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SEEDLING GROWTH PERFORMANCE OF *KIGELIA AFRICANA* (LAM.) BENTH. AS INFLUENCED BY DIFFERENT LIGHT INTENSITIES

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ABSTRACT: *Despite the high medicinal properties of Kigelia africana to most of the people of Nigeria and other nations of the world, it only exist as a protected and semi domesticated species This study investigated the effects of light intensities on the early growth performance of K. africana as an important step towards its domestication. Seedlings of K. africana were monitored under five light intensities namely; 60%, 45% and 30% light intensities, under tree canopy cover (5% light intensity) and control treatment was direct sunlight (100% light intensity). The experiment was laid in a Completely Randomized Design (CRD). Early growth rate of the species was significantly affected by different light intensities. Seedlings height and diameter ranged from 6.2–30.2 cm and 2–8.98 mm respectively (after 12 weeks) depending on light intensity. K. africana seedlings under direct sunlight did not perform well compared to the seedlings under low light conditions i.e. 30%, 45% and 60% light intensities, implying the seedlings need some shade for the establishment of early good growth while the species performed poorly under forest canopy, indicating that they may not do well under heavy shade. Thus, the species has the potential to survive when transplanted to the field*.

KEYWORDS*:* Kigelia Africana, Light Intensity, Early Growth, Multipurpose, Domestication.

INTRODUCTION

Light incident on plant requires the characterization of its intensity, duration, quality, and direction. Light is a source of energy and a source of information for green plants. It is a source of energy for photosynthesis, and a source of information for photoperiodism (night/day length), photomorphogensis (light quantity and quality) and phototropism (light direction). Plants are sensitive to light quality and quantity which play a vital role in their physiological development (Aphalo and Ballaré, 1995).

Plants play a vital role in the management of various diseases and have been heavily utilized in the sustainable development of drugs that provide a major focus in global healthcare delivery (Graham *et al*., 2000). *Kigelia africana* (Lam.) Benth belongs to the family Bignoniaceae. It is a multipurpose tree species with many medicinal attributes and potentials. Its common names include sausage tree (Eng); worsboom (Afr); (Coates-Palgrave, 1988) pandoro (West Nigeria) (Aiyelola and Bello, 2006). It is a tree that grows up to 20m tall or more (Roodt, 1992).
The tree is evergreen where rainfall occurs throughout the year, but deciduous where there is a long dry season. The leaves are opposite or in whorls of three, 30 – 50 cm long, pinnate, with six

to ten oval leaflets up to 20 cm long and 6 cm broad; the terminal leaflet can be either present or absent. The flowers (and later the fruit) hang down from branches on long flexible stems (2-6 m long). Flowers are bisexual and produced in panicles; they are bell shaped (similar to those of the African tulip tree but darker and more waxy), orange to reddish or purplish green and about 10 cm wide. Individual flowers do not hang down but are oriented horizontally (Joffe, 2003) and some birds are attracted to these flowers. Their scent is most notable at night indicating their reliance on pollination by bats, which visit them for pollen and nectar (Hoyo *et al*., 1997). *K. africana* is abundant in the tropics and is widely used traditionally in Southern Nigeria as an herb remedy for various ailments such as anticancer, antiulcer, anti-aging, antioxidant, and anti malarial. It is also widely applied in the treatment of genital infections, gynecological disorders, renal ailments, fainting, epilepsy, sickle-cell anemia, eczema, central nervous system depression, respiratory ailment, skin complaint, body weakness, leprosy, worm infestation, tumours etc., especially in developing nations where orthodox medicine are expensive or inaccessible (Olatunji and Atolani, 2009).

Despite the high medicinal uses of *K. africana* by most people of Nigeria and to other nations of the world at large, it only exist as a protected and semi domesticated species. Anthropogenic activities have put a lot of pressure on the forest thereby depleting some genetic resources. To prevent total loss or extinction of important forest food trees and medicinal species, especially the endangered ones, there is need for them to be cultivated more intensively (Baiyeri, 2003; Ugwunze, 2003)

This study was carried out to investigate the response of *K. africana* seedlings to various light intensities and to also monitor the early growth characteristics and habits of the seedlings of the species under Five different light intensities using three screen chambers and under forest canopy cover, which were compared with the performance of seedlings of the species raised under direct sunlight as an important step towards its domestication.

MATERIALS AND METHODS

Study site

The study was carried out at the Department of Sustainable Forest Management (SFM) nursery, Forestry Research Institute of Nigeria (FRIN), Jericho hill Ibadan, Oyo State, Nigeria. FRIN is located on the latitude $07^{0}23'$N and longitude $03^{0}51'$E with the main total rainfall of 1548.9 mm, falling in approximately 90 days. The mean maximum temperature is 31.9^{0}C, minimum 24.2^{0}C and the relative humidity is 71.9% (FRIN, 2013).

