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MORPHOLOGICAL TRAITS OF SELECTED *Blighia sapida* K. D. Koenig. TREES AND FRUITS FROM RAINFOREST AND SAVANNA ZONES OF SOUTHWESTERN NIGERIA

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ABSTRACT

Forest fruit trees products are essential for the livelihood of millions of poor farmers in tropical developing countries and many of these fruit trees have not been domesticated but only exist in their natural habitat but many are eroded due to overexploitation. Thus, this study was carried out to determine the morphological characters of *Blighia sapida* in rainforest and savanna zones of Ondo, Osun and Oyo States, Nigeria. Ten percent (10%) of the total number of local governments in each ecological zone were selected for this study. Three (3) *Blighia sapida* trees were selected from each local government and their diameter, height and crown diameter were measured. Sampled matured *Blighia sapida* fruit were collected from three (3) trees selected and the seed weight, fruit length, aril weight and length of the fruit were measured. The data were subjected to descriptive statistics. The result of tree variables show that the highest crown diameter of 11. 82cm was recorded in Ondo State rainforest and the least value of 4.74cm was observed in Oyo State savannah zone. But for dbh the highest 1.88m was found in Osun savannah while least 0.32m was recorded in Ondo savannah and for the total height the highest was 11.77m and least was 6.05m for all were in Oyo rainforest and savannah respectively. The results of the fruits morphology of fruit of *B. sapida* collected from different trees showed that the highest seed weight, fruit weight and aril weight were 15.37g, 97.00g and 22.61g in Ondo State savannah zone and 61.53g for the pod weight in rainforest zone. The result of fruit length of the *B. sapida* collected from ecological zone in different State differs from one zone to another. The morphology trait of the *B. sapida* tree varies across the study areas thereby contributing to the variations in the fruit parameters. The morphological traits is a good devise for a proper domestication strategy that will encourage the wide use of the plant as food supplements in food manufacturing companies.

Keywords: Savanna, Rainforest, *Blighia sapida*, Characters, Domestication.

INTRODUCTION

Non-timber forest products tree species are essential for the livelihood of millions of poor farmers in tropical developing countries. They are part of the threatened biological assets of the rural poor representing an appreciable wealth of agro biodiversity that has the potential to contribute to improve incomes, food security and nutrition (Simons and Leakey, 2004). Healthy forest ecosystems are particularly important to the rural poor in developing countries, especially those with very close connection with their natural ecosystems. Angelsen and Wunder (2003) noted that timber, non-timber forest products (NTFPs) and animal protein from forest ecosystems are all used by the rural poor for subsistence, as well as sources of income and employment. In some centuries, rural communities have depended on the exploitation of natural resources from forests in order to satisfy their basic subsistence needs. It has been estimated that about 90% of the world's poor depend on forests for at least a portion of their income (World Bank, 2000). In Africa for example, 600 million people have been estimated to rely on forests and woodlands for their livelihoods (Anderson, 2006), and in India, 50 million people are estimated to directly depend on forests for their subsistence alone.

Blighia sapida is a wild fruit plant which belongs to the family of Sapindaceae. It is native to tropical West Africa including Benin, Cameroon, Côte d'Ivoire, Ghana, Guinea, Liberia, Nigeria, Senegal and Togo. It is also referred to as ackee or ackee apple. The trunk diameter can reach 12 m and it supports a dense crown of spreading branches over 182 cm above the ground. The ackee is indigenous to the forests of most West African countries where the fruits are rarely eaten but are used for other purposes. For example, In Ghana for instance *Blighia sapida* is used as ornamental plants and also as shades. The green fruits of this plant produce lather when mixed with water and are therefore used for laundry while the seeds find use in soap making because of their oil content the wild, densely branched and symmetrical, with smooth gray bark as reported by (Oteng-Amoako, 2006).

