Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 21, Issue 1, 2021
PRINT ISSN 2284-7995, E-ISSN 2285-3952

PHENOTYPIC VARIATION OF FRUITS, SEED GERMINATION AND EARLY GROWTH OF *BLIGHA SAPIDA* K.D. KONIG IN SELECTED LOCATIONS OF ONDO STATE, NIGERIA

Johnson Adeyinka OLUSOLA[1], Olubukola Victoria OYERINDE[2], Faithful Olayinka IYAGIN[3], Oluronke Olubunmi SOBOLA[4]

[1]Federal College of Agriculture, Department of Forestry Technology, Akure, Nigeria. Email: johnsonolusola5@gmail.com
[2]Federal University of Technology, Department of Forestry and Wood Technology, Akure, Nigeria. Email: voyerinde@gmail.com
[3]Kogi State University, Department of Forestry and Wildlife, Anyigba, Kogi State, Nigeria. Email: fiyagin@yahoo.com
[4]Federal University Wukari, Department of Forestry and Wildlife, Wukari, Taraba State, Nigeria. Email: ronkesobola@gmail.com

Corresponding author: johnsonolusola5@gmail.com

Abstract

Tropical forest contains many plant species that are cultivated for food but they are neglected and underutilized despite their importance. This study examined phenotypic variation of trees and fruits of Blighia sapida conducted at (Akure, Owo and Akoko) within Ondo State, Nigeria. Five healthy trees were selected and twenty (20) matured fruits were collected from each tree. Data collected from selected trees were tree growth, fruits and seeds. The result indicates that highest tree height 14.0 m was recorded in Akoko and 8. 00 m was found in Akure B. sapida trees but tree dbh shows that 19. 46 cm, 19.44 cm and 18.34 cm were found for Owo, Akoko and Akure trees while 8. 48 m, 7. 60 m and 7. 12 m were for crown diameter found for Akure, Owo and Akoko tree respectively. But for seed parameter it shows that 1.85, 1. 75 and 1.71 were found for the seed no/fruit for Akoko, Owo and Akure, and 2.14, 2. 03 and 1.99 cm for seed length for Akoko, Akure and Owo respectively. Seed breadth ranged from 1. 67 cm – 1.81 cm and seed weight ranged from 8. 19g -7.61g. Fruit parameters show that highest fruit length was found in Akoko with 4. 90 cm while Owo fruits had least with 3.78 cm, for fruit breadth Akoko had the highest value of 4.08 cm Owo had the last value of 3. 37 cm but for fruit weight Akoko had the highest with 42. 33 g while Akure had the least weight of 42.20 g respectively. The variation in fruit and seed of B. sapida could be due to climatic, edaphic factors and cultural factors.

Key words**:** *phenotypic variation, fruit, seed, Blighia sapida, growth*

INTRODUCTION

Tropical rainforests are the most species rich and diverse terrestrial ecosystems in the World [25]. While occupying about 7% of the world's total land area, tropical forests contain over half of all plant and animal species on the planet [8, 10]. About 40% of the world's 275,000 flowering plants are found in tropical forests [29] in which many contain edible fruits, nuts and vegetables species. The tropical forest ecosystems represents important home of natural resources that helps developing countries and improve their economic wellbeing. More than 1.6 billion people worldwide depend on forest for their livelihood [1]. Tropical forests are full of tree species that people use every day of their lives for their own needs (food, fodder, medicines, building materials, resins, dyes, and flavourings) and these are regarded as Non-Wood Tree Products (NWTPs). Therefore, the people in developed and developing world rely on these forest products, due to the value of wood and non-timber products provide by the forest which is an immeasurable. Forest resources and their roles in livelihood are in many forms [30, 32] which include food supply, income earning, employment, education, medicine and energy. Thus, their contributions to local diets, potential in

ameliorating prevailing food problems and alleviating poverty are enormous [19].

Blighia sapida (K.D. Koenig) belongs to the family Sapindaceae, and it is commonly known as Ackee in English. In Nigeria, the Yoruba calls the plant "Isin". It is a woody perennial multipurpose fruit tree species native to the Guinean forests of West Africa [15, 16]. It is an ever green tree with a dense crown. *B. sapida* occurs naturally from Senegal to Cameroon and Equatorial Guinea, and possibly also in Gabon. It is commonly planted in its natural area of distribution, as fruit tree and ornamental shade tree. It has been introduced in many other tropical countries and in some subtropical regions such as Florida (United States) and is widely cultivated as fruit and ornamental tree in India and tropical America.

