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VARIATION IN MORPHOMETRIC TRAITS OF TREES, PODS AND SEEDS OF PARKIA BIGLOBOSA (JACQ) G. IN SOUTHWESTERN, NIGERIA

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Abstract

Tropical forests contain many important indigenous tree species that are edible and of socio-economically. The morphological traits of Parkia biglobosa (Jacq) G pods and seeds from three different States in Southwestern Nigeria were investigated. Tree growth measurements (height, crown diameter and diameter at breast height) were made on 10 trees of Parkia biglobosa selected from two villages from a Local Government in three States (Ekiti, Ondo and Osun), resulting into 60 trees for the study were sampled and analyzed. The pods were measured for morphological parameters (pod number, pod weight, pod length, pod breadth, and number of seeds). Means for each parameter were computed and analysis of variance (ANOVA) was carried out to determine if there were significant differences between States. The result of tree growth parameters differs from one State to another. It reveals that height ranges from 3.3- 13m (Osun), 2.7-13.5m (Ekiti) and 5.3-9.5m (Ondo State). Crown diameter shows that the tree in Osun varies between 4-18m, 7.5-20.2m, and 6- 23.2m for Ekiti and Ondo. Tree mean dbh varies from one state to the others, ranges between 9.1-18.9cm (Osun); 11.8-20.8cm (Ekiti) and between 10.7cm and 13.4cm (Ondo State) respectively. There were significant variations in morphological traits from one State to the other. Mean pod number varied from 31- 40.6, with trees from Ondo show higher number than Ekiti and Osun States. The morphological values were found to be higher in Ondo State than those recorded in Ekiti and Osun States respectively. The differences between States are a reflection of the different agro-climatic and soil conditions of Southwestern States. These morphological differences expressed will be very useful for promoting domestication and commercialization of Parkia biglobosa in Nigeria.

Keywords*: Growth parameters; Variation; Morphology; Parkia biglobosa; Southwestern Nigeria.*

Introduction

The forest is mainly seen as a source of many products, including timber but it is also the source of many Non-Timber Forest Products (NTFPs) [1]. These NTFPs play important role in rural communities around the world. Some of the roles include provision of varieties of products which are consumed and income generation to rural households. The products include food, fodder, medicines, spices, resin, dyes and construction materials, fuel wood, and utensils [2]. Farmers have long recognized the importance of trees. Therefore, they deliberately incorporate trees in production systems [3, 4]. Rural households depend on forest resources to meet their subsistence need for staple and supplementary foods, construction materials, fuel,

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medicine, cash, local ecosystem services and farm inputs [5]. In rural areas, the contribution of multipurpose indigenous agroforestry fruit trees such as *Parkia biglobosa* to food supply is essential for food security as they help to bridge 'hunger period' when stored food supplies are dwindling and the harvest is not yet available. In West Africa, *Parkia biglobosa* species has important socio-economic and cultural values for local people. Moreover, it is a food species whose importance is well recognized both regionally and internationally [6]. In Nigeria *P. biglobosa* is an important tree species which generates non-timber forest products as well as a basic and therapeutic food and is a source of wealth for many rural dwellers.

Parkia biglobosa (Jack.) G. Don. also known as Igba/Iyere (Yoruba), dawadawa (Hausa), African locust beans (English), is a native of Africa and is an important multipurpose tree of West African Savannah land as well as one of the most common species of the parkland agro-forestry system [7]. More attention have been given to economically important species of tree plants especially *P. biglobosa* in recent years due to an increasing recognition of its contribution to fulfill basic needs of rural people, household economics, food security and conservation of natural resources [8]. *Parkia biglobosa* is a perennial tree legume which belongs to the family *Leguminosae* and sub-family *Mimosoideae.* It grows in the savannah region of West Africa up to the southern edge of the Sahel zone [9]. These trees are not normally cultivated but can be seen in population of two or more in the savannah region of Nigeria [10, 11]. The Parkia tree play vital ecological role in cycling of nutrients from deep soils, by holding the soil particles to prevent soil erosion with the aid of roots, the trees also provide shades for farmers [9].

