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Morphological Variation of *Adansonia digitata L* Trees, Fruits and Seeds in Taraba State, Nigeria

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ABSTRACT

Information of phenotypic and genetic variation is a prerequisite for the domestication and improvement of baobab fruits from the wild. Farm-level tree growth characteristics, fruits and seeds phenotype of *Adansonia digitata* from Taraba state, Nigeria were assessed. Growth variables such as tree height, crown diameter, diameter at breast height were assessed on 15 trees of *Adansonia digitata* from 3 villages. Morphological characteristics of the fruits and seeds were measured. Means of each variable were computed and ANOVA was carried out to determine if there were significant differences between the locations. The result of the tree growth variables differs in the three locations. The mean height of the trees ranged from 6.42m in Yoro to 7.30m in Wukari, the crown diameter was 4.34cm in Wukari, 7.80m in Yoro while 11.08m was recorded for Kurmi. Tree mean dbh also ranged from 1.45m in Kurmi to 2.04m in Wukari. There were significant differences ($p<0.005$) in morphological variation of the fruits while that of the seeds showed no significant difference in the three selected locations. Mean fruit weight ranged from 205.15 ± 2.67g to 321.71 ± 18.09g, fruit length ranged from 15.64 ± 0.61 to 18.80 ± 0.77cm and fruit breadth from 8.97 ± 0.26 to 10.50 ± 0.23cm. The fruit weight, length, and breath were found higher in Wukari when compared to those from Yoro and Kurmi. The differences expressed for some of the growth characteristic of *Adansonia digitata* from different locations revealed sign of genetic differences and adaptation to different environmental conditions and soil type. This variation is important for domestication of *Adansonia digitata* and tree improvement through selection and breeding.

Keywords: Domestication, Diversity, Morphology, Phenotype, Breeding

Introduction

Forest trees contribute immensely to food security, nutrition and livelihoods in several ways; they serve as direct source of food, fuel and cash income to people in rural areas (Oyerinde *et al.,* 2018). Forest trees serve as basic to the survival of forest-dwellers, particularly many indigenous people, and are important providers of ecosystem services such as; maintenance and restoration of soil fertility, protection of watersheds and water course (FAO,2013). In addition, maintenance and incorporation of trees in agricultural landscape is a sure way for rural energy supply, economic development and poverty alleviation (FAO, 2013; Sobola *et al*., 2015).

Indigenous fruit trees can support environmental and social sustainability by providing food as well as promoting economic growth, most especially in the rural area of Nigeria (Akinnifesi *et al.,* 2008a). Varieties of edible indigenous fruits (baobab,

desert date, black plum, and tamarind), have been identified in Africa, and are widely consumed culturally and traditionally, supplementing peoples diet (Cemansky, 2015). In recent times, indigenous fruits and nuts of Africa's humid tropics are increasingly being recognized for their contribution to food security, health (nutrition/medicine), income generation, employment and environmental benefits. However, most of this important fruit trees are found in the wild, deliberate planting posed to be very scanty among farmers leading to vast disappearance of some of this important species in their natural environments (Franzel, *et al.*, 2008). Farmers have been able to enjoy the fruit of these plentiful wild trees without developing any knowledge of how to propagate them successfully (Cemansky, 2015). The restoration of ecosystems and conser-vation of endangered species involves the recovery of indigenous species, propagation and the deliberate reintroduction of species that would have been lost. However, cultivation of the trees yielding these fruits and nuts is constrained by lack of improved planting materials that are true-to-type and have a short enough juvenile phase to fruit production.

One of the important forest fruit trees with multiple benefits is *Adansonia digitata* L. also known as the Baobab tree. It belongs to the Malvaceae family and occurs throughout semi-arid and arid zones of Africa. It is a massive, deciduous tree up to 25m in height and may live for hundreds of years (Assogbadjo *et al.*, 2011). Baobab is a multipurpose tree with multiple uses, every part of the plant has been reported to be very useful (Gebauer *et al*., 2002; De Caluwé *et al*., 2010). The leaves of *A. digitata* are used in the preparation of soup and seeds are used as a thickening agent in soups, they can also be fermented and used as a flavoring agent, or roasted and eaten as snack (Kaboré, 2011). The pulp is also useful in drink production while the bark is used in making ropes and mat while the root is used medicinally for the cure of arthritis (Sidibe and Williams, 2002; Vertuani *et al*., 2002). Additionally, baobab oil, extracted from the seed, is used in the cosmetics industry and is also sold internationally (Gruenwald and Galiza, 2005). *Adansonia digitata* has a wide range of geographical distribution in Nigeria but its survival is, however threatened by bush fire, overexploitation grazing and lack of natural regeneration (Assogbadjo *et al.*, 2011). Presently, there is scarcity of information on phenotypic and genetic structure of baobabs in Taraba State, Nigeria, even though the species is extremely important socially and economically, but the knowledge of variation of phenotype in any species is prerequisite in agro forestry and successful domestication purposes (Dawson *et al*., 2008). The current study was undertaken to determine the pattern of fruit and seed variation occurring between and within five baobab populations selected from different agro ecological zones in Taraba State.