Experimental design and treatments

Twenty-five (25) seedlings (one week old) with uniform sizes were used in this experiment. Five (5) seedlings were placed under each screen chamber, under forest canopy and under direct sunlight which served as control treatment. The experimental design used for this study was Completely Randomize Design (CRD). This is because there was only one source of variation which was light intensity. The three screen chambers (i.e. 30%, 45% and 60%), under forest canopy (5% light intensity) and under direct sunlight which serves as the control (100% light intensity) constituted the treatments. This study investigated the effects of different light intensities on the seedling growth of *Kigelia africana*. This was accomplished by raising seedlings of *K. africana* in the nursery under five different light intensities which were three screen chambers, under forest canopy and under direct sunlight (Control). The separation of light intensities in the screen chambers were accomplished by the use of wire mesh (single, double and triple layers) that allows the penetration of only certain amount of energy within the PAR (400 to 700nm waveband) region of the electromagnetic spectrum. The percentage penetration of light intensity entering each screen house was determined with the aid of a photo meter.

Data collection and analysis
K. africana seedlings under each treatment were used to monitor growth characteristics. Growth characteristics such as total height (cm), collar diameter (mm) and number of leaves where taken every week while total biomass (g) and root length (cm) were taken every four weeks and lasted for the period of twelve (12) weeks. For biomass estimation, one seedling whose height was closest to the mean height of the five seedlings in each experiment was selected for destructive sampling. The data (early growth parameters) were then subjected to one-way analysis of variance to compare the effect of the different treatments on the early growth characteristics of *K. africana* seedlings. Means found to differ significantly were separated using Duncan Multiple Range Test (DMRT) procedure. Results were summarized in tables and figures.

RESULTS

Mean Height
The height growth development of *K. africana* seedlings for the growth period of twelve weeks is presented in Figure 1 below. The height of seedlings under 30%, 45% and 60% light intensities were similar, with 45% light intensity giving the best height growth for the seedlings. The seedlings under forest canopy did not do well compared to other treatments. Results indicated that there was a steady increase in the growth in height of the seedlings subjected to various treatment between the second and the twelfth week. However, the increase in the height of the seedlings under forest canopy was minimal compared to other treatments (Fig. 1).

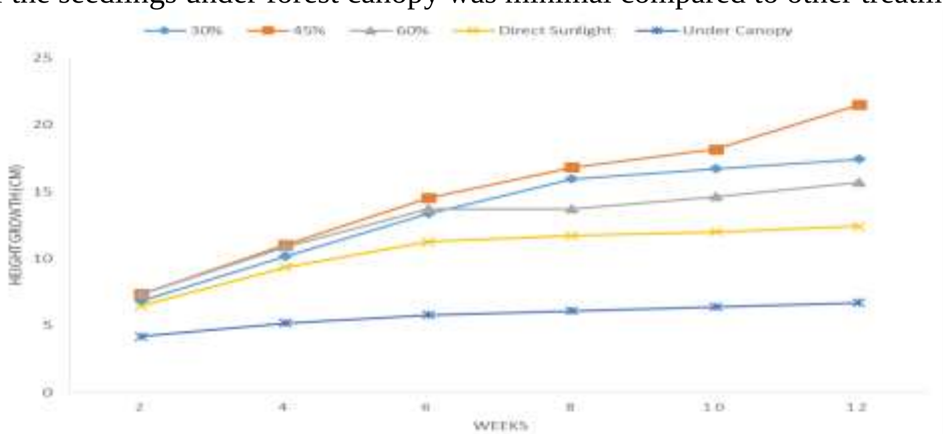

Figure 1: Effect of different light intensities on height growth of *Kigelia africana* seedlings
By the end of twelve weeks, the mean height growth of *K. africana* seedlings grown under 45% light intensity was 14.30 cm, 30% light intensity had mean height of 13.16 cm, 60% had mean height of 12.41 cm, under direct sunlight had mean height of 10.34 cm and lastly followed by seedlings under forest canopy with the mean height of 4.87 cm (Tab. 1 & Fig. 4).

Table 1: Mean separation results for effect of light intensities on height, collar diameter and leave production of *K. africana* seedlings.

Light intensity	Height (cm)	Collar diameter (mm)	Number of leaves
Direct sunlight	10.34 ± 1.37^{b}	5.63 ± 0.63^{c}	13 ± 0.84^{bc}
Under canopy	4.87 ± 1.34^{a}	1.77 ± 0.31^{a}	6 ± 01.34^{a}
60%	12.41 ± 0.81^{bc}	5.91 ± 0.39^{c}	12 ± 0.44^{b}
45%	14.30 ± 2.86^{c}	5.79 ± 0.87^{c}	$14\pm0.1.51^{c}$
30%	13.16 ± 1.03^{c}	4.80 ± 0.20^{b}	15 ± 2.19^{c}

Mean±SD followed by the same superscripts in column are not significantly difference (p>0.05)