In most of these agrarian communities, Nigeria inclusive, forest foods are essential dietary supplements especially during lean agricultural production periods or times of emergency. The Nigerian Study/Action Team [12] submitted that leaves, fruits, nuts and oils obtained from wild plants are sources of food for humans, livestock and wildlife in many parts of Nigeria. *A. Latif et al* [13] reported that forest resources are directly contributing up to 80% of the livelihoods of the people in Pakistan living in extreme poverty. Therefore, determination of the morphological characteristics of *P. biglobosa* pods is carried out with the aim of promoting its conservation and selection of trees for domestication, utilization for animals and humans food and as a commercial product locally and internationally.

Parkia biglobosa is one of the several indigenous fruits under domestication [14, 15] and widely commercialized in Nigeria. Works on *Parkia biglobosa,* especially in Nigeria, revealed its phenotypic and genotypic variation and allowed the selection of superior trees based on fruit and pulp weight, fruit width, pulp taste and pulp colour [16] and Cameroon [17, 18]. It is also emphasized that most food consumed by the rural dwellers consist mainly of cereal, starchy root and tuber crops thus leading to various health problems associated with protein and vitamin/ mineral deficiencies. In addition, the attractive yellow color indicates the presence of phyto-nutrient possibly vitamin A and the sour taste which shows the presence of ascorbic acid (Vitamin C) [19]. It also serves as condiment in preparation of various stew, soups and sources for the consumption of cereals. It is usually pressed into cake and preserved for later use. It is very useful in the preparation of some indigenous drinks [20].

Materials and Methods

Study area

This study was carried out in the savannah vegetation area of Ondo, Ekiti and Osun States of Southwestern Nigeria**.** Ondo State covers an area of about 14,788.728km^2 and lies on longitudes 4°30'−6°0' E and latitudes 5°45'−8°15' N. The State is located entirely within the tropics with two broad climatic seasons: rainy season (April-October) and dry season (November – March). The temperature ranges between 21 to 29°C and humidity is relatively high throughout the year. The annual rainfall varies from 2,000mm in the Southern areas to 1,150mm in the northern areas. The State comprise of vegetation with high forest zone (rain forest) in the south and sub-savannah forest in the northern zone.

Ekiti State is mainly an upland zone, rising over 250 meters above the mean sea level. It lies between latitude 7°15'-7°40' N and longitude 4°51' - 5°45' E. It lies on and area underlain by metamorphic rock. It is generally characterized as landscape that consists of old plains broken by step-sided out-crops that may occur singularly or in groups or ridges. The State is also dotted with rugged hills. The temperature ranges between 21 and 28°C with high humidity. Tropical forest exists in the south, while savannah occupies the northern peripheries. All the State enjoys tropical climate with two distinct seasons. These are the rainy season (April–October) and the dry season (November–March).

Osun State has a total land area of 9,396km^2 out of which 722.57km^2 are gazzatted as Government Forest Reserves. The population of the State according to 2006 census is 3,423,535. Osun State lies between latitude 4^{o}03' E and 5^{o}05' E and Longitude 6^{o}95' N and 8^{o}05' N [21]. The climate of Osun State is tropical with distinct wet and dry seasons. The mean daytime temperature varies between 25°C in the North to 30°C in the south. The wet and dry seasons are associated with the prevalence of moist maritime southwesterly monsoon from the Atlantic Ocean and the dry continental Northeasterly Harmattan from the Sahara desert [21]. Annual rainfall reaches 1000 to 2000mm; the wet season could last 230 to 260 days per year while the distribution of rain is markedly bimodal, with a temporal cessation in August. Soils in Osun State are generally deep to very deep, well drained and composed of loam, sandy loam, loamy sand and sandy clay loam. The State is covered by secondary forest and in the northern part, the derived Savannah mosaic predominates. Originally, virtually all parts of the State had natural lowland tropical rain forest vegetation; but this has since given way to secondary forest regrowth's.

Data Collection

Matured fresh fruits and seeds of *Parkia biglobosa* were directly collected from mother trees by hand. The mother trees were collected from two towns from a Local Government Areas in each of the States and two towns were selected from each LGA where there was good concentration of *P. biglobosa* trees. The location selected are: Ekiti State; Moba Local Government Area (Ikun and Otun- Ekiti towns), Ondo State; Akoko North-West Local Government Area (Oke-Agbe and Ikaramu-Akoko towns), and Osun State, Odo-Otin Local Government Area (Ila-Odo and Ijabe towns).

