Seedling Emergence and Growth of *Terminalia superba*Eng. EL. Diels under Different Light Conditions

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Abstract
One of the ecological factors essential to the growth and survival of tropical forest tree species is availability of light in terms of amount, quality and duration. The effects of direct light (DL), low light (LL) and medium light (ML) on seed germination and seedling growth of *Terminalia superba*were investigated. Seeds were soaked in water under ambient conditions for 24 h and sowed under the three light conditions. Germination occurred earlier at 13 days after sowing (DAS) under LL and DL but ML caused a delay till 15 DAS while germination was completed at 25, 29 and 33 DAS under LL, DL and ML respectively. The seedling height increased over the assessment period and varied significantly among the light conditions with LL producing the tallest plants. Mean collar diameter increased over the assessment period and was highest under LL except at week 12 but the values did not differ significantly from the other light conditions. The number of leaves increased and ranged between 7.11 and 15.56, 8.11 and 17.00 and 8.78 and 16.89 under DL, ML and LL respectively but the highest values under ML were similar to the other light conditions. The good germination and growth performance suggest that *Terminalia superba* would withstand shade at the early stage and can be incorporated into agroforestry and mixed plantation systems.

Key words: *Terminalia superba*, light conditions, germination, emergence, seedling growth

Introduction
Plant growth is influenced by many environmental factors, one of which is light through the direct effects it plays in photosynthesis and phototropism. These roles make light a fundamental part in plant establishment, growth and regeneration of tropical evergreen and deciduous forests (Phonguodume*et al.,* 2012). Henmann and Hugh (2010) observed that the surrounding vegetation and habitat environment, especially light and temperature, affect the ecological and physiological responses of tropical rainforests.

Tree growth had increased with light or gap size (Balderrama and Chazdon, 2005; de Gouvenain *et al*., 2007; Herault*et al.,* 2010) but tree species differ in light requirements especially at the seedling (early growth) stage. The growth rates of tropical tree species vary among the species and in response to resources availability, especially light, soil moisture and nutrients and individual conditions such as size and vigour (Dalling*et al*., 2004; Herault*et al*., 2010). The light that reaches the forest floor in a forest ecosystem varies depending on the forest structure. The knowledge of light requirements of tropical tree species will determine the suitability for mixed forest plantations, agroforestry and even how such species can be incorporated in ecological restoration.

Phonguodume *et al*.(2012) stated that there is limited information about the effect of light intensities on growth and biomass allocation of tree species. Guenni*et al.* (2008) reported that shade tolerance of species adapted to open habitats will depend on the capacity of the plants to adjust morphologically and physiologically to a given level of irradiance. At the ecosystem level, reduced irradiance has a considerable impact on plant productivity. Wright and van Schaik (1994)opined that correlations between plant performance and irradiance suggest that light limits many tropical forest trees.

Terminalia superba is a large tree in the family Combretaceae and is native to West Tropical Africa (Burkill, 1985). It is commonly called Black Korina while the local names in Nigeria are Afara (Yoruba) and Baushe (Hausa). It has potential importance in paper making, offering the capability of producing a relatively wide range of pulps (Dupuy and Mille, 1993). The wood is normally creamy white with no noticeable distinction between the sapwood and heartwood (Groulez and Wood, 1985). The wood is soft to medium-hard, light in weight, somewhat weak, easy to saw and machine. It also accepts paints and varnish well (Lamprecht, 1999). It is used in plywood manufacture, furniture and joinery, for plinths, mouldings, general fittings and door faces (Lemmens *et al*., 1995). The fibre of *Terminalia superba* has potential importance in paper making, offering the capability of producing a relatively wide range of pulps. The leaves serve as diuretic and roots as laxative (Neuwinger, 2000). The bark is also used for dyeing textiles black. The bark decoction and macerations are used in traditional medicine to treat wounds, sores, haemorrhoids, diarrhoea, dysentery, malaria, vomiting, gingivitis, bronchitis, aphthae, swellings, ovarian troubles, expectorant and anodyne (Neuwinger, 2000). Furthermore, *Terminalia superba* was identified in Nigeria to have high potential for the development of integrated crop-livestock (sheep and goats) agroforestry technologies based on fodder yield and concentrations of crude protein as well as lignin (Orwa, 2009).