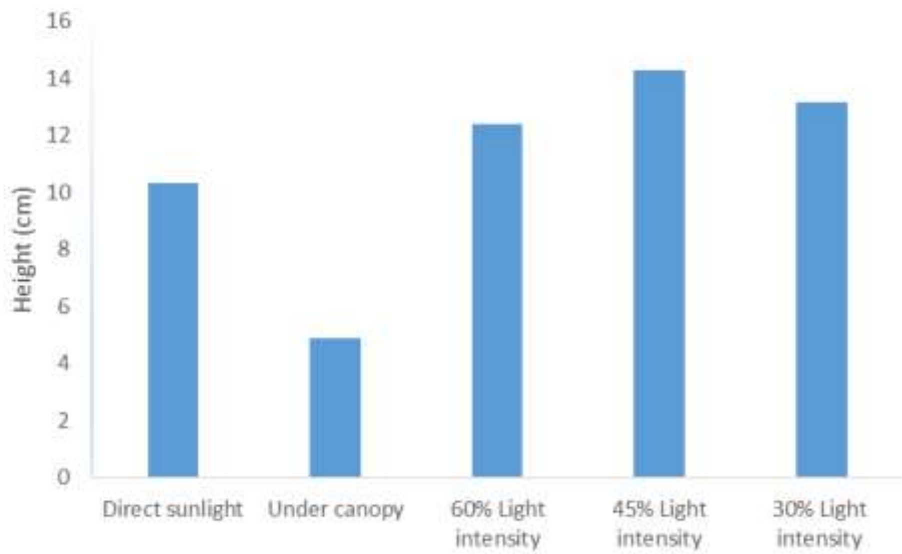

Figure 4: Effect of light intensities on the mean of height of Kigelia africana seedlings
The result of Analysis of Variance (ANOVA) revealed a significant difference (P<0.05) in the effect of light intensities on the height growth of the seedlings (Table 2). Mean separation showed that height growth of seedlings under 45% had the highest value, which was not significantly different from the height growth of seedlings under 30% and 60% light intensities but both were significantly higher than the height of seedlings grown under open nursery condition. The height of seedlings under forest canopy was significantly lower compared to the height of seedlings of other treatments (Table 1).

Table 2: ANOVA results for effect of light intensities on height, collar diameter and leave production of *K. africana* seedlings

Parameter Assessed	Source of variation	df	Sum of Squares	Mean Square	F	Sig.
	Light Intensity	4	278.01	69.50	25.58	0.00*
Height	Error	20	54.34	2.72		
	Total	24	332.34			
	Light Intensity	4	60.37	15.09	50.38	0.00*
Collar diameter	Error	20	5.99	0.30		
	Total	24	66.36			
	Light Intensity	4	226.16	56.54	28.85	0.00*
Number of leaves	Error	20	39.20	1.96		
	Total	24	265.36			

***- Significant ($p \leq 0.05$)**

Mean Collar Diameter

Figure 2 below shows the growth development in collar diameter for *K. africana* seedlings grown under different light intensities for the period of twelve weeks. Result indicated there was a steady increase in collar diameter of *K. africana* seedlings grown under various light intensities except for seedlings under forest canopy that had slow development (Fig. 2).

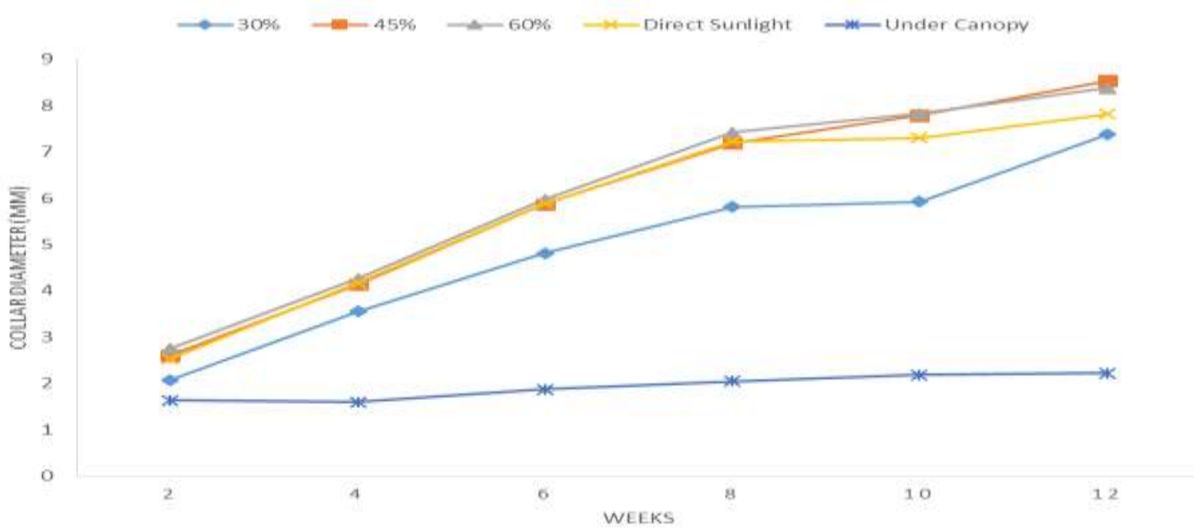

Figure 2: Effect of different light intensities on Collar diameter growth of *Kigelia africana* seedlings

At the end of twelve weeks, of growth showed that *K. africana* seedlings grown under 60% light intensity had the highest mean collar diameter of 3.07 mm, which was closely followed by 45% light intensity with 3.05 mm mean collar diameter, direct sunlight with 2.95 mm, 30% light intensity with 2.53 mm and lastly by seedlings under forest canopy with the lowest mean collar diameter of 1.77 mm (Tab. 1 & Fig. 5).