Although *B. sapida* tree is largely overlooked by researchers in many region most especially the silvical requirement [22], but the tree is highly valued by farmers and is an important component of traditional agroforestry systems in many part of local villages. Recently, *B. sapida* has emerged as high-priority species for domestication in Benin after a national survey and ranking of Non-Timber Forest Products (NTFPs) [6]. General reasons for domesticating *B. sapida* are income generation, improvement of livelihoods strategies, satisfaction of farm household needs and agroecosystem diversification [7, 11]. Unfortunately, these locally important species are often neglected leading to the erosion of their diversity and usefulness, further restricting development options for the poorest. Research to increase the value of these species and to make them more widely available would broaden the agricultural resource base and increase the livelihood options for rural communities. Though, research into *B. sapida* silvicultural activities have not been well documented, this is reflected in the scarcity of literatures on this species with respect to its silvical requirements. Thus this study therefore investigated the phenotypic variation that occurs in the fruit of *B. sapida* collected from different ecosystems in Ondo State and raised at the nursery under different soil media.

MATERIALS AND METHODS

Study Area

The study was carried out in Ondo State, Nigeria; Ondo State was one of the seven States created on 3rd February, 1976. Hence, the present Ondo State is made up of Akoko, Akure, Okitipupa, Ondo and Owo Divisions. The State lies between latitudes $5^0$45' and $7^0$52'N and longitudes $4^0$20' and $6^0$05'E. Ondo State is bounded on the east by Edo and Delta States, on the west by Ogun and Osun States, on the north by Ekiti and Kogi States and to the south by the Bight of Benin and the Atlantic Ocean. The climate of Ondo is humid tropical with seasonal variation. The mean annual rainfall is about 2,000 mm with double maximum in the months of July and September and a short relatively dry period in August. December through to February constitutes the major dry season while January and February are the driest months with each having less than 30 mm rainfall [20]. The mean monthly relative humidity is about 70%. Ondo State has a temperature which ranges from about 20.6ºC to 33.5ºC. The monthly mean temperature is about 27ºC, a condition that is conducive to the development of tropical rainforest. Ondo State has a total land area of 15,500 km^2. The population of the State according to 2006 census is 3,441,024, with a medium population density of 245 inhabitants per km^2. The natural vegetation is the high forest, composed of many varieties of hardwood timber such as *Melicia excelsa, Antiaris africana, Terminalia superba, Lophira procera* and *Symphonia globulifera*. In the Northern districts, the vegetation consists of woody savanna featuring such tree species as *Blighia sapida* and *Parkia biglobosa.* The swamp flats are the domain of the fresh water swamp forests in the interior and the units of mangrove vegetation near the coast. The sand ridges are characterized by savanna and stunted rain forests. Over most of the State, the natural vegetation has been very much degraded as a result of human activities, particularly the bush fallow system. As a result, the original forest is now restricted to few forest reserves. An important aspect of

the vegetation of the State is the prevalence of tree crops. The soils in Ondo State are predominantly ferruginous tropical soils and are typical of the variety found in the intensively weathered areas of basement complex formations in the rainforest zone of southwest in Nigeria [26]. The soils of Ondo State were derived from the basement complex rocks which are mostly well drained, with a medium texture. The soils, classified as Ondo association, are of high agricultural value for both tree and arable crops. The swamp flats are characterized by swampy organic and flooded organic soils, while the major part consists of decomposed and partly decomposed organic matter; whereas areas affected by tide bear saline soils. The latter soils are mostly useless for agricultural practices.

Methods of data collection

The sampled trees used for this study were selected purposeful from three towns within Ondo State. Selected towns for the study were Akure, Owo and Akoko respectively and they were selected based on division of the State as well as availability of these trees species under study. The study was restricted to these towns alone because of the abundance of *B. sapida* trees. Five trees were selected from each town tree height; crown diameter and diameter at breast height of each tree were measured using Spiegel relaskop, measuring tape and girth diameter tape respectively.

Sample measurements

The sampled trees used for this study were selected purposeful from three towns within Ondo State. Selected towns based on abundant of the trees were Akure, Owo and Akoko. Five trees of the *B. sapida* were selected from each of the selected towns. Selected trees were measured for tree growth characteristics such as tree height, crown diameter and diameter at breast height using Spiegel Relaskope, Metric tape and Girth tape, respectively. Twenty (20) fresh and matured fruits of *B. sapida* were harvested from each tree., Mature and ripe fruits were considered to be those with scurfy brown, woody, fragile shell with brown pulp and blackish-brown, and hard shiny seeds. For the purpose of fruit harvesting, four branches with matured and ripe fruits were collected from the lower, middle and upper parts of the each of the sample tree's canopy. It was ensured that harvested fruits did not have visible insect damage or disease symptoms. Thus, a total of 100 fruits were collected from each town, making a total of 300 fruits for the study. A minimum distance of 100 m was maintained between each selected tree in order to reduce the chances of sampling trees from the same parents (sampling sibling). Fruits collected from the same tree were bulked, kept in a separate bag and labeled for further analysis. Seed characteristics such as number of seeds per fruit, seed length, seed breadth and seed weight were measured using graduated ruler, vernier calipers and electronic balance. The fruit length, fruit breadth and fruit weight collected from each tree were also measured with the aid of graduated ruler and using electronic weigh balance.

