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Effects of Light Intensity on Growth of *Dialium Guineense* Willd seedlings

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Abstract

Investigation was conducted on the effect of light intensity on the growth of seedlings of *Dialium guineense* at the Forestry Research Institute of Nigeria, Ibadan, Nigeria. One hundred and twenty (120) seedlings were transplanted into polythene pots placed in cages with 1 layer, 2 layers and 3 layers of 1mm green plastic mesh to receive 75% (L2); 50% (L3) and 25% (L4) respectively. Seedlings in the open received 100% light (L1). Ten (10) seedlings per treatment were assessed weekly. Leaf, stem and root biomass were determined fortnightly. Relative Growth Rate, Absolute Growth Rate (AGR), Net Assimilation Rate (NAR) and Shoot-Root Ratio (SRR) were determined. Data collected were analysed using ANOVA at $\alpha = 0.05$ and LSD was used to separate significant means. Significant difference was observed in stem diameter and Total Dry Weight (TDW) among the different light intensities. Seedlings exposed to 100% light intensity had highest TDW (0.577g) while those under 25% intensity had the least (0.232g). The highest mean value for RGR and AGR were found in seedlings raised under 100% light intensity while those under 75% and 50% had the least values of 0.036g/wk and 0.012g/g/wk respectively. The highest NAR (0.0108g/cm²/wk) was however recorded in seedlings under 75% light intensity and the least (0.0077g/cm²/wk) found in 50% light intensity. Exposure of seedlings of *D. guineense* to 100% light intensity therefore enhanced their growth and dry matter accumulation.

Keywords: **Light intensity, *Dialium guineense* seedlings, Growth analysis determination**

Introduction

Trees provide several beneficial environmental functions; it plays indispensable roles in creating and preserving a quality environment (Nwoboshi, 1999). Forest trees contribute to the fundamental ecological process which keeps the planet in a state of quasi-equilibrium. They are fundamental to the maintenance of biosphere, conserve biological diversity, shield the earth landscape from abrupt changes, bring order to the flow and quality of water and help to stabilize climate change (IPCC, 2007). Forest fruits act as buffer solution against poverty and provide protection against adverse environmental condition. Forest fruit trees help to provide the stable environmental condition for sustainable food production. They restore soil productivity through nutrient recycling and provide a store house for genetic diversity. Indigenous plants have enormous nutritional, medicinal social and economic potential (Schreckenberg *et al.,* 2006; Adekunle and Akinlemibola, 2008).

One of the indigenous fruit trees with enormous potential for plantation establishment, especially at this period of food insecurity is *Dialium guineense* (Velvet tamarind) which belongs to the family Fabaceae – Caesalpinioideae. It is commonly found in humid dense forests, dry dense forests and forest galleries in west and central Africa (Arogba *et al*., 1994). It is an important leguminous plant that is widely distributed in the tropics. Its native range includes Nigeria, Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Côte d'Ivoire, Equatorial Guinea, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Sao Tome and Principe, Senegal, Sierra Leone, Sudan and Togo (Keay, 1989). *Dialium guineense* is edible and widely consumed by the people of Southern Nigeria. The pulp is red with a sweet sour, has a stringent flavour similar to baobab but sweeter. It is peeled and eaten raw; it can be a little constipating. It has been suggested for use in agroforestry as leguminous tree capable of fixing nitrogen and a fodder for animals in silvopastoral (Ubani and Tewe, 2001). Its fruit is consumed raw and can be fermented to produce alcoholic beverage. The wood is a good source of charcoal. In Nigeria, *D. guineense* flowers from September to October and fruits from October to January while in Ghana, from September to November the tree is covered with small white flowers in panicles. Fruits ripen in March to May but could extend beyond July. Animals, which like to eat pulp in which the seeds are embedded, help disperse the seeds. However, the fruit can also be transported by water since it floats; transporting by sea currents may lead to long-distance dispersal (Arogba *et al*., 1994).