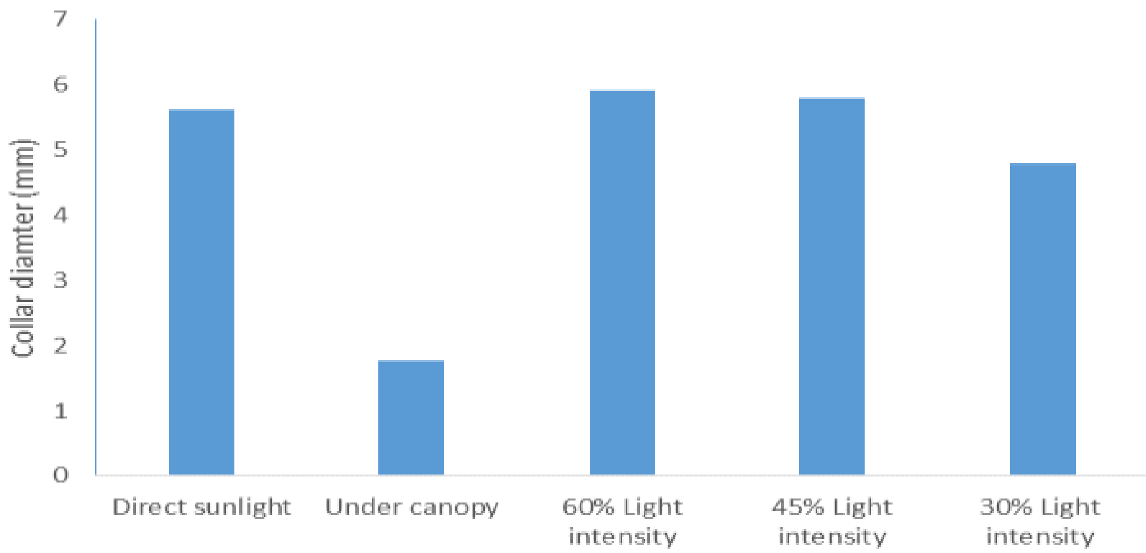

Figure 5: Effect of light intensities on the mean of collar diamter of Kigelia africana seedlings

The result of ANOVA showed a significant difference ($P<0.05$) in the mean collar diameter growth of the seedlings under the different light intensities (Table 2). The result of mean separation revealed that the collar diameter of seedlings grown under direct sunlight and 30% light intensity were not significantly different (Tab. 1). Also, there was no significant difference between the mean collar diameter of seedlings grown under 45% and 60% light intensities. The mean collar diameter of seedlings under forest canopy was significantly different from other treatments.

Mean Number of Leaves

Result showed that during the growth period of twelve weeks, the leaves production dropped in the seedlings under 60% light intensity after eight weeks while the number of leaves also increased steadily in the seedlings under 30%, 45% and direct sunlight, except for seedlings grown under forest canopy with only a marginal increase in the number of leaves (Figure 3).