It is popularly called Gwanja Kusa in Hausa, Isin in Yoruba and Okpu in Igbo. *B sapida* occurs naturally from Senegal to Cameroon and possibly also in Gabon. *Blighia sapida* is a large tree reaching up to 35m in when ripe, the fruit sections split and the shiny black seeds become visible (Plate 1 a & b). The fruit turns red on reaching maturity and splits open with continued exposure

to the sun (Morton, 1987; ICRAF, 2009). Initial growth of *B. sapida* is fast on moderately fertile soils. Seedlings grow best in gaps in the forest canopy; with a mean annual height increment of 70 cm. Crane and Berladi (2008) noted that, in Florida, trees raised from seedlings start producing fruit after 3–6 years, while grafted trees produce fruit in 1–2 years. McMillan *et al*., (2003) also recorded an attack by *Verticillium dahliae*, causing wilt and dieback. Tree domestication in agroforestry is defined as a farmer-driven and market-led process, which matches the intraspecific diversity of locally important trees to the needs of subsistence farmers, product markets, and agricultural environments. The first step before developing a domestication strategy for any species is to collate all available information on the species including botanic descriptions, geographic distribution, ecology, forest inventories, and farmers' survey, harvesting techniques, trade figures, conservation status and genetic variation patterns (Simons and Leakey 2004). For *B. sapida,* some of these required key issues have been recently addressed (Ekué *et al.*, 2004; Dossou *et al.*, 2004; Codjia *et al.*, 2003). Nevertheless, farmers' knowledge on uses, processing, management and perception about intraspecific variation are not yet fully documented. The documentation provides testable hypotheses for research that can accelerate the delivery of improved tree planting material to farmers (Weber *et al.*, 2001). This paper addresses the morphological variations of *B. sapida* trees and fruits across the rainforest and savanna vegetation zone of Southwestern Nigeria with an aim to increase knowledge for domestication and sustainable management.

Plate 1: (a) A young plant of *Blighia sapida* Tree (b) Fruit of *Blighia sapida* showing aril & seed

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METHODOLOGY

Study Area

This study was conducted within the Southwestern region of Nigeria (Fig 1). A multistage sampling technique was used for this study. During the first stage selection techniques, Ondo, Oyo, and Osun States were randomly selected out of the six States in Southwestern Nigeria. At the second stage selection, it involved selection of two ecological zones (rainforest and savanna ecosystem) each was purposively selected based on the availability of the *B. sapida* trees in the region. Ondo State lies between latitudes $5^0$45' 00"N and $7^0$45' "N and longitudes $4^0$15'00"E and$6^0$0' 00"E. The State has a land area of about 15,500km^2 and it was bounded on the East by Edo and Delta States, and on the West by Ogun and Osun States, while in the North it was bounded by Ekiti and Kogi States and to the south by the Bight of Benin and the Atlantic Ocean. Osun State covers an area of approximately 14,875km^2, lies between latitude $6^0$45'00"N and $8^0$15'00"N and longitude $4^0$0'00"E and $5^0$10'00"E in south western Nigeria. The State is bounded by Ogun, Kwara, Oyo, and Ondo States in the South, North, West and East respectively. Oyo State is located in the Southwestern zone of Nigeria. It covers a total of 27,249km^2 of land mass, situated between latitude $7^0$0'00"N and $9^0$15'00"N and longitude $2^0$30'00"E and $4^0$30'00"E. Oyo State was bounded in the south by Ogun State, in the North by Kwara State, in the West it is partly bounded by Ogun State and partly by the republic of Benin, while in the East by Osun State (Adekunle, 2009).

Sampling Techniques and Data Collection

Ondo State has a total of 18 Local Government Areas, 4 out of it were in the savanna and 14 in the rainforest. In Oyo State, there are 33 LGAs, 24 were in the savanna and 9 (Olawale, 2015) in the rainforest while in Osun state which has a total of 30 LGAs, 18 were in the savanna and 12 in the rainforest. For this study, 10% of the LGAs in each vegetation zone were randomly selected. For vegetation zones where the percentage of the local government was not up to one (1), one local government was picked. Three matured *B. sapida* trees were purposively selected from each local government and the diameter at breast height; total height and crown diameter of the selected *B. sapida* tree were measured using girth tape, relaskop and diameter tape respectively. Thereafter, samples of matured *B. sapida* fruit were collected from the three trees and the seed

weight, fruit weight, pod weight, aril weight and fruit length were measured using weighing balance and veneer caliper. The fruits from the three trees were combined together for analyses.