Successful stand establishment of *D. guineense* plantation is essential for efficient production of its fruit. Many factors such as temperature and light intensity variations are known to affect tree growth and development. The study aims at understanding the effects of different light intensities on seedling growth performance of *D. guineense*. This will enhance the establishment and effective management of the seedlings on the field.

Materials and Methods

The experiment was carried out at Forestry Research Institute of Nigeria, FRIN, Ibadan. One hundred and twenty 18-month old seedlings were transplanted into polythene pots filled with 2kg top soil and placed in cages covered with one layer, two layers and three layers of 1mm green plastic mesh net which were constructed to receive 75% (L2); 50% (L3) and 25% (L4) respectively. A light meter (Model SOLEX SL100 Lux Metre) was used to monitor the light intensities within and outside the cages on five different days during the experimental period. Seedlings grown in the open place received 100% (L1) light intensities (Odeleye *et al*., 2001). Thirty seedlings were arranged in a Completely Randomised Design (CRD) under each treatment and watered daily. Ten seedlings from each of the treatment were randomly selected every week for determination of seedling height, collar diameter, number of leaves and leaf area. Leaf, stem and root biomass were also determined at the end of the experiment. Three seedlings were randomly selected from each treatment and carefully uprooted and all soil particles washed off in running water. The seedlings were separated into roots, stem, and leaves components. The fresh weight of the different seedling components was determined for each seedling using an electronic mettler balance (H35). The dry weight was determined by drying roots, stems and leaves in an oven at $70^{o}C$ until constant weight was attained. Data collected on growth parameters were analysed using descriptive statistics and Analysis of Variance (ANOVA). LSD test was used to separate the means at 5% level of probability. Data collected on dry weights and leaf areas were used to evaluate Relative Growth Rate (RGR), Absolute Growth Rate (AGR), Net Assimilation Rate (NAR) and Shoot-Root Ratio (SRR) as described by Adewusi (1997):

$$RGR\ (g/g/wk) = \frac{lnTDW_2 - lnTDW_1}{t_2 - t_1} \quad \text{(i)}$$

$$AGR\ (g/g/wk) = \frac{TDW_2 - TDW_1}{t_2 - t_1} \quad \text{(ii)}$$

$$NAR(g/cm^2/wk) = \frac{TDW_2 - TDW_1}{LA_2 - LA_1} \times \frac{lnLA_2 - lnLA_1}{t_2 - t_1} \quad \text{(iii)}$$

$$\text{Shoot : Root (SRR)} = \frac{\text{Dry Shoot Weight}}{\text{Dry Root Weight}} \quad \text{(iv)}$$

Where:

TDW_1 = Initial total dry weight (g) and TDW_2 = Final total dry weight (g)

t_1 = Initial time and t_2 = Final time

LA_1 = Initial leaf area (cm²) and LA_2 = Final leaf area (cm²)

ln = Natural Logarithm

Results

Effect of light intensity on growth of D. guineense seedlings

Though analysis of variance (ANOVA) for seedling height indicated that there is no significant difference at 5% probability level among the light intensities, average seedling height showed differences with seedlings in L_3 (50%) having the highest value of 9.97 cm while the lowest value was found in L_1 (100%) with 7.18 cm. There was significant difference in the mean collar diameter among the light intensities at (α= 0.05). The best performance in collar diameter, 1.64mm was observed among the seedlings in L_3 (50%) and the least is 1.3mm in L_2 (75%). On leaf production, the highest number of leaves was observed in L_4 (25%) which had 6.07 leaves while the least was observed in L_1 (100%) with 4.87. The highest mean leaf area was also observed in L_4 (25%) with 7.40 cm² and the least was recorded in L_2 (75%) with 4.85cm² (Table 1).