Method of data analysis

The experimental design was Completely Randomized Design (CRD) with the three locations selected serving as the treatments. One-way analysis of variance was employed to test for the significant differences in the morphological characteristics of *B. sapida* trees from the three locations as well as the phenotypic variations of the fruits and seeds of the species. Significant means were separated using Duncan's multiple range tests. In addition, the data were also subjected to descriptive statistics. All statistical analyses were performed using Statistical Package for Social Scientists (SPSS 16.0).

RESULTS AND DISCUSSIONS

Phenotypic variation of *Bligha sapida* trees, fruits and seeds

The mean tree growth characteristics from three different locations in Ondo State, Nigeria are shown in Table 1 below. The tree with the highest Dbh was found in Owo with (19.46 cm) and the least was encountered in Akure (18.34 cm). For the crown diameter, the highest value (8.48 m) was recorded in Akure, followed by Owo (7.60 m) and the least value (7.12 m) was recorded in Akoko. The tallest tree (14.00 m) was found in Akoko

while the shortest tree (8.00 m) was found in Akure as presented in Table 1.

Table 1. Variation in tree height, tree Dbh and crown diameter among the selected location

Locations	Height (m)	Tree Dbh (m)	Crown diameter (m)
Akoko	14 ±1.58[a]	19.44±1.74[a]	7.12±0.78[b]
Owo	13.6 ±1.5[a]	19.46±1.11[a]	7.60±0.17[ab]
Akure	8.00 ±0.77[b]	18.34±1.07[a]	8.48±0.34[a]

N B. The values assigned with the same superscript in the same column are not significantly different at 5% level of significant. Mean are followed by the standard error of the mean
Source: Data Analysis, 2019.

The result of seed number per fruit, seed length, seed breadth and seed weight was presented in Table 2 below.
The result revealed that fruits from selected trees from Akoko area of Ondo State had the highest number of seeds per fruit (1.85) while the least value of seed no per fruit was recorded with the fruits collected from Akure area 1.71 respectively. But for the seed length, seed breadth and seed weight from the selected study locations, the results of the study revealed that fruits collected from Akoko area had higher values than others locations. Seed length mean ranged from 1.99 cm to 2.14 cm with the highest value recorded from the Akoko location while the least was found at Akure with 1.99 cm respectively. But for the seed breadth the least was found at Owo fruits location with 1.67 cm and the highest value of 1.81 cm were found at Akoko fruit. The result of seed weight shows that the highest weight was found with the fruit from Akoko and the least weight was revealed with the fruit from Akure with 7.61g respectively. The result of the effect of seed sources on seed no, seed length, seed breadth and seed weight shows that there were no significant different among the location at ($p>0.05$) in Akoko, Akure and Owo respectively.

Table 2. Variation in seed no/fruit, seed length, seed breadth and seed weight among the selected locations

Location	Seed no/ fruit	Seed length (cm)	Seed breadth (cm)	Seed weight (g)
Akoko	1.85±0.07[a]	2.14±0.08[a]	1.81±0.08[a]	8.18±0.40[a]
Akure	1.71±0.07[a]	1.99±0.08[a]	1.69±0.08[a]	7.61±0.37[a]
Owo	1.75±0.07[a]	2.03±0.08[a]	1.67±0.07[a]	7.61±0.38[a]

N B: The values assigned with the same superscript in the same column are not significantly different at 5% level of significant. Mean are followed by the standard error of the mean.
Source: Data Analysis, 2019.

The mean fruit length, breadth and weight from different sources in Ondo State are presented in the Table 3 below. It was discovered that fruits from Akoko had the highest mean of fruit length (4.90 cm), follow by Akure with mean value of (4.57 cm) and the least mean of fruit length (3.78 cm) was recorded on Owo.
More so, it was observed that there was no significant difference between the fruit breadth from Akoko (4.08 cm) and Akure (3.97 cm) but the mean fruit breadth from Owo (3.37 cm) was significantly lower. The result revealed that fruits weight was not significant difference at 5% level of significant across the three locations as shown in Table 3.