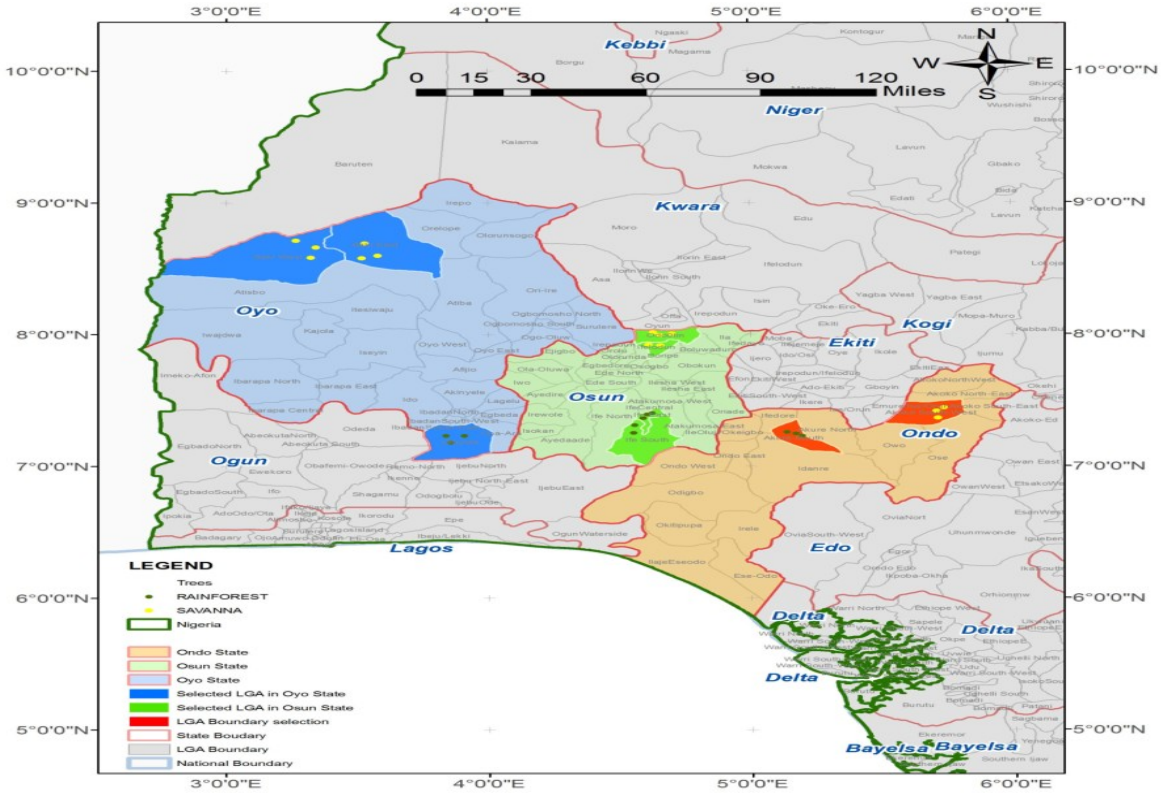

Figure 1: Selected LGAs and Tree locations in the study area

Method of Data Analysis

Data obtained from the measurement of morphological variables of *B. sapida* trees and fruits were analyzed using descriptive statistics. Test for correlation between the different variables were further carried out using Pearson correlation tool in SPSS 17.0.

