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# EVALUATION OF RESPONSES OF *Tetrapleura tetraptera* (Schum. and Thonn.) Taub. TO VARYING GROWTH CONDITIONS

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## ABSTRACT

Knowledge of suitable growth conditions is vital to successful establishment of indigenous tree stand. Hitherto, influences of different light regimes and sowing media on germination and growth of *T. tetraptera* are unknown. Thus, we investigated optimum conditions for its propagation. The study was laid out in 4×5 factorial experiment with sowing medium and light intensity as the two factors, using topsoil, sterilized-riversand, sawdust and a mixture of sawdust and topsoil in ratio 2:1. Variations in light intensities were achieved through contruction of light chambers. Twenty seeds each were sown in twenty germination-trays, making. Germinations from each tray were recorded. After four weeks of seedling emergence, growth parameters were taken. The seedlings were then potted, and nursed for 24 weeks. Individual plant biomass was determined by sectioning the seedlings into roots, shoots and leaves. The sections were air-dried to constant weights, and dried weights were taken. Total biomass accumulation was obtained for each seedling by adding the biomasses of all parts. Data were analysed using descriptive statistics and analysis of variance. The result revealed that seeds sown under shade had the highest mean germination (81.2 ± 7.5%). The mean seedling heights in 25% light (12.69 ± 3.65 cm) and shade (12.68 ± 1.98 cm) were not significantly different but significantly different from 50%, 75% and 100% lights. The least height growth (8.02 ± 2.56 cm) was recorded under 100% light. Similar trends were observed for collar diameter and leaflet number with best results under 25% light with 3.59 ± 1.44 mm and 29 ± 23, respectively. Seedlings raised with topsoils produced the best results. Seedlings raised with riversand also performed well for all the light intensities, but under shade. It is concluded that *T. tetraptera* performed excellently-well under shade, in terms of germination. However, shade hindered seedling post-emergence growths.

**Keywords:** Light intensity, sowing media, germination, seedling growth, biomass accumulation

## Introduction

The intensity and quality of light are important for plant growth, morphology and various physiological responses. Changes in light spectrum is expected to have strong influence on the leaf anatomy, morphology and physiology (Macedo *et al.*, 2011). In order to shift or adapt to different light regimes, or microclimate, plants developed some mechanisms, which include morphological and physiological changes at various levels (Fan *et al.*, 2013). According to Wu *et al.* (2017), slight variation in light intensity leads to significant changes in leaf morphology and structure of most plants. According to Yang *et al.* (2014), the dry matter of plant parts and whole plant as well as the photosynthetic rate, transpiration, stomata conductance and the shoot diameter decrease under low light conditions. However, shaded environments increase the height and lodging rate of plant, which is capable of impeding the transportation of nutrients, water and photosynthetic products, and ultimately causes huge losses to agricultural production. Besides, plant leaves that expand under high light conditions presents lower photosynthetic pigment contents than leaves,which expand under low light conditions (Mielke and Schaffer, 2010).

The intensity of the light is also the main factor that controls the central process of plants, such as germination, leaf production and development, photosynthesis, buds and flower initiation, and cell division (Yang *et al*., 2014; Kong *et al*., 2016). Indeed, the numerous plant processes improve with increasing light intensity, up to a moderate level, which brings intense developmental and physiological changes to occur, resulting in the rapid increase of those processes (Yang *et al*., 2015; Wu *et al*., 2016). Literature is replete with the importance of high light intensity on seedling growth and survival. For instance, Baligar *et al*. (2018), reported that increasing light intensity increase plant growth parameters (that is, shoot, leaf and root) and decrease their growth with decrease light intensity. However, some plant species living under forest understory, cannot outcompete tall trees; and therefore, they developed strategies of shade-tolerance to cope with low light and also to optimize the light captured (Gommers *et al*., 2013).

Tropical forest trees have been categorized on the basis of their light requirements for germination. The germination of seeds of pioneer tree species is enhanced by direct solar radiation (Ademon *et al*., 2017). A wide range of light levels occurs in tropical rain forests. These light levels depend, largely, on the forest structure. Closed canopies may intercept up to 99% of the incident light, and thus may reduce light levels to as low as 1% relative to the light level in the open sky. Plant biomass production is considered to be a very important aspect since it requires the interaction of factors such as light, water, carbon dioxide and the continuous flow of mineral salts for its proper development (Souza *et al*., 2017). The intensity, duration and interval of light on plants influence its development, directly interfering with photosynthesis (Taiz and Zeiger, 2013; Péllico-Netto *et al*., 2015).