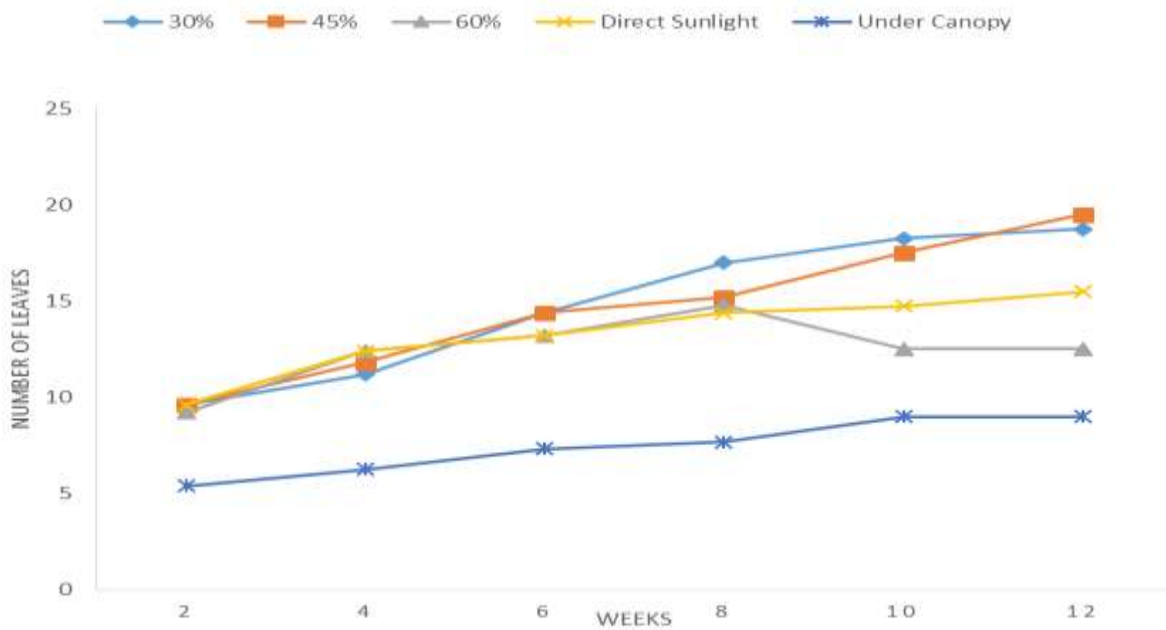

Figure 3: Effect of different light intensities on the number of leaves production of *Kigelia africana* seedlings

Table 1 above shows that after twelve weeks of growth, *K. africana* seedlings grown under 30% light intensity had 15 leaves which was the highest mean number of leaves. Seedlings under 45% light intensity had 14 mean number of leaves, direct sunlight had 13 mean number of leaves, 60% light intensity had 12 while seedlings under forest canopy had mean number of 6 leaves (Figure 6).

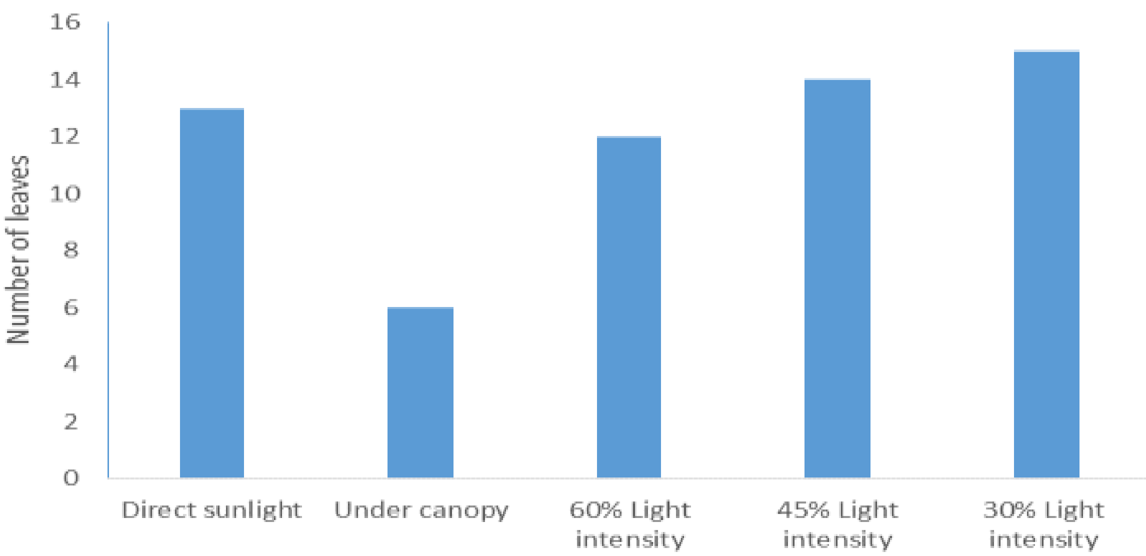

Figure 6: Effect of light intensities on the mean of number of leaves of Kigelia africana seedlings

The results of analysis of variance (ANOVA) in Table 2 revealed a significant difference ($P<0.05$) in the number of leaves produced by *K. africana* under the different light intensities. the result of mean separation showed that the number of leaves produced by seedlings grown under 30%, 45%, 60% and under direct sunlight do not differ significantly from each other but are significantly higher than the seedlings grown under forest canopy which has the least number of leaves (Table 1).

Biomass Estimation

The dry weight of the seedlings of *K. africana* selected from each treatments were used as the biomass accumulated.

Leaf Biomass Accumulation

Mean values of leaf biomass presented in Table 3 shows that at the end of three months, 60% light intensity had the highest value of leaf biomass 1.9 g followed by 45% and 30% light intensities with 1.7 g and direct sunlight with 1.3 g while under forest canopy came last with a distant 0.1 g weight (Figure 7). ANOVA results (Table 5) shows that the effect of light intensity on leaf biomass accumulation during the three months period was significantly different. The mean separation (Table 4) shows that the leave biomass of seedlings grown under 30%, 45%, 60% light intensities and direct sunlight are not significantly different from each other but significantly different from the leave biomass of seedlings grown under forest canopy.