RESULTS

Morphology of *B. sapida* Trees across the Study Areas

The result of individual trees selected from each ecosystem was measured and the results of the tree height, crown diameter and diameter at breast height were showed in the figure 2. The result of tree variables from Osun State showed that crown diameter revealed that rainforest trees had the mean value of 8.61 cm while the trees in the savanna had the crown diameter mean value of 7.91 cm which is lower than the rainforest respectively. But for the diameter at breast height,

trees from the savanna had the highest value of 1.88 m while the trees from the rainforest had 1.33 m and the value of trees total height for rainforest tree was significantly lower with the value of 10.51m than trees total height from the savanna with a height of 10.54 m respectively. Also, the results of crown diameter of trees assessment of *B. sapida* encountered from Oyo State also showed that crown diameter of the trees of *B. sapida* from rainforest were higher with 5.5 m than the trees from savanna zone of the State with 4.74 m, and the result of tree diameter of *B. sapida* sampled from Oyo State revealed that rainforest zone trees were higher with 1.35 m averagely than 0.78 m for the trees from the savanna area of the State. Meanwhile, the results of the total trees height showed that trees from rainforest had 11.77 m and this was higher than the trees from the savanna zones of the State with 6.05 m mean value respectively. The results of On-farm trees assessment for the trees in Ondo State showed that crown diameter of trees from rainforest zone of the State had 11.82 m and this is higher than the trees from the savanna zone of the State with the average of 7.77 m. The result of the tree diameter at breast height followed the same trend where the trees from the rainforest had the average of 1.00 m and the trees from the savanna were with 0.32m as an average trees diameter. Also, the trees total height from the rainforest was significantly higher with an average of 9.6 m than the trees from savanna with 7.4 m respectively.