Table 3. Variation in fruit length, fruit breadth and fruit weight among the selected locations

Location	Fruit length (m)	Fruit breadth (m)	Fruit weight (g)
Akoko	4.90±0.07[a]	4.08±0.05[a]	42.33±0.14[a]
Akure	4.57±0.06[b]	3.97±0.05[a]	42.20±0.13[a]
Owo	3.78±0.07[c]	3.37±0.08[b]	42.35±0.07[a]

NB: The values assigned with the same superscript in the same column are not significantly different at 5% level of significant. Mean are followed by the standard error of the mean
Source: Data Analysis, 2019.

Cumulative germination rate of *Blighia sapida*

Result of cumulative germination of *Blighia sapida* based on the seed sources and as affected by the sowing media started on the

10th days after sowing for all the sowing media used for this experiment, though the percentage of the germinated seeds differs from one source to the other. The result of seed sown using top soil as sowing media revealed that seeds from different sources start germinating after 10th days after sowing and its germination lasted until 23rd days after sowing. At the end of germination period seeds from Akoko had the highest germinated seeds with the 50% while the seeds sourced from Owo and Akure had 33% germinated seeds respectively. Also, results of cumulative germination percentage of the seeds sown when river sand was used as the sowing medium revealed that seeds sourced from Akoko also had the highest germinated seeds with 63% while seeds from Owo and Akure had the same record of germinated seeds respectively with percentage of 50%. But the result differs when mixture of 50 % of the top soil were mixed with 50% of river sand, at the end of the germination counts, it shows that seeds sourced from Akoko had the highest germination percentage with the value of 50% follow by Akure 47% while Owo had the least germination of 37% respectively (Figure 1).

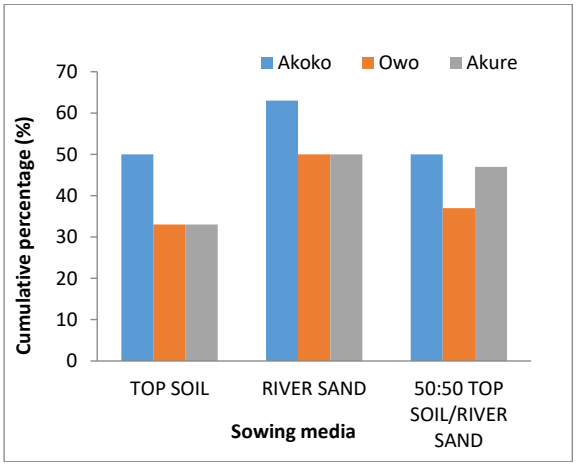

Fig. 1. Effect of seed sources on germination percentage of *Blighia sapida*
Source: Data Analysis, 2019.

At the end of twelve weeks of early growth monitoring, the mean height growth characteristics of *Blighia sapida* seedlings of seeds germinated from the different locations in Ondo State were monitored. The highest plant height was observed with the seedling sourced from Owo, while the least was found with seedlings from Akure with a total height of 16.48 cm with seedlings monitored with top soil as sowing media. But for the seedlings monitored with river sand as sowing media, the height was found with Akure seed sourced with a total height of 19.98 cm while 17.9 cm was the least with seedlings sourced from Owo while the soil that was mixed shows that Akoko seed sourced had the highest plant total height with 19.78 cm as the highest while the least was found with Akure seed sown with the mixed soil respectively. It was discovered that plant height varied significantly from one location to the other at 0.05 level of significant (Figure 2a). The result of no of leaves accumulated by the seedlings was presented in the figure 2b below and it was discovered that no of leaves were not significant from one seed location to the others as shown in Table 4.

The highest no of leaves by seedling was found with seedlings planted in river sand and sourced from Owo, followed by the seedling grown on river sand as sowing media. But the least seedlings with no of leaves were found with seedlings planted with top soil sourced from Owo and Akoko. Collar diameter result was shown in figure 2c and the seedling collar diameters were not significantly different from on sowing media to the other. It was found from the result that seedlings planted and raised with top soil showed that seeds from Owo had 0.50 cm collar diameter and shown the highest collar diameter while Akoko seeds had the lowest but for seeds planted with river sand seeds sourced from Akoko performed better with 0.74 cm collar diameter and the least was recorded with the seed sourced from Akure station. Result of sowing media with mixed soil shows that seeds from Akoko had the highest collar diameter with 0.51 cm and Akure seed had the least collar diameter with 0.47 cm. Number of branchlet produced by each seedlings were counted and it was discovered that seeds sown with top soil shows that Akure seeds were found to have higher number of branchlet followed by Owo seedlings and the least was found with Akoko seedlings with only 4 no of branchlets.