Table 3: Summary of biomass production for *K. africana* seedlings subjected to different light Intensity

Month	Treatment	Root L (cm)	Stem H (cm)	Total H (cm)	Leaf Biomass (g)	Stem Biomass (g)	Root biomass (g)	Total Biomass (g)
1	Direct Sunlight	18.1	9.36	27.46	0.8	0.8	1.11	2.71
	Under Canopy	7.2	5.18	12.38	0.05	0.01	0.02	0.08
	60%	8.5	10.88	19.38	0.91	0.67	2.01	3.59
	45%	11.8	11.04	22.84	1.04	0.5	1.02	2.56
	30%	16.4	10.16	26.56	0.91	0.73	0.93	2.57
2	Direct Sunlight	21.6	11.72	33.32	1.45	1.1	2.25	4.8
	Under Canopy	10.2	6.1	16.3	0.12	0.01	0.03	0.16
	60%	11.2	13.74	24.94	1.65	1.03	2.61	5.29
	45%	15.3	16.82	32.12	2.01	0.96	1.91	4.88
	30%	24.2	15.96	40.16	1.97	1.26	1.46	4.69
3	Direct Sunlight	22.1	12.43	34.53	1.3	1	1.3	3.6
	Under Canopy	21.8	6.7	28.5	0.1	0.1	0.1	0.3
	60%	24.4	15.7	40.1	1.9	1.6	1.8	5.3
	45%	17.9	21.5	39.4	1.7	1.4	2.5	5.6
	30%	37.6	17.45	55.05	1.7	1.3	2.2	5.2

Table 4: Mean separation result for the effect of light intensity on biomass production of *K. africana* seedlings

Treatment	Leave Biomass	Stem Biomass	Root Biomass	Root length
Direct Sunlight	1.18^{b}	0.97^{b}	1.55^{b}	20.60^{b}
Under Canopy	0.09^{a}	0.04^{a}	0.05^{a}	13.07^{a}
60%	1.49^{b}	1.10^{b}	2.14^{b}	14.70^{a}
45%	1.58^{b}	0.95^{b}	1.81^{b}	15.00^{a}
30%	1.53^{b}	1.10^{b}	1.53^{b}	26.06^{c}

Mean followed by the same superscripts in column are not significantly difference (p>0.05)

Stem Biomass Accumulation

The result of the stem biomass presented in Table 3 showed that after three months, highest value of stem biomass was obtained from seedlings grown under 60% light intensity with the mean value 1.6 g, which was followed by seedlings under 45% light intensity with 1.40 g, 30% and direct sunlight followed with mean value 1.30 g and 1.0 g respectively (Figure 7). While the least mean value for stem biomass accumulation was recorded under forest canopy with 0.10 g. ANOVA result (Table 5) showed that effect of light intensities on the stem biomass production of seedlings during the period of three months was significantly different. The mean separation (Table 4) shows that the stem biomass of seedlings grown under 30%, 45%, 60% light intensities and direct sunlight are not significantly different from each other but significantly different from the stem biomass of seedlings grown under forest canopy.

Table 5: ANOVA results for effect of light intensities on biomass accumulation of *K. africana* seedlings

Biomass accumulation	Source of variation	df	Sum of Squares	Mean Square	F	Sig.
Stem biomass	**Light Intensity**	4	2.41	0.60	5.47	0.01*
	Error	10	1.10	0.11		
	Total	14	3.51			
Root biomass	**Light Intensity**	4	7.73	1.93	6.39	0.01*
	Error	10	3.03	0.30		
	Total	14	10.76			
Leave biomass	**Light Intensity**	4	4.69	1.17	6.30	0.01*
	Error	10	1.86	0.19		
	Total	14	6.56			
Root length	**Light Intensity**	4	347.98	87.00	1.67	0.23ns
	Error	10	521.87	52.19		
	Total	14	869.86			

****- Significant (p≤0.05)   ns- not significant (p>0.05)***

Root Biomass

Mean values of root biomass production for *K. africana* seedlings are presented in Table 3 showed that at the end of third month of biomass estimation, root biomass of seedlings under 45% light intensity condition had the highest root biomass of 2.50 g; which was followed by seedlings under 30% light intensity with 2.20 g which was closely followed by seedlings under 60% light intensity with 1.80 g. Seedlings under direct sunlight had 1.30 g while seedlings under forest canopy had the least root biomass of 0.10 g (Figure 7). The result of ANOVA showed that root biomass production of seedlings subjected to different light intensities was significantly different (Table 5) while mean separation result shows that the root biomass production of seedlings subjected to 30%, 45%, 60% light intensities and direct sunlight were not significantly different from each other but were significantly different from the root biomass obtained from seedlings grown under forest canopy (Table 4).