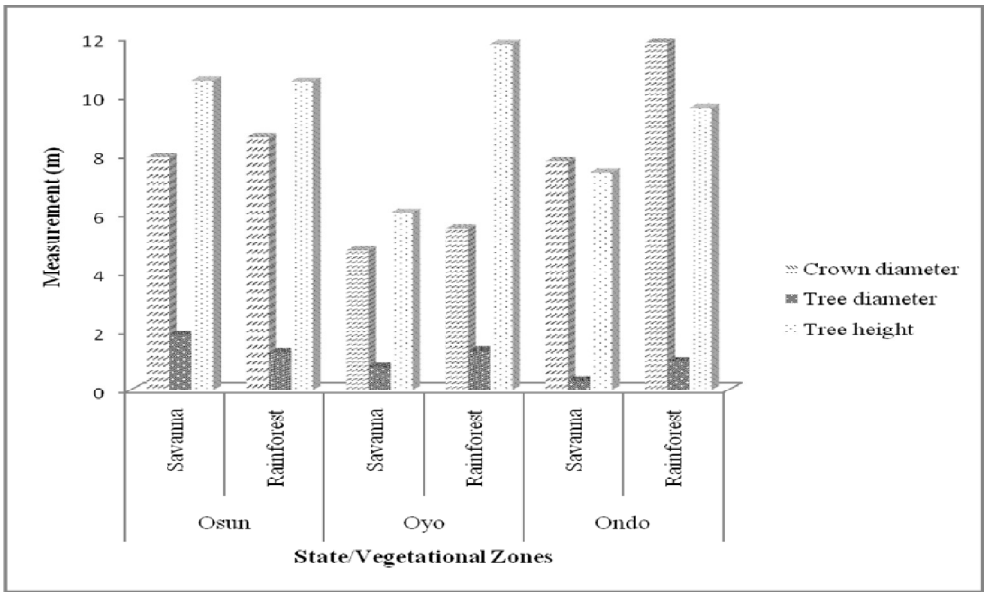

Figure 2: Morphology of *Blighia sapida* Trees in the States/Vegetation Zones

Results of Fruit Morphology for *B. sapida* Fruit across the Study Area

The results of the fruits morphology of fruit of *B. sapida* collected from different trees sampled in Southwest of Nigeria were showed in Figure 2. The result revealed that seed weight from Osun State savannah shows a higher significant of 11.85 g than the seed weight from the rainforest ecosystem with 4.77 g. More so, it was observed in all the seed variables measured, for fruit weight from Osun State, the mean value was 61.28 g for savanna seed while it was 42.81 g for the fruit weight of *B. sapida* from rainforest the same State. Likewise, for the aril weight, *B. sapida* mean result from savanna had 8.26 g of aril weight which was higher than the aril weight from the rainforest zone of the State with the average of 4.79 g of aril weight. The result of pod weight of the of the fruits of *B. sapida* from rainforest ecosystem of Osun State were significantly lower with the mean value of 33.24 g than the pod weight of 41.03 g for the pod weight of *B. sapida* fruits from savanna ecosystem from the same State respectively. The results of fruits morphology of *B. sapida* from Oyo State shows that for the *B. sapida* collected from rainforest had the mean value of 10.43 g seed weight and for the seed weight of savanna ecosystem had the mean of 14.01g respectively. Also, the fruit weight of *B. sapida* fruits, aril weight, and pod weight from the same Oyo State had 51.98 g, 5.86 g and 35. 72 g for the rainforest fruits measured, but the fruits of *B. sapida* measured from savanna zone had higher mean values of 63.42g, 8.34 g and 41.05 g respectively. The results of *B. sapida* fruits measured from Ondo State revealed that the fruits from the savanna area of the State were significantly higher than the fruits from the rainforest ecosystem zone with the mean value of 7.48 g, 80.05 g, 10.75 g and 61.53 g for seed weight, fruits weight, aril weight and pod weight for the fruits collected from rainforest zone whereas the mean value of the *B. sapida* fruits were 15.37g, 97.00g, 22.61g and 60.79 g respectively for the fruits morphology from savanna zone of Oyo State respectively. The result of fruit length of the *B. sapida* collected from ecological zone in different State of Southwest of Nigeria differs from one zone to the others. The result of the fruits length from Osun showed that the fruits from savanna zone had 50.4 mm and the fruits from rainforest had 54.73 mm. But for the fruits from savanna zone of Oyo State had 57.72 mm where the rainforest fruit had a 52.24 mm fruit length respectively. The case was also the same for the fruits from Ondo State in which the fruits from savanna zone had a mean value of 46.60

mm which was higher than the fruits from rainforest zone of the State with mean value of 44.49 mm (Fig. 2)