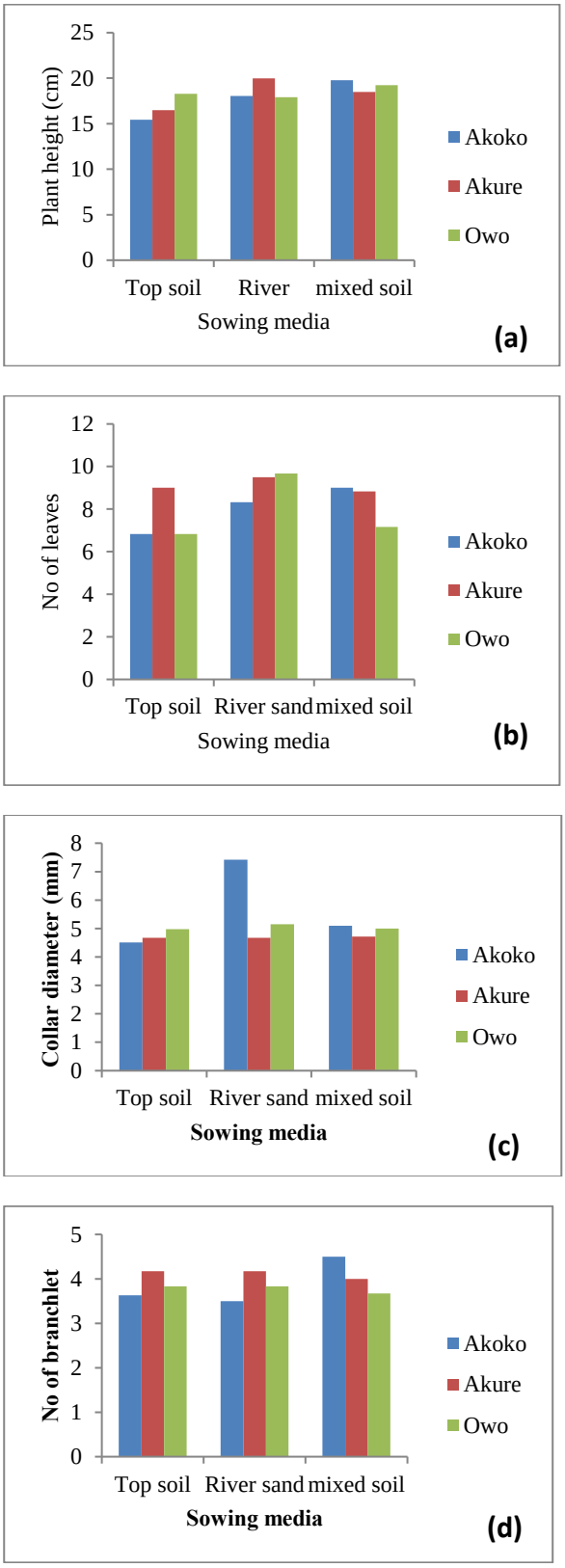

Fig. 2. Effect of sowing media on (a) Plant height (b) no of leaves (c) collar diameter (d) no of branchlet of *Blighia sapida*
Source: Data Analysis, 2019.

River sand seedlings shows that Akure seedlings had the highest no of branchlets with 4 while in the sowing media with mixed soil found that Akoko had the highest no of branchlet with 5 and the least were found with Akoko and Owo with 4 seeds each, also, it was shown that mixed soil was significantly higher than river sand and top soil potting mixture.

Table 4. Summary of Duncan's Multiples Range Test for the Early Growth Parameters of *Blighia sapida* Seedlings

Growth parameters	Treatment	Mean
No of leaf	River sand	9.17[a]
	Top soil	7.56[a]
	Mixed Soil	8.33[a]
Plant height	River sand	18.37[ab]
	Top soil	16.24 [b]
	Mixed soil	19.17[a]
Collar diameter	River sand	5.18[a]
	Top soil	4.69[a]
	Mixed soil	4.85[a]
No of branchlets	River sand	3.83[a]
	Top soil	3.89[a]
	Mixed soil	4.06[a]

Note: Means with the same letters on the same column are not significantly different (P <0.05).
Source: Data Analysis, 2019.