Table 1: Effect of light intensity on growth of *D. guineense* seedlings

Treatments	Stem hei (cm)	Mean Colla Diameter (cr	Number leaves	Leaf are (cm^2)
L1(100%)	7.18c	1.33b	4.87c	4.88 bc
L2(75%)	7.95b	1.30c	5.52a	4.85c
L3 (50%)	9.97a	1.64a	5.38a	7.40a
L4 (25%)	8.59b	1.63a	6.07b	7.26a
LSD (α = 0.05)	**2.87**	**0.22**	**2.87**	**2.27**

Means with same letter(s) are not significantly ($p<0.05$) different from each other.

Total dry weight of seedlings

Seedlings which received 100% light intensity had the highest mean 0.577g in terms of total dry weight followed by those ones that received 75% intensity having 0.51 g. Seedlings which received 25% had the least TDW value of 0.23 g in terms of biomass accumulation (Fig. 1).

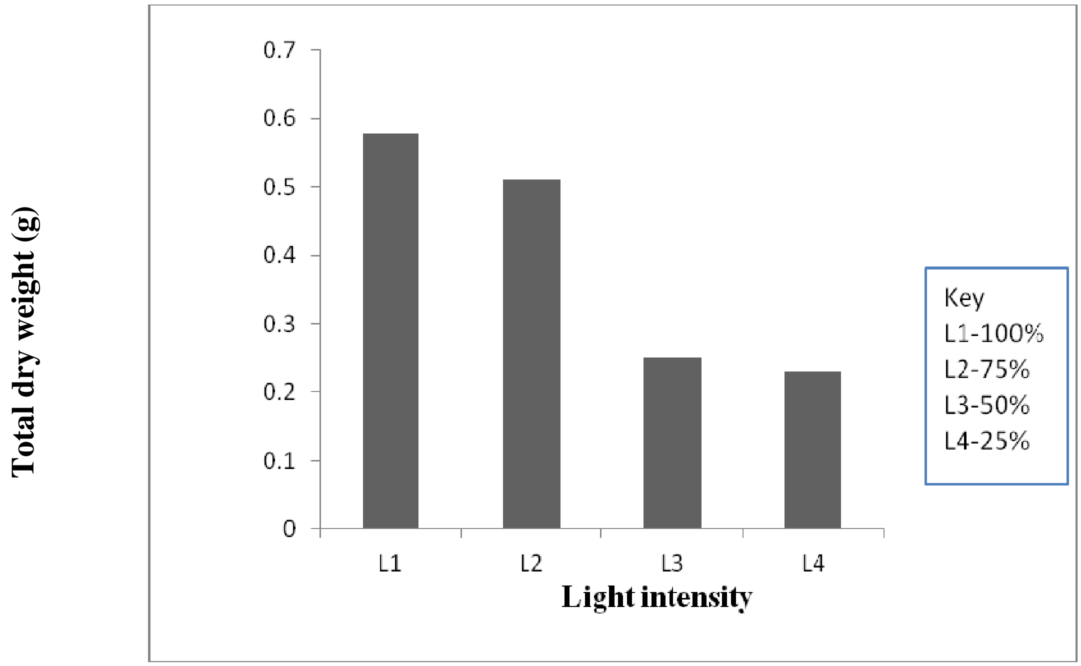

Fig. 1: Total Dry Weight of Seedlings under different Light Intensities.

Relative growth rate (RGR)

The highest mean RGR value was found in seedlings under 100% light intensities and the least found in those under 75% light intensity (Table 2). Between 2nd and 4th weeks, seedlings under 100% light intensity had the highest RGR value (0.97g/wk) with the least observed in those raised under 75% (0.23g/wk). The highest value (0.06g/wk) in week 10 – 12 was observed in seedlings under 75% and least (0.04g/wk) in those raised under 50% light intensity.