Materials and Methods

Study area

This study was conducted in Taraba State, Nigeria. The State lies between latitude 6° 30' and 8° 30'N of the equator and between longitudes 9° 00' and 12° 00'E of the Greenwich meridian at the North Eastern part of Nigeria. The State had a land area of 60,291km^2 with a population of 2, 294, 8000 (National Population Census of 2006). Taraba State is regarded as nature's gift to the nation because of its abundant natural resource that

was endowed in the State. It is an agrarian community, blessed with tropical climate, characterized by dry and wet seasons. The dry season reach its peak in January and February, when the dusty north east trade winds blow across the State (Oruonye and Abbas, 2011; Taphee and Janguar, 2014). Rainfall starts in the month of April and ends in November in the southern part, while in the north, rainfall starts in May/June and ends in October/November. Thus, the southern part of the State usually has 7-8 months of rainfall, while, the North has about 6-5 months of rainfall. The mean annual rainfall is 1,350mm while the maximum temperature ranged between 30°C and 39.4^{o}C and the minimum temperatures range between 12°C and 23°C (Oruonye, 2011).

Data Collection

Data for this research were collected purposively from three (3) Local Governments Areas (Wukari, Yorro and Kurmi Local Government Areas). The locations were purposively selected for the study following a reconnaissance survey carried out to locate where there is abundance of *Adansonia digitata* trees within the State. This was followed by purposive selection of one Village each, from the Local Government Areas. The selected villages are; Wukari LGA (Tar-orshi village), Yorro LGA (Lankavri village), Kurmi LGA (Ndakuru village). Five trees that have sufficient fruits with no visible insect damage, distress or disease symptoms were selected from each village. A minimum distance of 100m was maintained between each selected tree in order to reduce the chance of collecting seedlot predominantly by half siblings (Norman, 2013). Tree growth characteristics of the individual trees were obtained from a total 15 trees in the study sites. Diameters at Breast Height (DBH) were taken at 1.3m above the ground level of the each sampled trees and they were measured using girth tape. The height of the trees was measured with the use of Spiegel relascope while tree crown diameter was measured manually by projecting the edges of the crown to the ground and measurement was taken using measuring tape. Fruits were collected from the lower, middle and upper parts of the trees. Measurement of morphological characteristics such as pod and seed diameter, pod and seed length as well as pod and seed breadth were taken using electronic veneer caliper while pod weight and seed weight were obtained with the use of weighing balance.

Data analysis

Two- way analysis of variance (ANOVA) was used to test the differences in morphological characteristics of tree variables, pods and seeds and means were separated using Duncan Multiple Range Test (DMRT).

Results

The distribution of tree growth characteristics of *Adansonia digitata* in three selected Local Governments Area in Taraba State, Nigeria is presented in Table 1. The mean tree heights of *Adansonia digitata* trees varied across the three Local Governments as shown in Table 1. The highest tree mean height (7.30±0.36m) was recorded in Wukari LGA while the lowest mean height (6.42±0.65m) was recorded in Yorro LGA. The tree diameter at breast height (DBH) for the three locations ranged from 1.45m to 3.0m. While the mean DBH of the trees were 2.04±0.32m, 1.66±0.07m and 1.45±0.13m for Wukari, Yoro and Kurmi Local Government Areas respectively (Table 1). The value for the mean tree crown diameters ranges from 4.34±1.02m to 11.08±1.09m, ANOVA revealed a significant

difference at (p<0.05%) in the tree crown diameters across the three LGAs. However, there was no significant difference (p<0.05) in the mean height and diameter at breast height recorded for the trees across the LGAs.

Table 1: Tree growth characteristics of *A. digitata* (Means±SE) across the three locations

Variables	Local Government Areas		
	Wukari	**Yoroo**	**Kurmi**
Tree height(m)	7.30±0.36 [a]	6.42±0.65[a]	7.10±0.35 [a]
DBH (m)	2.04±0.32 [a]	1.66±0.9 [a]	1.45±0.15 [a]
Crown diameter (m)	4.34±1.02 [c]	7.8±0.24[b]	11.08±1.09[a]

NB: *The values assigned to the same letter in the same row are not significantly different at 0.05%*

Morphological Characteristics of *Adansonia digitata* Fruits and Seeds in the Study Area

Table 2 indicates the morphological characteristics of *Adansonia digitata* fruits and seeds in the study area. The result of the fruit weight/tree, fruit length/tree, fruit breadth/tree and number of seeds/tree showed significant differences (P>0.05) across the LGAs. However, the pulp weight/tree, seed weight / tree, seed length/tree andseed breadth/tree, in the three locations were not significant (P>0.05). The highest fruit weight (321.71±18.09g) was recorded for samples from Wukari LGA, while the least (205.15±26.76g) was recorded in Yoro LGA .