In each town, matured fruits were collected from 10 trees that have sufficient fruits with no visible insect damage or disease symptoms, fruits were collected from the lower, middle and upper parts of the tree. A minimum distance of 100m was maintained between each selected tree in order to reduce the chance of sampling the same parental tree (sampling siblings). Four bunches of the fruits were collected from the 10 sampled trees from each village and were used for fruit and seed characteristics analysis. Pod number per bunch, pod length and pod breadth were taken using electronic caliper while pulp weight per bunch and seed weight per bunch were obtained with weighing balance.

Pulp and fruit processing

Diameter at Breast Height (DBH 1.3m above ground) of the sample trees was measured using girth tape. Latitude, longitude and elevation of sampled trees were recorded with GPS. The pulp and seeds collected were removed manually from the dry brown indehiscent pods of matured fruit by using hand to break the pods along the sutures (Shelling), de-pulping was done by manual by washing in water to remove the seeds from the pulp cover. Seeds were then sun dried, weighed, counted and packed.

Data analysis

Each of the tree measurement variable; pod and seed samples was aggregated by State. The means for each parameter were computed and analyses were carried out to investigate relationships among the States. Two-way analysis of variance (ANOVA) used (using SPSS version 10.0 for windows) to test the differences in morphological characteristics of tree parameters, pods and seeds and means were separated using New Duncan Multiple Range Test (DMRT).

Results

The distribution of tree growth characteristics of *P. biglobosa* in the three States in Southwest Nigeria was presented in Table 1 below. Mean tree heights of *P. biglobosa* trees across the States varied as shown in Table 1. Ekiti State had the highest mean height of 7.43m while the lowest mean height was from Ondo State with 6.92m. The mean height of tree samples were 7.43±0.68m (range: 2.7-13.5m), 7.11±0.61m (range: 3.3-13.0m), and 6.92±0.27m (range: 5.3-9.5m) for Ekiti, Osun and Ondo States in that order. The mean height across the three States was not significantly different ($P < 0.05$). The highest mean dbh was recorded in trees from Ekiti State (1.61±0.6m), followed by trees from Osun State (1.50±0.11m) and Ondo State had the least value (1.47±0.06m). There was also no significant difference in the mean dbh ($P < 0.05$).

Also, considerable variation was observed in the mean crown diameter of the trees across the three States with 13.71±0.85m, 12.80±1.08m and 9.20±0.92m for Ekiti, Ondo and Osun States respectively (Table 1). There was no significant difference in the mean values of tree height, and Dbh among the States under consideration. Whereas there are significant difference in the mean value of crown diameter of *P. biglobosa* trees from Ekiti and Ondo States.

Table 1. Tree growth characteristics of *P. biglobosa* (Mean±SE) from different States

Variables	States		
	Ekiti	Osun	Ondo
Tree height (m)	7.43±0.68 [a]	7.11±0.61 [a]	6.92±0.27 [a]
DBH (m)	1.61±0.06 [a]	1.50±0.11 [a]	1.47±0.06 [a]
Crown diameter (m)	13.71±0.85 [a]	9.20±0.92 [b]	12.80±1.08 [a]

NB: The values assigned the same letter in the same row are not significantly different at 5%

Morphological characteristics of P. biglobosa in the selected States

The disaggregated data for the different States showed that there were differences in morphological characteristics of this species across the States. The results of the descriptive statistics (minimum, maximum, mean, standard deviation and standard error) of all the parameters measured showed significant difference across the States (Table 2). Figure 2 shows the distribution of fruit pods and seeds attributes of *P. biglobosa* in the study area. The seed weight/tree, pod weight/tree and pod number/tree of trees from Ondo State were the highest when compared with samples from Ekiti and Osun States. Table 2 shows the pods and seeds attribute from the selected States. Trees with highest mean number of pods were from Ondo and Ekiti States are 40.60±2.21 and 37.15±2.00m, respectively which differed significantly ($P > 0.05$) from the average number of pods from Osun State. There were significant difference ($P > 0.05$) in the mean seed weight and pod weight of the trees across the states. Also, there were significant differences ($P > 0.05$) between the mean pod length per tree among the trees from Ondo state Ekiti and Osun States, but the mean pod breadth did not vary across the States.