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 [30]. The participation of farmers in domestication of forest food tree species has been reported by some researchers [17, 18, 9, 19]. Though, *B. sapida* had been classified by [11, 12] among endangered tree species in Nigeria. Thus, these species might go into extinction in the near future except steps are taken to conserve them or increase their population. Some of the reasons why farmers domesticate *B. sapida* were mainly for income generation, improvement of livelihoods strategies, satisfaction of farm household needs and agro-ecosystem diversification. Therefore, the phenotypic variation among the trees, fruits and seeds of the *B. sapida* from different locations of Ondo State was observed, though different locations within Ondo State had a little effect on the variations on the tree, fruits and seed parameters examined. Fruits from Akoko location in

Ondo State had better characteristic than Akure and Owo locations with the respective to highest mean values of weight, length and breadth of fruits. The result of this research was in agreement with the report of [4] who reported variation in morphological and productivity of individual baobabs according to the climatic zones. Also, [23] reported that there are variations in tree growth assessment of *B. sapida* from one State to another and from one ecosystem zone to another. However, the mean differences for most fruits and tree characteristics were comparable between Owo and Akure locations. Among the sampled trees from the three locations, the tree height analysis shows that there were significantly different among the trees sampled for this research, and also there is significant different statistically among the crown diameter of the sampled trees, but the tree diameter at breast height were not statistically different. The differences encountered in tree height and crown diameter of the sampled trees for this research could be due to environmental factors which seem to play an important role in determining the tree characteristic of *B. sapida*. Also, the differences expressed in the tree characteristic of *B. sapida* from the different locations could revealed that it has high genetic differences which is to be exploited [26]. Also, as reported by [15] they reported in their findings that differences among different sites largely attributed to climatic, edaphic, genetic and cultural factors which were in agreement with the findings of this research. Hence, it could be deduce from the result of the research that trees from Akoko had higher height and wider diameter than Owo and Akure trees this may be due to the agro-ecological zones and the soil factor which encourages the production of higher trees and wider diameter at breast height than other trees from other locations. In addition, management regimes within a given environment may also cause morphological variation in fruits and seeds especially for traits targeted by artificial selection [5]. As noted from the report by [14], that variables such as DBH, stem bole height, diameter of and numbers of leaflets, number of seeds and the diameters of fruit pods are highly important in localities from different climatic zones and locations which may also have effect on the tree performance and characteristics which was supported by the result of this findings. In general, sale of fruits is based on size (weight, length, width) [13], with bigger fruits fetching higher prices than smaller once. Thus, tree breeding may target trees with bigger fruits. However, there seems to be no relationship between taste and size of the fruit which complicates the choice of selection criteria.

Blighia sapida is easily established through seed or cutting. The seeds are sown either directly or in a poly pot or in any other containers, without any prior pre-treatment and its germination started. Our germination result shows that germination percentage of *B. sapida* seeds ranged from 33 to 63%. The germination recorded in this study is within the range for some forest seed species [2] for *Chrysophyllum albidum;* [24] for *Chrysophyllum albidum*), but generally lower than what was recorded by [25] for *Moringa oleifera*. The significant effect of potting mixture of *B. sapida* seed germination in this study is in agreement with the report of [3], [25, 7] they reported a significant effect on the germination of forest fruits and potting mixture of *Dacryodes edulis* and *Moringa oleifera* seeds. It was discovered from the result of this study that there was significant difference ($p \leq 0.05$) in germination percentage between different potting mixtures used at 95% probability level. It was indicated from the result of this finding that river sand had the highest germination percentage.

Therefore the results of seedling growth of *B. sapida* revealed that river sand was the best sowing media for germinating *B. sapida* followed by 50:50 topsoil/ river sand and the least was topsoil. This was supported by [6] who reported that effect of sowing media on seed germination and growth of some forest trees, therefore, the results revealed that potting mixture had significant effect on the collar diameter and seedlings height of *Blighia sapida* but does not have significant effect on the number of leaves. The seedlings on river sand showed superior and significant

growth performances in total height, collar diameter compared with seedlings in top soil and 50:50 topsoil/ river sand respectively. Since all seedlings were exposed to similar environmental condition, this difference in vigour among the seedlings can be attributed to environmental adaptation with respect to some traits such as height and diameter increment. The result of this experimental work is in agreement with the findings of [25] who observe superior and significant monthly increment in the height and diameter of *Moringa oleifera*. The work of [28] also indicated the same differential pattern of growth in seedlings progenies of *Parkia biglobosa* collected from different provenances in Nigeria. According to [33] when comparing trees from regions up to one-hundred kilometres apart, particularly regions that differ in climate, general geographical trends in growth are evident. The implication of this general observation is that over similar areas especially where there is little or no climatic variation, little or no geographic trend in growth will occur [33, 28]. This explains why there is no significant difference in the number of leaves, collar diameter and no of branchlet from all the sources. Therefore, current results help to fill the gap of information for *Bligha sapida* phenotypic diversity for fruit characteristics and individual seed traits for use in the domestication and tree improvement process.

