*	0.127	0.365	-0.036	-0.053*	0.204*		
SW (g)	0.755	0.643	0.509	0.435*	0.741**	0.707**	0.087**	
S30 (g)	0.746	0.365	0.415	0.328	0.803	0.662**	-0.286	0.813**

Key: VL = Length of vine; LL = length of leaves; LW = Width of leaves; WL = Weight of dried leaves; PL = Length of pod; PD = Diameter of pod; SP = Number of seeds per pod; SW = Seed weight per pod; S30 = Weight of 30 seeds.

Summary and conclusion

Variability among Cucurbitaceae is valuable for the study of biosystematics of the taxonomic group. Among the species in this study, *Telfairia occidentalis* had the longest vines, longest and widest leaves, longest pods, largest seeds and the most seeds per pod. *Citrullus lanatus*, *Cucumeropsis mannii*, *C. sativa*, *Cucurbita pepo* and *T occidentalis* were cultivated by many smallholder farmers, while *Lagenaria siceraria* and *Momordica charantia* were found as cultivated and in the wild. Four species; *Lagenaria abyssinica*, *L. breviflora*, *L. rufa* and *Luffa cylindrica* were collected from the wild only. The variations in fruits, seeds and other traits are documented by Ittah and Ajibodu, (2018).

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