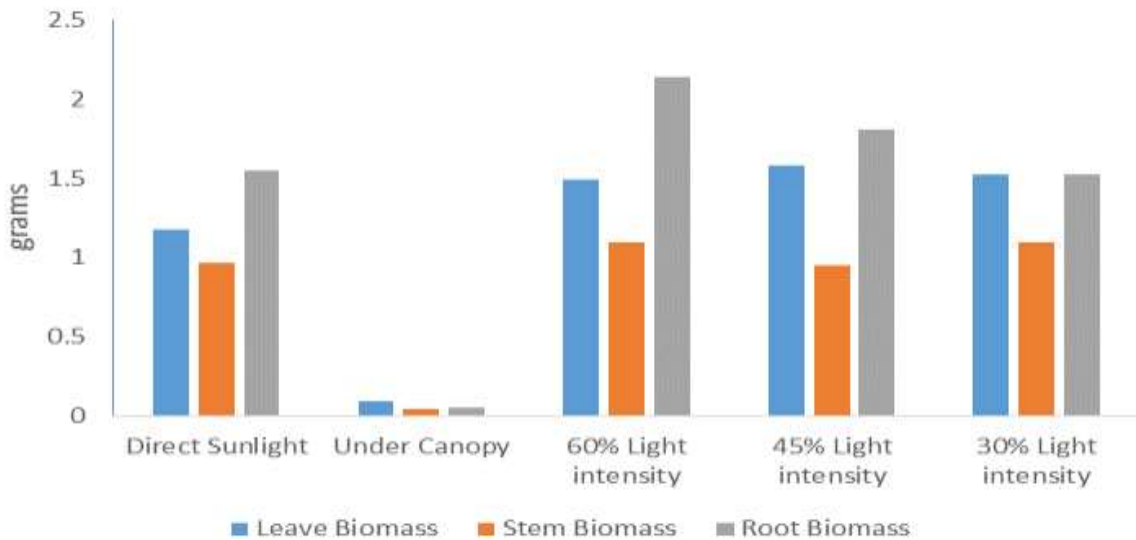

Figure 7: Effect of light intensities on the mean biomass accumulation of leaves, stem, and root of Kigelia africana seedlings

Root length

Mean values of root length of *K. africana* seedlings presented in Table 3 revealed that at the end of the third month of biomass estimation, root length of seedlings under 30% light intensity had the highest root length of 37.60 cm; which was followed by seedlings under 60% light intensity with 24.4 cm which was closely followed by seedlings under direct sunlight with 22.10 cm. Seedlings under forest canopy had 21.80 cm while seedling under 45% light intensity had the lowest root length of 17.90 cm (Figure 8). The result of ANOVA showed that there was no significant difference in the root length of seedlings grown under different light intensities (Table 5). The mean separation result shows that the root length of seedlings grown under forest canopy, 60% and 45% light intensities were not significantly different from each other but significantly different from root length obtained from seedlings grown under 30% light intensity and direct sunlight (Table 4).

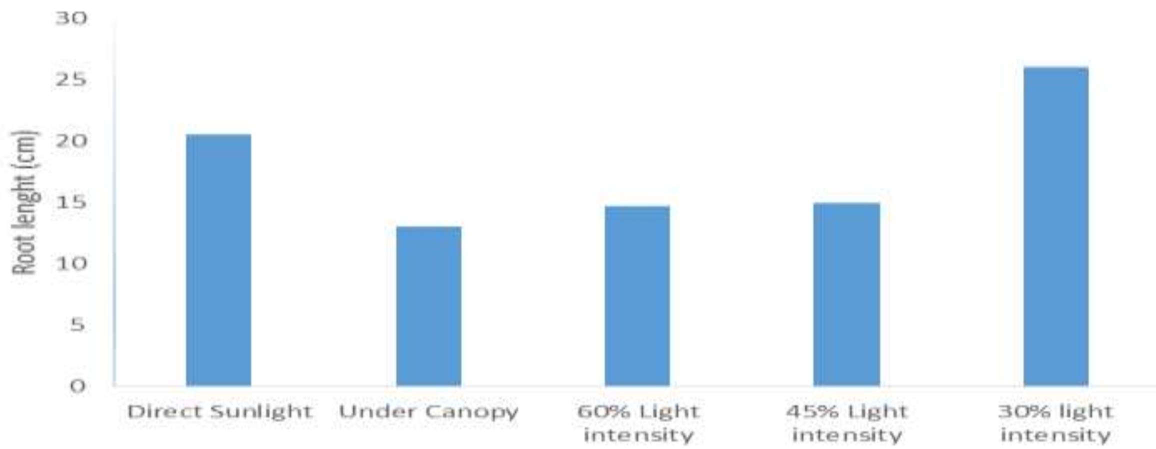

Figure 8: Effect of light intensities on the root length of *Kigelia africana* seedlings

DISCUSSION

Kigelia africana is a semi-evergreen, small to medium sized tree normally 10 – 12 m tall, occasionally up to 25 m, with a low – branching trunk up to 80 cm in diameter and rounded crown. The tree flower at the end of the dry season which occurs from November to December in West Africa. The result of this study indicated that the growth rate of the species starts early as indicated by growth characteristics investigated. The result obtained showed that there was a significant effect of light intensity on the early growth of *K. africana* seedlings. Seedlings growth height under low light environment (i.e. 30%, 45% and 60% light intensities) gave the best performance and do not have significant difference but significantly different from growth heights obtained from seedlings under direct sunlight and under forest canopy. For collar diameter growth, the seedlings under low light intensities condition gave the best performance. Thus, most of the light intensities favoured early height and collar diameter growth of *K. africana* because the seedlings have the ability to utilize any amount of light to manufacture its own food apart from under forest canopy that gave poor growth of the seedlings. The results obtained in this study correlate with what was reported for the growth height and collar diameter of *Chrysophyllum albidum* seedlings grown under different light intensities (Onyekwelu *et al*., 2013). The seedlings under most of the treatment produced higher number of leaves at the end of 12 weeks of growth compared with the number of leaves reported for some tree species (e.g. *Irvingia gabonesis* and *Dacryodes edulis*) (Ekeke *et al*., 2006; Ojeifo *et al*., 2007; Onyekwelu *et al*., 2013).