CONCLUSIONS

The result of this study had shown that there is significant different in the phenotypic variation of the trees and morphological features of *B. sapida* in Ondo State. Thus, it could be deduce from the result of this research that *B. sapida* from different location under studied revealed a significant variation across the different locations in terms of number tree height, diameter at breast height, fruit length and seed weight. This implies that domestication and conservation of *B. sapida* tree can be encouraged to increase their productivity. It will be important to extensively investigate the spatial genetic structuring in the *B. sapida* in the southwest so that the information could be used in tree domestication, conservation, management and improvement in the whole region. In addition, further molecular studies should be done to assess genetic diversity at large scale (regional) and fine scale (within countries) to complement on the current study.

REFERENCES

[1]Aberoumand, A., 2009, Nutritional evaluation of edible *Portulaca oleracea* as plant food. Food Anal Methods. 2:204–207.
[2]Aduradola, A.M., Adeola, B.F., Adedire, M.O., 2005, Enhancing germination in seeds of African star apple, *Chrysophyllum albidum* (G. Don). Journal of Food, Agriculture and environment 3(2): 292- 294.
[3]Agbogidi, O.M., Enujeke, E.C., Eshebgeyi, O.F., 2007, Germination and seedling growth of African pear (*Dacryodes edulis* Don. G. Lam H. J.) as affected by different planting media. American Journal of Plant physiology, 2 (4): 282- 286.
[4]Assogbadjo, A., Sinsin, B., Van Damme, P., 2005, Morphological and production of capsules baobab (*Adansonia digitata* L.) in Benin. Fruits 60 (5):327-340.
[5]Carmora, A., Casas, A., 2005, Management, phenotypic patterns and domestication of *Polaskia chichipe* (Cactaceae) in the Tehua Can Valley, Central Mexico. Journal of Arid Environments 60: 115-132.
[6]Codjia, J.T.C., Assogbadjo, A.E., Ekué, M.R.M., 2003, Diversité et valorisation au niveau local des ressources végétales forestières alimentaires du Bénin. Cahiers Agricultures 2003, 12:321-331.
[7]Codjia, J.T.C., Assogbadjo, A.E., Atègbo, E. A. D., 2003, Ressources végétales de la forêt classée de la Lama et alimentation des populations riveraines. Annales des Sciences Agronomiques du Bénin, 4(2): 121-142.
[8]Corlett, R.T., Primack, R.B., 2011, Tropical Rain Forests: An Ecological and Biogeographical Comparison. Oxford: Wiley Blackwell, 336 pp.
[9]Degrande, A., Schreckenberg, K., Mbosso, C., Anegbeh, P., Okafor, V., Kanmegne, J., 2006, Farmers' fruit tree-growing strategies in the humid forest zone of Cameroon and Nigeria. Agroforestry system 67:159–175.
[10]Ekué, M.R.M., Assogbadjo, A.E., Mensah, G.A., Codjia, J.T.C., 2004, Aperçu sur la distribution écologique et le système agroforestier traditionnel autour de l'ackée (*Blighia sapida*) en milieu soudanien au Nord Bénin. Bulletin de la Recherche Agronomique du Bénin 44:34-44.
[11]Ekué, M.R.M, 2003, Potentialités d'utilisation des ressources forestières alimentaires végétales du Bénin. XII World Forestry Congress; 21-28 September; Québec, Canada FAO 52.
[12]FORMECU, 1999, Forest resources study, Nigeria. Revised national report, Vol. 2. Prepared for

FORMECU by Beak and Geomatics International. Abuja, Nigeria: Federal Department of Forestry. 224 pp.

[13]Franzel, S., Akinnifesi, F.K., Ham, C., 2008, Setting priorities among indigenous fruit tree species in Africa: Examples from Southern, Eastern and Western African Regions. In: Akinnifesi, FK, Leaky RRB, Ajayi OC, Silesh G, Tchoundjeu Z, Matakala P, Kwesiga FR (eds.) Indigenous Fruit Trees in the Tropics Domestication, Utilization and Commercialization. Columns Design Ltd, Reading, UK.

[14]Houètchégnon, T., Charlemagne, G.D.S.J., Christine, O., Nestor, S., 2015, Morphological Variability of *Prosopis africana* (Guill., Perrott. Et Rich.) Taub in Benin, West Africa. American Journal of Plant Sciences, 6, 1069-1079. http://dx.doi.org/10.4236/ajps.2015.67111, Accessed on 5th March, 2020.