The fruits length (cm) across the three LGAs varied significantly and the highest mean (18.80±0.77m) was recorded in Wukari LGA while the least of 15.64±0.61cm was obtained in Yoroo LGA. The fruit breadth of *A.digitata* also ranged from 8.97±0.26 - 10.50±0.23cm while, the number of seeds per tree were 135.20±38.9, 130.28±26.92and 61.16±12.52 in Wukari, Yorro and Kurmi LGAs respectively (Table 2). The result revealed significant differences at (p>0.05) in fruit length, breadth and number of seeds/ tree across the three Local Government Areas. However, the mean seed weight were 64.66±15.34g, 52.85±14.01g and 48.53±11.17g for Wukari, Yorro and Kurmi, while seed length and breadth for Wukari, Yoro and Kurmi LGAs were (0.54±0.93cm, 0.39±0.06cm), (0.54±0.09cm, 0.47±0.81cm), and (0.37±0.06cm, 0.46±0.07cm) respectively. The mean values for pulp weight were 18.62±3.77g, 14.21±2.83, and 10.41±1.85 for Wukari, Yoro and Kurmi respectively. However, the result showed that there were no significant difference for the three variables (P<0.005) .

Table 2: Fruit pods and seed attributes of *Adansonia digitata* (Mean ±SE) from the locations

Variables	Local Government Areas		
	Wukari	**Yorro**	**Kurmi**
Fruit weight (g)	321.71±18.09 [a]	205.15±26.76 [b]	245.88±15.52 [b]
Fruit length (cm)	18.80±0.77 [a]	15.64±0.61 [b]	15.95±1.38[b]
Fruit breadth (cm)	10.50.±0.23 [a]	9.08±0.37[b]	8.97.±0.26 [b]
Pulp weight (g)	18.6±3.77 [a]	14.21±2.83 [a]	10.41±1.85 [a]
Number of seeds/pod	135.20.±38.92 [a]	130.28±26.92 [a]	61.16±12.52 [b]
Seed weight (g)	64.66±15.34 [a]	52.85±14.01 [a]	48.53±11.17 [a]
Seed length (cm)	0.54±0.93 [a]	0.39±0.06 [a]	0.54±0.09 [a]
Seed breadth (cm)	0.47±0.81 [a]	0.37±0.06 [a]	0.46±0.07 [a]

NB: *The values assigned to the same letter in the same row are not significantly different at 0.05%*

Relationship between the phenotypic variables of *Adansonia digitata* fruits and seeds

The relationship between the trees, fruit pods and seed of *A. digitata* is shown in table 3 and it indicated the correlation coefficient values obtained in this study. The table shows the presentation of the correlation matrix of all the trees variables and the phenotypic variables of *A. digitata* obtained in the study area. Generally, high positive and significant correlations exist among the variables. There were strong and positive relationship among pod weight and fruit weight (0.920). The result also revealed that the highest correlation coefficient value of 0.938 exist between the seed breadth and seed length of *A. digitata* examined in three LGAs of Taraba State as shown in table 3, while there is no coefficient value (0.00), though positive and not significant was obtained between crown diameter and seed breadth. Also, there was weak and negative relationship between crown diameter and seed breadth (-0.397). On the other hand, Table 3 also revealed that there was very low, positive and insignificant correlation coefficient (0.042) between dbh and seed breadth, and between the no of seed per pod and fruit length (-0.026) the result of correlation coefficient was low, negative correlated.

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Table3: Correlation coefficient for phenotypic variables of *Adansonia digitata*

	Variables											
Variables	Fruit Length	Fruit Breadth	Fruit Weight	Pod Weight	Pulp Weight	Number of Seeds/Pod	Seed Weight	Seed Length	Seed Breadth	Tree Height	Dbh	Crown Diameter
Fruit Length	1											
Fruit Breadth	0.115	1										
Fruit Weight	0.360**	0.743*	1									
Pod Weight	0.334**	0.626**	0.920**	1								
Pulp Weight	-0.166	0.186	0.093	0.149	1							
Number of Seeds / Pod	-0.026	0.186	0.154	0.192	0.694**	1						
Seed Weight	-0.032	0.226	0.135	0.178	0.732**	0.776**	1					
Seed Length	-0.171	-0.052	-0.017	0.059	0.732**	0.542**	0.671**	1				
Seed Breadth	-0.134	0.031	0.038	0.111	0.777**	0.614**	0.695**	0.938**	1			
Tree Height	0.297**	-0.124	-0.090	-0.036	0.012	0.023	-0.074	-0.087	0.039	1		
Dbh	0.386**	0.182	0.385**	0.399**	-0.028	0.206	0.068	0.034	0.042	-0.066	1	
Crown Diameter	0.295*	-0.397**	-0.255*	-0.221	-0.180	-0.099	-0.079	0.029	0.000	0.507**	-0.165	1