Table 2. Fruit pods and seed attributes of *P. biglobosa* trees (Mean±SE) from different States.

Variables	States		
	Ekiti	Osun	Ondo
Pod number/tree	37.15.±2.00 [a]	31.00±1.86 [b]	40.60±2.21 [a]
Pod weight/tree (g)	168.20±7.17 [b]	115.63±5.21 [c]	187.91±3.54 [a]
Pod length /tree (cm)	22.27.±0.73 [b]	22.60±1.39 [b]	29.28.±1.90 [a]
Pod breadth /tree (cm)	23.21.±0.76 [a]	22.18±1.02 [a]	24.31.±0.54 [a]
Seed weight/tree (g)	99.72±8.17 [b]	75.16.±4.05 [c]	127.84.±4.90 [a]

NB: The values assigned to the same letter in the same row are not significantly different at 5%.

Table 3 below shows the morphological characteristics of *P. biglobosa* trees across the States. A wide variation was observed in all the tree growth variables. Tree height, crown diameter and Dbh ranged from 2.7 to 13.5m, 4 to 23.2m and 0.8 to 2.8m, respectively while the mean tree height, crown diameter and Dbh were 7.15±0.31m, 11.90±0.60m and 1.51±0.05m, respectively. The total number of pods/tree ranged from 17 to 59 and the mean number of

pods/tree was 36.25±1.26. The seed weight, pod length and pod breadth ranged from 31.51 to 176.18g, 14.54 to 48.52cm and 12.05 to 31.04cm, respectively. The mean seed weight, mean pod length and mean pod breadth were 100.91±4.40g, 24.72±0.91cm and 23.23±0.47cm, respectively. The pod weight/tree ranged from 53.09 to 224.2g and the mean pod weight/tree was 157.25±39.15g.

Table 3. Descriptive statistics of morphological characteristics of *P. biglobosa* trees.

Aggregated data	Minimum	Maximum	Mean±SE
Height (m)	2.7	13.5	7.15 0.31
Crown Diameter (m)	4	23.2	11.90±0.60
Dbh (m)	0.8	2.8	1.51±0.05
Pod number	17	59	36.25±1.26
Pod Weight (g)	53.09	224.2	157.25±39.15
Pod Length (cm)	14.54	48.52	24.72±0.91
Pod Breadth (cm)	12.05	31.04	23.23±0.47
Seed Weight (g)	31.51	176.18	100.91±4.40

Relationship between the phenotypic variables of Parkia biglobosa pods and seeds

The relationship between the fruit pod and seed of *P. biglobosa* is shown below as indicated by the correlation coefficient values obtained in this study (Table 4). The table shows the presentation of the correlation matrix of all the phenotypic variables of *P. biglobosa* obtained in the study area. Generally, high positive and significant correlations exist among the variables. There were strong and positive relationship among pod number per tree and pod weight per tree (0.703), which is the highest correlation coefficient value, while the least coefficient value (0.079), positive and significant was obtained between seed weight per tree and height. Also, there was strong and positive relationship between pod number per tree and seed weight per tree (0.586). On the other hand, Table 4 revealed that there was very low, negative and insignificant correlation coefficient (-0.112) between height and pod length per tree and also between the pod length per tree and crown diameter (-0.024).

Table 4. Correlation coefficient for phenotypic variables of *P. biglobosa*

Variables	Variables						
	Pod number/tree	**Height**	**Pod weight/tree**	**Seed weight/tree**	**Pod length/tree**	**Pod breadth/tree**	**Crown diameter**
Pod number/tree	1						
Tree height	0.098	1					
Pod weight/tree	0.703**	0.032	1				
Seed weight/tree	0.586**	0.079	0.787**	1			
Pod length/tree	0.148	-0.112	0.420**	0.405**	1		
Pod breadth/tree	0.193	0.031	0.422**	0.337**	0.318*	1	
Crown diameter	0.360**	0.432**	0.286*	0.357**	-0.024	-0.09	1