[15]Katsvanga, C.A.T., Jim, L, Gwenzi D, Muhoni, L, Masuka, P, Moyo, M. 2007, Characterisation of community identified *Uapaka kirkiana* phenotypes for domestication. Journal of sustainable development in Africa Vol. 9(4):356-366.

[16]Keay, R.W.J., 1989, Trees of Nigeria. Oxford science publication, Clarendon press. Oxford. pp. 476.

[17]Leakey, R.R.B, Schreckenberg, K, Tchoundjeu, Z., 2003, Participatory domestication of West African indigenous fruits. International Forestry Review. 5:338–347.

[18]Leakey, R. R. B., Tchoundjeu, Z, Smith, R. I, Munro, R.C., Fondoun, J., Kengue, J., Anegbeh, P.O., Atangana, A.R., Waruhiu, A.N., Asaah, E., 2004, Evidence that subsistence farmers have domesticated indigenous fruits (*Dacryodes edulis* and *Irvingia gabonensis*) in Cameroon and Nigeria. Agroforestry System 60:101–111.

[19]Legwaila, G.M., Mojeremane, W., Madisa, M. E., Mmolotsi, R.M., Rampart, M. 2011, Potential of traditional food plants in rural household food security in Botswana. Journal of Horticulture and Forestry 3:171–177.

[20]Okafor, J.C., 1991, Improving edible species of forest product. Unasylva 42 (165): 17-22.

[21]Ola-Adams, B.A., Hall, J.B., 1987, Soil plant relation in a National Inviolate plot at Akure, Nigeria. Journal of Tropical Ecological. Vol. 3, pp. 57-79.

[22]Olayode, O.O., 2015, Lengths of storage and pretreatments effects on the seedling growth of *Blighia sapida* (K.D. Konig), Agricultural, Biological Journal of North America, 6(6): 155-159.

[23]Olusola, J.A., Awoku, A.E., Adeduntan, S.A., 2018, Morphological traits of selected *Blighia Sapida* K.D. Koenig. Trees and fruits from rainforest and savanna zones of Southwestern Nigeria Journal of Forestry research and management. Vol. 15(3), 20-36.

[24]Onyekwelu, J.C., Fayose, O.J., 2007, Effect of storage methods on the germination and proximate composition of *Treculia africana* seeds. Proceedings of conference on international Agricultural Research for Development. University of Gottingen, October 9-11, 2007.

[25]Onyekwelu, J.C., Olabiwonnu, A.A., 2010, Seed germination and early growth of *Moringa oleifera* seedlings. Forests and Forest Products Journal 3, 12-19.

[26]Onyekwelu, J.C., Olusola, J.A., Stimm, B., Mosandl, R., Agbelade, A.D., 2014, Farm-level tree growth characteristics, fruit phenotypic variation and market potential assessment of three socio-economically important forest fruit tree species, Forests, trees and livelihoods, DOI: 10.1080/14728028.2014.942386, Accessed on 10th February, 2019.

[27]Onyekwelu, J.C., Adekunle V.A.J., Adeduntan, S.A., 2005, Does Tropical Rainforest Ecosystem possess the ability to recover from severe degradation? In: Popoola, L., Mfon, P., Oni, P.I., (editors) Proceedings of Forestry Association of Nigeria. Pp.145-163.

[28]Oyun, M.B., 2002, Germination and early growth of Parkia biglobosa from different Seed source in Nigeria, Forestry and Fisheries, 4, 2002, pp. 28-31.

[29]Primack, R. B., 2010, Essentials of conservation biology. 5th ed. Sunderland (MA): Sinauer Associates, Inc; 601 pp.

[30]Simon, A. J., 2003, Tree Domestication in Tropical Agroforestry. Agroforestry systems, pp.61- 62.

[31]Tee, N.T., 2007, Marketing and utilization of *Borassus aethiopum* (mart) in North eastern Nigeria, PhD Thesis Department of Forest Resources Management, University of Ibadan, Nigeria. 200 pp.

[32]Tee, N.T., Ageende, A.,k 2005, Community woodlot production as a sustainable forest management option in Benue: Prospects, Proceedings of 30th Annual conference of FAN held in Kaduna, Kaduna State, Nigeria 7th -11th Nov., 2005, pp.375-388.

[33]Wright, J., 1976, A volumetric temperature/salinity census for the Middle Atlantic Bight 1.976, https://agupubs.onlinelibrary.wiley.com/doi/10.4319/lo.1976.21.4.0563, Accessed on 24th August, 2019.