Terminalia superba is a highly valued timber tree of the semi-deciduous and closed wet forest formations of West and Central Africa. It is a pioneer species that regenerates well after forest exploitation with the seedlings abundant along roadsides and in forest gaps (Kimpouni, 2009). This is an indication of the light requirements. Therefore, an intensive investigation of the germination responses of *Terminalia superba* seeds and seedlings to varying range of light conditions is crucial to its wide use in plantation establishment across different ecosystems.

Materials and Methods

Seed collection and germination of Terminalia superba seeds under different light conditions

Matured seeds of *Terminalia superba*were obtained from the Seed Store of Forestry Research Institute of Nigeria (FRIN), Ibadan. Fifty-four seeds of *Terminaliasuperba* were pre-treated by soaking them in water at room temperature for 24 h and sown in seed trays placed under three light conditions: Direct Light (DL), Medium Light (ML) and Low Light (LL). The seedlings under DL were without any form of shade; seedlings under ML were covered with a box of single-layered mosquito net and those under LL were covered with a box of double-layered mosquito net. Germination count was done daily until no further germination took place for about one week.

Seedling growth of Terminalia superba under the light conditions

Twelve (12) uniformly-growing seedlings under each light condition were pricked out into polythene pots previously filled with topsoil in three replicates in a completely randomized design. The seedlings were watered daily in the morning and growth assessment was carried out after one week at fortnight intervals for twelve weeks. The growth variables measured were seedling height, seedling collar diameter and number of leaves. The data collected were subjected to one-way Analysis of Variance (ANOVA) and the treatment means separated.

Results

Germination of Terminalia superba seeds under different light conditions

Table 1 shows the germination of *Terminalia superba* seeds under the light conditions. Germination began 13 days after sowing (DAS) under DL and LL but was delayed to 15 DAS under ML. Germination was completed at 25 DAS under LL, 29 DAS under DL and 33 DAS under ML. The germination percentage was the same (73%) under shade (ML and LL) and higher than DL (60%).

Table 1: Mean germination percentage and rate of *Terminalia superba* seeds

Light conditions	Start of Germination (DAS)	End of Germination (DAS)	Germination Percentage (%)
Low light (LL)	13	25	73
Medium light (ML)	15	33	73
Direct light (DL)	13	29	60

DAS = Days after sowing

Seedling growth of Terminalia superba under the different light conditions

Seedlingheight

Table 2 shows the heights attained by the seedlings under the different light conditions. Seedling height values were significantly different from one another under the light conditions across the assessment period. At 2 weeks, LL gave the tallest seedlings and differed from DL only but there was no significant difference between ML and LL. At 4, 6 and 8 weeks, the tallest seedlings were produced under LL which differed significantly from the other light conditions. There was no significant difference between DL and ML. There was no significant difference between ML and LL at 10 and 12 weeks but these were significantly different from DL. The highest mean seedling heights were obtained at 12 weeks with values of 37.02cm under DL, 36.92cm under ML and 35.58cm under LL.

Table 2: Mean seedling height (cm) of *T. superba* under different light conditions across assessment period

Assessment period (weeks)	Light conditions Direct light	Medium light	Low light
2	5.50[b]	6.37[ab]	7.41[a]
4	7.97[b]	8.54[b]	10.15[a]
6	10.87[b]	11.43[b]	13.29[a]
8	15.83[b]	16.76[b]	19.28[a]
10	22.37[b]	25.20[a]	26.29[a]
12	37.02[b]	36.92[a]	35.58[a]

Note: means with the same letter(s) in each row are not significantly different at $\alpha = 0.05$

Seedling collar diameter

The mean seedling collar diameter values under the different light conditions are shown in Table 3. The highest collar diameter was obtained under LL over the assessment period but the values were not significantly different from ML and DL. The highest mean seedling collar diameter (1.21mm) obtained at 12 weeks under ML was not significantly different from 0.99mm and 0.84mm under LL and DL respectively.