The poor performance of *K. africana* seedlings under forest canopy implies that the species will not grow well under closed canopy while its performance in full light condition and reduced light environment is an indication that the species requires some light for its early good growth. Though seedlings height growth was generally higher in low light environment but statistically comparable with that of those under full light environment, the higher height and collar diameter of seedlings grown under low light environment tends to suggest that *K. africana* seedlings will require some shade for establishment and early growth which is in agreement with what was reported on the light intensity requirement of *C. albidum* (Onyekwelu *et al*., 2013). *K. africana* seedlings planted under forest canopy had the least performance out of all the various treatments in the experiment. Thus, seedlings of the species cannot be nurtured under forest canopy.

CONCLUSION

It was revealed from the study that raising *K. africana* seedlings under different light intensities further improves its growth characteristics as *K. africana* seedlings grown under low light conditions i.e. 30%, 40% and 60% light intensities enhanced seedlings growth characteristics such as height, collar diameter and number of leaves. It is therefore suggested that the domestication and cultivation of *K. africana* can be embarked upon base on the information given in this study. Since, low light conditions led to increase in growth and biomass accumulation of *k. africana* seedlings. The yield may be enhanced by cultivating the species under low light intensity. Propagation and availability of this species will allow its sustainable use for curing some diseases, thus improving human health status, generation of income (alleviating poverty) through sales of its products and could also help in carbon sequestration in the mitigation of global warming.

REFERENCE

Aphalo P. J. & Ballaré C. L. (1995). On the importance of information-acquiring systems in plant-plant interactions. – Functional Ecology 9: 5–14.

Aiyelola A.A. and Bello O.A. (2006). Ethnobotanical potentials of common herbs in Nigeria: a case study of Enugu state. Educ. Res. Rev. 1(1):16-22.

Baiyeri, K.P., (2003): Evaluation of nursery media for seedling emergence and early seedling growth of two tropical tree species. Moor J Agric Res 4 (4): 60 –65.

Coates-Palgrave K (1988). Trees of Southern Africa, edn. 2. Struik, Cape Town.

Ekeke, B.A., Oyebade, B.A. and Adesina, M., (2006). Germination and Seedling Growth as Influenced by Seed Size of *Dacroyodes edulis (G. Don) H. J. Lam* in Nigeria. European Journal of Scientific Research, 15 (3): 336 – 343

FRIN (2013). Forestry Research Institute of Nigeria, Annual Meteorological Report

Graham, J.G., Quinn, M.L., Fabricant, D.S. and Farnsworth, N.R. (2000). Plants used against cancer – an extension of the work of Jonathan Hartwell. J. Ethnopharmacol. (Elsevier) 73: 347-377.

Hoyo, J., Elliott, A., & Sargatal, J., eds. (1997). *Handbook of the Birds of the World* 4: 415. Lynx Edicions.

Joffe P (2003). Kigelia Africana (Lam) Benth. Pretoria National Botanical Garden (www.plantzafrica.com) {Accessed 19th June, 2009}

Ojeifo, I.M., Emuh, F.N., and Igbenije-Ogor, B., (2007). Effect of different temperature regimes on seed germination and growth parameters of *Dacryodes edulis*. Agricultural Journal 2(1):16 – 19.

Olatunji, A. G. and Atolani, O. (2009). Comprehensive scientific demystification of Kigelia Africana: A review *African Journal of Pure and Applied Chemistry* Vol. 3 (9), pp 158-164.

Onyekwelu J.C., Stimm B., Mosandl R. and Adeyinka J. (2013). Domestication of Socio-Economically Important Forest Food Tree Species: Effect of Light Intensities on Germination and Early Growth of *Chrysophyllum albidum* and *Irvingia gabonesis*. 'Agricultural development within the rural-urban continuum' Tropentag, Sept 17-19, 2013, Stuttgart-Hohenheim

Roodt V (1992). Kigelia Africana in the shell Field Guide to the common Trees of the Okarango Delta and Moremi Game reserve. Gaborone, Botswana; shell Oil Botswana. LCCN: 9398015, LC: QK402.B6 R66 1992, Dewels: 582.1609883: 20-110.

Ugwunze, O.S. (2003) Effects of growth media on the emergence and early growth of African breadfruit (*Treculia africana* Decne). B Agric. Project Report, Dept. of Crop Science, University of Nigeria, Nsukka, Nigeria, P.36