Absolute Growth Rate (AGR)

Highest mean AGR, 0.06g/wk, was observed in seedlings under 100% light intensity, followed by those under 75% with 0.04g/wk while those under 50% had the least value, 0.02g/wk (Table 3). Seedlings under 100% had the highest AGR value (0.28g/wk) in weeks 2 – 4 while those under 50% had the least value (0.05g/wk). AGR values of 0.04g/wk and 0.01g/wk for seedlings under 100% and those under 50% light intensities are the highest and least values respectively in weeks 10 – 12.

Table 2: Relative growth rate of *D. guineense* seedlings under different light intensities (g/wk)

Intensity	2 – 4	4 – 6	6 – 8	8 – 10	10 – 12	Mean
L1 (100%)	0.9714	0.0120	0.0176	0.0092	0.0518	0.2148
L2 (75%)	0.2342	0.0124	0.0303	0.0427	0.0628	0.0765
L3 (50%)	0.3019	0.0447	0.0147	0.0768	0.0410	0.0958
L4 (25%)	0.3696	0.0654	0.0020	0.0326	0.0529	0.1045

Table 3: Absolute Growth Rate of *D. guineense* seedlings under different light intensities (g/wk)

Intensity	2 – 4	4 – 6	6 – 8	8 – 10	10 – 12	Mean
L1 (100%)	0.2810	0.0080	0.0120	0.0060	0.0360	0.0686
L2 (75%)	0.0965	0.0065	0.0165	0.0230	0.0345	0.0354
L3 (50%)	0.0485	0.0100	0.0035	0.0200	0.0120	0.0188
L4 (25%)	0.0580	0.0155	0.0005	0.0085	0.0300	0.0225

Net Assimilation Rate (NAR)

The highest mean NAR value (0.01g/cm²/wk) was found in seedlings under 75% light intensities and the least (0.008g/cm²/wk) found in seedlings under 50% light intensity (Table 4). Between 2nd – 4th weeks, seedlings under 100% had the highest NAR value (0.037g/cm²/wk) while the least was in those under 25% (0.022g/cm²/wk). The highest value (0.007g/cm²/wk) in week 10 – 12 was observed in seedlings under 75% and those under 25% while the least (0.002g/cm²/wk) in seedlings under 100%.

Shoot to root ratio

The seedlings from all light intensities have similar shoot to root ratio. The shoot to root ratio of 3:1 was found in seedlings under 25% light intensity at 2nd week while 1:3 was observed in seedlings under 75% from 4th to 12th week. The rest have shoot to root ratio values of 1:2 (Table 5).

Table 4: Net Assimilation Rate of *D. guineense* seedlings under different light intensities (g/cm²/wk)

Intensity	2 – 4	4 – 6	6 – 8	8 – 10	10 – 12	Mean
L1 (100%)	0.0373	0.0008	0.0013	0.0008	0.0021	0.0085
L2 (75%)	0.0357	0.0029	0.0046	0.0045	0.0065	0.0108
L3 (50%)	0.0226	0.0034	0.0008	0.0072	0.0043	0.0077
L4 (25%)	0.0221	0.0070	0.0002	0.0079	0.0065	0.0087

Table 5: Shoot to Root Ratio of *D. guineense* seedlings under different light intensities

	Weeks after transplanting					
Intensities	**2**	**4**	**6**	**8**	**10**	**12**
L1 (100%)	1:2	1:2	1:2	1:2	1:2	1:2
L2 (75%)	1:2	1:3	1:3	1:3	1:3	1:3
L3 (50%)	1:2	1:2	1:2	1:2	1:2	1:2
L4 (25%)	3:1	1:2	1:2	1:2	1:2	2:1