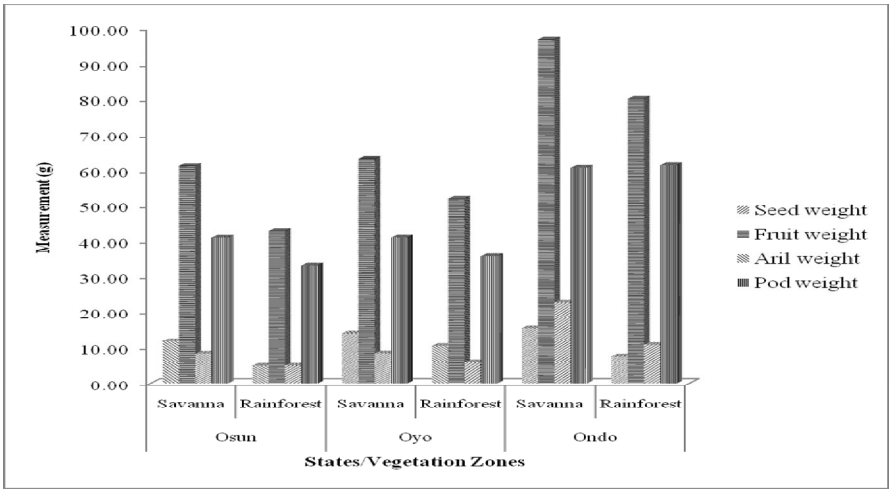

Figure 2: Weight of *Blighia sapida* Fruit in the States/Vegetation Zones

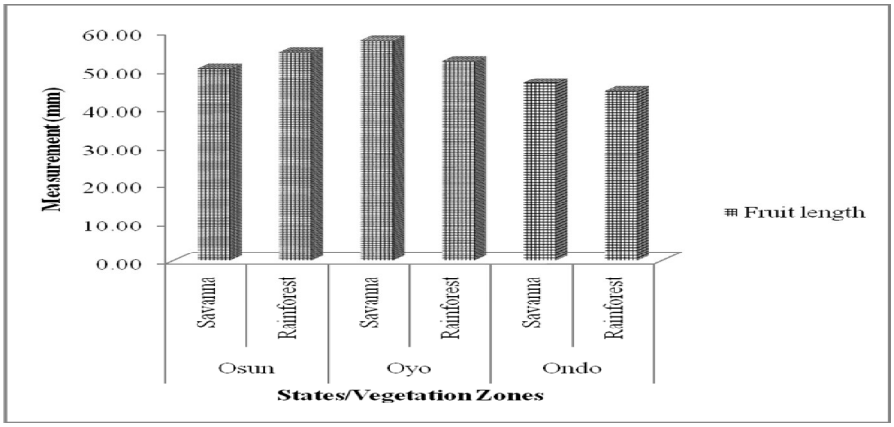

Figure 3: Length of *Blighia sapida* Fruit in the States/Vegetation Zones

Correlation between the Morphology of Fruit and Tree of *B. Sapida* across the Study Areas

The correlation matrix result between fruits and trees measured in the study areas were presented in Table 1 and 2. Generally, high, positive and significant correlations were found to exist between the fruits and tree growth variables. Results from savanna zone of the study area (Table 1), revealed that there is a positive significant correlation between the aril weight and the fruit

weight (0.99), pod weight and fruit weight (0.99) and there is a perfect correlation between pod weight and aril weight with (1.00) respectively. Also it was noted from Table 1 that the relationship that exist between the fruit weight and seed weight was positive but not significant at 0.005 level of significant with (0.83), aril weight and seed weight (0.80), pod weight and seed weight (0.80) tree height and crown diameter (0.76), tree height and tree diameter (0.83) respectively. But the correlation matrix between fruit length and seed weight, fruit length and fruit weight, fruit length and aril weight as well as fruit length and pod weight were not significant and it was negatively strong with the values of (0.21), (-0.73), (-0.76) and (-0.76) respectively (Table 1).

The result for correlation matrix between fruit of *B. sapida* and trees parameter from rainforest zones were presented in Table 2 below. Results showed that there were strong positive correlation between the aril weight and fruit weight (0.99) and the result was significant at 5% level of confidence limit. Also the relationship that exists between pod weight and fruit weight, tree height and tree diameter, pod weight and aril weight (0.99), (0.89), (0.99) were also strong and positive respectively. But correlation that exists between fruit length and fruit weight (-1.00), fruit length and aril weight was strong correlation significant but has negative (Table 2). Also, correlation that exist between tree height and crown diameter (-0.99), tree diameter and pod weight (-0.98) tree diameter and crown diameter (-0.93) were negative but strong correlation exist between the two variables (Table 2).

Table 1: Correlation table for the fruit and trees of *B. sapida* fruits from savanna zones

	Seed weight	Fruit weight	Aril weight	Pod weight	Fruit length	Crown diameter	Tree diameter	Tree height
Seed weight	1							
Fruit weight	0.825	1						
Aril weight	0.797	0.999*	1					
Pod weight	0.794	0.999*	1.000	1				
Fruit length	-0.211	-0.726	-0.759	-0.761	1			
Crown diameter	-0.169	0.418	0.461	0.465	-0.928	1		
Tree diameter	-0.995	-0.763	-0.731	-0.728	0.110	0.268	1	
Tree height	-0.771	-0.276	-0.229	-0.225	-0.460	0.758	0.832	1

**Correlation is significant at the 0.05 level (2-tailed).*

Table 2: Correlation Matrix table for the Fruit and Trees of *B. sapida* from rainforest zones