Table 3: Mean seedling collar diameter of *T. superba* under the light conditions during assessment period

Assessment period (weeks)	Light conditions Direct light	Medium light	Low light
2	0.36[a]	0.38[a]	0.39[a]
4	0.47[a]	0.51[a]	0.52[a]
6	0.59[a]	0.59[a]	0.60[a]
8	0.69[a]	0.71[a]	0.71[a]
10	0.86[a]	0.76[a]	0.85[a]
12	0.84[a]	1.21[a]	0.99[a]

Note: means with the same letter(s) in each row are not significantly different at $\alpha = 0.05$

Number of leaves

The mean number of leaves under the different light conditions at 2, 6, 8 and 10 weeks was not significantly different from one another (Table 4). However, at 4 weeks, seedlings under LL produced significantly higher number of leaves than DL but both did not differ from ML. At 12 weeks, there was no significant difference in the number of leaves under ML and LL conditions but these significantly differed from DL. The highest mean number of leaves was obtained at 12 weeks with a value of 17.00 under ML followed by 16.89 under LL and15.56 under DL. The seedlings placed under DL produced the least number of leaves throughout the assessment period.

Table 4: Mean number of leaves of *T. superba* seedlings for the light conditions across assessment period

Assessment period (weeks)	Light conditions Direct light	 Medium light	 Low light
2	7.11[a]	8.11[a]	8.78[a]
4	7.78[b]	8.78[ab]	9.11[a]
6	10.00[a]	10.67[a]	10.89[a]
8	11.89[a]	13.34[a]	13.22[a]
10	13.55[a]	14.67[a]	14.77[a]
12	15.56[b]	17.00[a]	16.89[a]

Note: means with the same letter(s) in each row are not significantly different at $\alpha = 0.05$

Discussion

The highest germination percentage of *Terminaliasuperba* seeds was observed under LL and ML conditions but LL favoured earlier initial germination at 13 DAS compared to 15 DAS under ML. Olayode and Olatunji (2014) had observed that low light condition produced the highest germination percentage in *Parkiabiglobosa* seeds. Similarly, the highest cumulative germination of *Chrysophyllumalbidum* seeds was obtained under forest canopy whereas the highest germination percentage of *Irvingiagabonensis* seeds was under 100% light intensity indicating variable and species-dependent effects of light intensity on seed germination (Onyekwelu *et al*., 2012). This study shows that seeds of *T. superba* can germinate well under different light conditions since all the light conditions ensured above 50% germination percentage Seedling height, collar diameter and number of leaves were enhanced by ML followed by LL. This is in contrast to the report by James and Bell (2000) that low light (10% light) reduced growth, biomass and leaf area in two *Eucalyptus globulu* ssp. *Globules* (James and Bell, 2000). DL had the least values for number of leaves, seedling height and collar diameter across the assessment period, suggesting that for best the growth of *Terminaliasuperba* seedlings, some amount of shading may be needed. It is also possible that the variations in seedling growth characteristics occurred as a result of the differences in light conditions. Light as a climatic factor is vital to plant growth and determines where different species are found because of the key role in plant community dynamics (Olayode and Olatunji, 2014). Shade tolerance has been extensively studied in forests because competition for light and interspecific differences in shade tolerance are important determinants of forest structure and dynamics (Gravel *et al*., 2008). The results of this study are an indication that *Terminaliasuperba* can be readily adopted in agrisilviculture since it would be able to withstand shade at the early stage without any adverse effects on growth. Orwa *et al*.(2009) earlier reported the high potentials of *Terminaliasuperba* for the development of integrated crop-livestock (sheep and goats) agroforestry technologies in Nigeria based on the fodder yield and concentrations of crude protein as well as lignin.

Conclusion

Low light favoured seed germination of *Terminaliasuperba* in terms of earliness which was similar to direct light but the germination percentage of low and medium light conditions was the same. Therefore, it is recommended that the seeds should be sown in shaded environment in order to enhance earliness and total germination percentage. Low light condition increased the number of leaves, height and collar diameter of the seedlings but the differences from medium light were not significant as the seedlings aged. The performances of the seedlings showed that *Terminaliasuperba* can be successfully raised under different light conditions although partial shading is recommended in order to obtain high germination percentage and best growth at the early stage.

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