Discussion

Light plays important role in the germination, growth and development of seedlings because of the passage of heat through radiation. A key trait governing community structure and dynamics is the ability of species to cope with light and water limitations, especially during the establishment stage and plants exposed to shade optimize photosynthesis to adapt to the decrease in light quality and quantity (Gommers *et al.*, 2013). According to Akinyele (2013), it is essential that plants are grown under conditions of optimum light intensity that will result in maximum growth and development. The basic process of growth and development in plants is brought about by the solar energy used in photosynthesis (Taig and Zeiger, 1991). This solar energy produces the end products which powers the cellular processes in plants leading to increased growth and development. A study carried out by Sánchez-Gómez *et al.* (2006) showed important species-specific differences in survival and growth along the irradiance gradient imposed on species. The result of this study showed that imposed shade lower the growth capacity of this species. In all the variables observed, seedlings subjected to 100% light intensity consistently showed better growth, while seedling exposed to 25% light intensity had least growth performance. It is obvious that *D. guineense* seedlings subjected to reduced light intensity were unable to recover from the exposure leading to a reduction in dry matter accumulation. This is in agreement with Rao (1988) who found that deep shade negatively affects seedlings growth of *Quercus floribunda* and *Cuoressus torulosa*. Kiyono (2000) also found that canopy opening which improved light conditions accelerated seedling growth of *Eusideroxylon swageri*.. Lees *et al*. (1996) also discovered that light intensities influence total height, leaf area and dry matter production of *Dryobalanops aromatic, Hopea helferi. Hopea odorata, Hopea wightiana* and *Shorea singkauany*. Generally in *D. guineense* seedlings, total dry weight, absolute growth rate and relative growth rate increased in 100% light intensity than other light intensities. However, these findings contradict that of Nwoboshi (1972) who examined the growth response of *Tectona grandis, Terminalia ivorensis* and *Nauclea diderichii* seedlings under varying relative light intensities and concluded that the optimal light intensity were 75% for *Terminalia ivorensis,* 53 – 75% for *Tectona grandis* and anything over 25% for *Nauclea diderichii.* Moriya *et al*. (1996) also observed that seedlings of camphor tree under different conditions of light intensity had increased dry matter production, absolute growth rate and relative growth rate compared with those of control. Odeleye *et al.* (2001) found that reduced light intensities imposed at the vegetative stage increased the vegetative growth of soyabean.

In a study carried out by Akinyele and Dada (2015), light enhanced growth of *T. superba* with the best leaf count and collar diameter occurring in seedlings exposed to 100% while those exposed to 75% had the highest stem height. This is also in accordance with the report of Ibrahim (2010) who found that the highest germination percentage of seeds and all measured growth characteristics of seedlings are higher in 100% light intensity treatments for *Cassia fistula* (Linn.), *Enterolobium saman* (Jacq.) and *Delonix regia* (Boj).

It also agreed with Ahmed (2000) who indicated the importance of light intensity during early growth, since it enhances germination. Full light intensity treatment and, to a lower extent, the 50 % light intensity treatment enhanced the growth of *Acacia seyal* Del. and *Acacia mellifera* (Vahl) Benth. This result agreed with that of Osunkoya *et al*. (1994) who observed that twelve forest trees under experiment showed reduced growth with decreasing light intensity. Ahmed (2000), also, reported the best growth of two *Acacia* seedlings under high light intensity, compared to 50 % light intensity. Similar results were obtained for different forest species (Veenendaal *et al*., 1996) for *Terminalia superba* and *Entandrophragma utile;* and Palik *et al*. (1977) for long leaf pine.

The results obtained for relative growth rate did not follow any discernable trend but had the highest mean value in 100% while it has the least in 50%. Net assimilation rate also did not follow any definite trend but the best was observed in seedlings under 100% which means it has more photosynthesizing tissues than the other ones grown under the remaining light intensities.

Conclusion and Recommendation

Seedlings subjected to 100% light intensity had overall best growth performance compared to others in the other intensities, while seedlings subjected to 25% had poor performance. It is concluded that this tree species demands high light intensity especially in the early stage for proper growth and development. The results have shown that height and other growth parameters as well as biomass accumulation depend on light intensities received. Good light intensity is recommended for seedling growth and development in proper plantation establishment for this particular species.

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