	Seed weight	Fruit weight	Aril weight	Pod weight	Fruit length	Crown diameter	Tree diameter	Tree height
Seed weight	1							
Fruit weight	0.212	1						
Aril weight	0.144	0.998*	1					
Pod weight	0.055	0.987	0.996	1				
Fruit length	-0.209	-1.000	-0.998*	-0.988	1			
Crown diameter	-0.513	0.730	0.775	0.829	-0.732	1		
Tree diameter	0.156	-0.932	-0.955	-0.978	0.933	-0.928	1	
Tree height	0.598	-0.656	-0.707	-0.768	0.659	-0.995	0.885	1

**Correlation is significant at the 0.05 level (2-tailed).*

DISCUSSION

Assessment and description of trait variation is important in fruit tree assessment, thus, assessment of the morphological features of fruits, seed and tree growth characteristics of *B. sapida* tree in different ecosystem as well from different State was aimed at knowing the differences that exists in trees, fruits and seeds of selected fruit tree species under investigation. The results of this study show that the tree growth assessment of *B. sapida* tree varies significantly from one State to another and from one ecosystem zone to another. Also similar variation was observed in the fruit and seed morphology. Therefore, this was in agreement with the report of Assogbadjo *et al*., (2005) who reported variation in morphological and productivity of individual baobabs according to the climatic zones. Environmental effects on the biotic variables have also been observed in other edible trees in Africa. Some previous studies such as the research on *Adansonia digitata* in Senegal (Assogbadjo *et al*., 2005) and Benin Maranz and Wiesman (2003), supported the result of this finding that there are differences in trees parameters from one region to another region. The result of this study showed that crown diameter obtained from rainforest zone had higher value of 8.61 m than savanna trees species with 7.91 m. This could be attributed to higher rainfall in rainforest zone which will aid higher vegetative

development. Katsvanga *et al*., (2007) reported that differences exist among different sites are largely attributed to climatic, edaphic, genetic, and cultural factors in Malawi when they investigated phenotypic variation in fruit and seed morphology of *Adansonia digitata* from five selected wild populations in Malawi, thus the result obtained in this research is in line with their report. Also, the result of this study revealed that trees from the savanna area of the study site have tendency to store food component around the circumference of the trees than the trees from the rainforest (Maranz and Wiesman, 2003). The bigger trees of the species in the savanna ecosystem may be attributed to their older age and thus larger stem. In addition, the bigger diameter of *B. sapida* trees in the savanna zone can be attributed to differences in the climatic conditions from one ecosystem to the other (Giffard, 1967). The climatic condition in the savanna zone of the study sites is more suitable for the growth of *B. sapida* trees than the climatic condition in the rainforest zone, since the *B. sapida* is mostly found in the derived savanna species (Keay, 1989). The value of trees total height for rainforest tree was significantly lower with the value obtained in the savanna ecosystem. Therefore, it was discovered from the result that for all trees sampled from Osun State that the trees growth variables measured from the rainforest had higher values than those in savanna zone of the State. It showed that these trees species were more favourable with environmental condition in rainforest than savanna zone of the State (Barminas *et al.*, 1998; Maley and Brenac, 1998). The reason could be due to higher rainfall that the State experienced in the rainforest region than savanna of the State.

In order to fulfill the goal of meeting the demands of subsistence farmers and product markets, the knowledge of intraspecific diversity of the *B. sapida* trees is fundamental. Current results help to fill the gap of information for *B. sapida* phenotypic diversity for fruit characteristics and individual seed traits for use in the domestication and tree improvement process. The present results have revealed substantial variation in fruit traits (fruit weight, length and width, seed number and weight and pulp weight) between the State and their ecological zones (Figure 2). The result revealed that seed weight from Osun State shows a higher significant than the seed weight from the rainforest ecosystem. 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*., 2008). The result of fruit length of *B. sapida* for Osun