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

Discussion

Tree Growth Characteristics across the Vegetation Zones

Domestication is an accelerated and human induced evolution to bring wild or semi-wild trees into wider cultivation, the consequences of which are an alteration, loss or gain of genes (Akinnifesi *et al*., 2004). For a successful domestication of indigenous trees there is need for phenotypic selection based on tree characteristics in the field as well as that of fruits. This will enhance the selection of best performing provenance (Atangana *et al*., 2001 and Anegbeh *et al.*, 2003). The result of this study revealed significant variation in crown diameter, fruit length, fruit breadth and fruit weight of *Adansonia digitata* in the three selected Local Government Areas. The differences expressed for some of the growth characteristic of *Adansonia digitata* from different local government revealed high genetic differences among the trees sampled and measured. Okello (2010) also observed a significant variation in growth characteristics of *Adansonia digitata* across three vegetation zones in in Kordofan States, in Sudan.

Moreover, the differences observed in crown diameter of the tree are an indication that environmental factors play an important role in determining trees characteristics. It is a well established fact that the larger crown diameter of a tree, the more the quantity of fruits produced (Katsvanga *et al*., 2007).

The knowledge in phenotypic variation is fundamental in developing efficient forest conservation, domestication and tree breeding strategies (Sreekumar and Renuka, 2006). In addition, the knowledge of intraspecific diversity of the baobab trees is fundamental to fulfilling the goal of meeting the demands of subsistence farmers and product markets. The present results have revealed substantial variation in fruit traits across the study sites. Fruit and seeds from Wukari local government showed better trait than other area in the state with respect to the mean weight, length and breadth of pods. The findings are important because they suggest the potential of achieving high genetic gains through classical tree breeding and through vegetative propagation. The results support the assertion that use of clones in fruit trees might increase productivity rapidly (Akinnifesi *et al.*, 2008a). Moreover, the selective advantages in the drier areas and the heat land load of developing seed before fruit abscissions and the accelerated rate of water inhibitions which whereby favored rapid germination and fruit development could also be responsible (Nobel, 1991; Maranz and Wiesman, 2003). However, the values obtained for fruit sizes and weight in this study is higher when compared to those obtained by Munthali (2012) in Malawi. This is an expression of high polymorphism existing in populations of baobabs in the state. In general, all the populations possess fruit sizes that are of economic value and can be used for domestication purposes. Franzel *et al*., (2008) noted that the sale of fruits is based on size (weight, length, width); with bigger fruits fetching higher prices. Hence, domestication effort should be targeted on trees with bigger fruits as this may significantly uplift the life of many rural masses through the income generation from the sales of Baobab products. Furthermore, the result of this study helps to fills the gap on knowledge for *Adansonia digitata* phenotypic variation for fruit and seeds characteristic in the domestication and tree improvement process. The qualitative characteristic such as number of seeds per fruits, fruit length and

fruits 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 (Akinnifesi *et al*., 2008b). Therefore, the further improvement of these qualitative characteristics should be considered. The high fruit diversity across the area could be due to climatic, edaphic, genetic and cultural factors (Katsvanga *et al*., 2007).

The variation in fruit characteristic for each tree among the ecosystems indicated that the higher the fruit weight, the higher the fruit breadth. There is also a positive correlation between the seed weight and the pulp weight recorded in this study. Which is consistent with the findings of Oyerinde *et al*. (2018) who revealed a strong positive relationship between pod weights and seed weight in *Parkia biglobosa*. Variation in phenotypic characteristics of fruits and seeds has been attributed to influence by environmental factor largely by the amount of rainfall of the actual area of specification (Katsvanga *et al*., 2007).

Conclusion

The result of this study revealed significant variation only in crown diameter, fruit length, fruit breadth number of seeds/tree and fruit weight of *Adansonia digitata* in Wukari, Yorro and Kurmi LGAs in Taraba state. The growth characteristics of trees in Wukari LGA revealed a better and higher growth characteristic with respect to tree height, DBH and crown diameter. The differences expressed in the growth characteristic of *Adansonia digitata* from different LGAs is an indication of a high genetic differences. Highest mean values of fruit weight, length and breadth and number of seeds /fruit in Wukari LGAs shows that environmental factors play an important role in determining tree characteristics.

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