** Correction is significant at the 0.01 level (2 - tailed)

Discussion

The results of this study revealed that there were statistically significant variations in the height of tree, crown diameter, Dbh, pod number per tree, pod weight per tree, seed weight per tree, pod length per tree and pod breadth per tree of *P. biglobosa* across the selected States. This observation could be due to the substantial effects of the environmental such as rainfall, different temperature, soil types and distribution of the trees and land use types. This finding was in support of the report of [22]. Moreover, the reason for the differences in some of the morphological variation in height of the tree, diameter at breast height, crown diameter among others across the selected State could also be due to soil differences across the States, because difference soil types have difference nutrients thus, soil tend to enhance tree and fruit characteristics that are capable attributing to the seed development and maturation phase which increase seed mass [23]. Among the States, the height and diameter at breast height were statistically similar implying that the environmental factors such as rainfall, humidity, temperature play an important role in determining the tree growth characteristics, fruit and seed phenotypic of *P. biglobosa* that occurred in different States. Though, trees from Ekiti State had

higher tree height than other States; this may be due to the agro-ecological zone and soil in the State which encourages the physiological of the sampled trees such as height, production of better tree crown and diameter at breast height than other States. The differences expressed in the growth characteristics of *Parkia biglobosa* from the States could reveal that it has high genetic differences [24]. Therefore, in order to fulfill the aim of meeting the needs of subsistence farmer and farm produce for marketing, the knowledge of morphological characteristic of *P. biglobosa* tree is fundamental [25, 26].

All fruits and seeds variables varied significantly among trees in the States. As revealed by [27], there is significant variation among trees in natural population of indigenous fruit tree species in Africa. Also, from the results of this study, there were significant variations based on aggregated characteristics of the fruits and seeds. This result agreed with some other works that several factors such as natural, human and animal selections have historical interaction and greater effects in producing the geographic variation in tree species [28, 29] *Parkia biglobosa* trees in Ondo and Ekiti States had higher pod number, pod weight, pod length and breadth and seed weight. This confirms the report given by [15] that heavier fruits have potentially greater energy reserve for rapid and improved seedling development. However, the results of pod length and pod breadth indicated that Ekiti and Ondo States had higher values; this may be due to the advantages of the location of the States and the accelerated rate of water imbibition which favored rapid germination and fruit development [17]. These results support the report that the use of clones in fruit trees can increase productivity and that the potential of gaining high genetics can be achieved through classical tree breeding and vegetative propagation [30]. The qualitative characteristic, such as pod number per tree, pod length and pod breadth, could be an indication of strong genetic control which is strongly inherited such that substantial percentage of the progeny might be similar to their parents [31]. Therefore, further improvement of these qualitative characteristics should be considered.

Moreover, the high variations found in the fruit characteristics support the assertion that additive gene effects, environment and interaction of genotypes had an influenced [28]. It has also been reported that high fruit diversity among states could be due to climatic, edaphic, genetic and cultural factors [25]. The variations in the fruit and seed characteristics of this species are consistent with the results from other indigenous fruit trees, such as *Irvingia gabonensis* [23, 25] and *Dacryodes edulis* [32] *Sclerocarya birrea* [20]. As indicated in the results of the correlation matrix (Table 4), the higher the pod weights the higher the seed weight. This supported report of [33]. They also noted strong relationship between seed weight and fruit weight in *strychnos cocculoides*. *T. Hailemariam et al.* [34] reported on how fruit weight is also influenced by environmental factors largely by the amount of rainfall. Other studies that reported high values and that compared with the findings on *Parkia biglobosa* phenotypic variations in this study are [16, 25, 27]. *G.A. Fayenuwo* [21] reported that pulp weight in most fruits is not comparable with seed weight and that the percentage fruit pulp varies according to the origin.

Conclusion

The phenotypic variation of pods and seeds of *P. biglobosa* were observed in three States, Southwest Nigeria in this study. Ondo state had better characteristics than the other two States with respect to the highest mean values of weight, length and breadth of pods. The differences in the seed and pod properties between Osun and Ondo state were little pronounced. The results of this study will help to fill the knowledge gap on phenotypic variation in fruit and seed of *P. biglobosa* for domestication and tree improvement process.

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