State had higher length in rainforest than savanna fruits but the case was different for Ondo and Oyo fruits length the fruits length were higher in savanna than rainforest. The result of this study revealed that there are variations in some of the morphological such seed weight, fruit weight, aril weight pod weight and fruit length between the rainforest and savanna ecosystems and this variations cut crosses different State of Southwest Nigeria. As revealed by Bani-Aameur and Ferradous (2001), that there is significant variation among trees in natural population of indigenous fruit tree species in Africa. Previous research findings are generally agreed that several factors are responsible for the significant variations in tree fruit and seed characteristics. They opine that such factors as natural, human and animal selections have historical interaction that has a greater effect in producing the geographic variation in tree species (Zobel and Tobet, 1984; Hamrick *et al*., 1992). Also, it could be argued that this variation could be due to differences in genotype or by the diversity of environmental conditions in each ecosystem, which affects the behavior of a plant (Djekota *et al*., 2014). Souberou, *et al*., (2005) reported that the fruit parameters of *Vitallaria paradoxa* was higher on trees found on farms than those found in fallow and forests areas.

For the results of relationship that exist between the fruits and seeds variable in rainforest and savanna ecosystems of the study area, the morphological parameters of *B. sapida* fruits were found to significantly affect those of their seeds. The sizes of the seeds depended on the sizes of the fruits, with large fruits having larger seeds and the small fruits having smaller seeds as observed both in rainforest and savanna. In agreement to the results of this study, Ekeke *et al*. (2006) and Oyebade *et al*. (2011) reported that the bigger the fruits, the bigger the seeds and vice versa and that the trend appears to be consistent with fruits of particular parent trees. The strong and positive correlation identified between several *B. sapida* fruit and seeds morphological characteristics in this study is an indication that bigger fruits will result in higher aril weight and larger seed and thus more economic return for farmers, which is in agreement with the positions of (Oyebade *et al.*, 2011; Onyekwelu *et al*., 2015). The strong and positive correlations between fruit weight and pulp weight, fruit weigh and seed weight, e.t.c., underscore the need to use seeds from big fruits for domestication, since their trees may produce big fruits, which are more economically attractive to farmers. Over the years, the idea about the traits of interest for the domestication of *B. sapida* was based on descriptive accounts of the variation in fruit

characteristics between trees (Ladipo *et al.*, 1996). There is still no good assessment of the range of genetic variation in traits of likely importance, though there was a study conducted by (Shiembo *et al,*. 1997) on it. Therefore, the domestication effort should now target raising trees that produce fruit with good taste, high fruit pulp mass and big fruit kernel (Onyekwelu *et al*., 2015). The fruit and seed morphological characteristics of *B. sapida* from the rainforest and derived savanna ecosystems in this study compared favorably with some published results (Atangana *et al*., 2001; Anegbeh *et al*., 2003) but higher than the results of (Etebu, 2013) in which there results of significantly varied within a species. There were strong and positive correlations between many of the *B. sapida* fruit and seed morphological characteristics in this study. In many cases, correlation coefficient was more 90%. The implication of this is that fruit weight affects other size-related variables such as kernel, seed weight, fruit pulp, e.t.c (Atangana *et al*., 2001; Anegbeh *et al*., 2003; Etebu 2013; Onyekwelu *et al*., 2015). Since bigger *I. gabonensis* fruits were fund to produce larger fruit pulp and bigger seed kernel, selecting and using bigger fruits for domestication will enhance the commercial viability of the species and thus make it more attractive to farmers.

CONCLUSIONS

It was deduced from the result that all other variables measured for the fruit were dependent on the fruit weight except for the length of the fruit which varies slightly across the study areas. It was further discovered that an increase or decrease in tree height affects tree diameter but does not relatively affect the crown diameter. In general, the study revealed that selection or breeding programs should focus on *B. sapida* trees with preferred traits important for local populations. For example the trees in Ondo have a large crown diameter which is valuable for shade recreation and Aril weight in savannah was highest which could be preferred for industrial use. These differences needs to be taken into account in any research/developmental program related to domestication and management of *B. sapida*.

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