Poorter *et al*. (2012) examined factors controlling the allocation of biomass to leaf, shoot and root in a wide range of species. The most important factors were determined to be quantity of light available, water and nutrients availability, temperature and plant age. However, the growth responses of trees to different light levels depend not only on photosynthesis and the level of carbon fixation. Evidence from field studies indicates that plants allocate more carbon to shoots under light limitations (Girardin *et al*., 2016). At the meristem, the allocation of carbon among different cell-types may also change. These changes in carbon allocation as a result of light availability may affect tree development and morphology. The carbon allocation in trees is often expressed as biomass allocation. Biomass allocation is usually assessed by harvesting plants and determining the masses of different parts.

Onyekwelu *et al*. (2012) observed that, effect of light intensity on seed germination is variable, and may be species-dependent. In addition, light is the main environmental factor involved in seedling survival and growth among habitats. The biomass of roots, shoots, leaves and whole plant was found to decrease under low light (Zervoudakis *et al*., 2012). However, due to the temporal and spatial variation of light intensity, plants species acclimatize and develop plasticity to cope with variation in light regimes. The world's forests play an important role in maintaining fundamental ecological processes, as well as providing livelihoods and supporting economic growth (FAO, 2014). However, the over-exploitation of forest resources has endangered the population of these forest resources. A number of earlier investigations have reported that environmental factors such as light intensity can significantly improve growth and alter the metabolite concentrations. But little is known about consequential effects of light on early growth of *Tetrapleura tetraptera*.

In Nigeria, several tree species serve as source of food, wood, fibre and medicine to indigenous people. Trees also have added value of conservation for scenic purposes, stabilization of climate, maintenance of water supply and preservation of erosion. These forest resources were misused by man due to overexploitation and lack of purposeful management, with a resultant negative effect on the environment (Tomalak *et al*., 2010). *Tetrapleura tetraptera* has great potential to protect the environment, and providing medicines and food. In traditional medicine, the fruit is utilized for the management and treatment of arthritis and other inflammatory conditions, and adult onset type-2 Diabetes (Ozaslan *et al*., 2016). Research has shown the efficiency and potential of *Tetrapleura tetraptera* in the management and control of those ailments that were traditionally treated using the species (Okoronko and Echeme, 2012; Atawodi *et al*., 2014). Other benefits derived from *Tetrapleura* include food and energy. However, despite the enormous benefits and potentials of *Tetrapleura tetraptera*, it remained uncultivated in Nigeria, and its population in the wild is endangered due to overexploitation (Aniedi *et al*., 2013). One of the major constraints affecting the establishment of large plantations of some forest tree species as well as their introduction to other ecological zones is lack of adequate silvicultural information such as, suitable soil type, light and moisture requirements, and the combined effects of these variables on the growth and development of plant species (Akinyele and Wakawa, 2017).

Domestication of tree species that can withstand diverse environmental condition while yielding multiple benefits is crucial, as there is the likelihood of plants experiencing stress even outside the arid/semi-arid region. Therefore, there is need to understand individual plant response to factors such as light and its effects on plant growths and development for continuous provision of goods and services despite unfavourable environmental condition. Traditionally, *Tetrapleura tetraptera* in the family *Fabaceae*, is found to be one of the most useful indigenous species which provide the local community with range of benefits. Even with the economic usefulness of *Tetrapleura tetraptera*, the population of the plant is declining due to over-exploitation and inadequate information on silvicultural techniques for optimal development. The potentials of the species have virtually not been improved, and may be heading towards extinction since best propagation methods may not have been explored. Besides, little is known about the influence of light intensities on the germination of *Tetrapleura tetraptera*. Information about *Tetrapleura tetraptera* growth under abiotic cultural practices is rare.

Therefore, there is need to investigate the species, as a candidate for agroforestry practices and afforestation programme, for growth performance under different light intensities for likely economic benefit, in erosion control and to reduce green gas emission. The main objective of this study is to evaluate early growth of *Tetrapleura tetraptera* under different light intensities and growing media. Light is fundamental to the initial stage of seedling growth in forest nurseries, and management is important according to the physiological needs of each species of interest. Studies associated with light intensity aiming at a quality production are of extreme importance for development in forest-based activity, conservation, and reforestation programmes. For the forest productivity to be efficient, it is fundamental to identify responses that promote and maintain plant growth and development in time, considering different environmental conditions. The essential ecological and silvicultural information needed on the trees includes flowering and fruiting patterns, seed germination and growth requirement to facilitate domestication and improvement of their potentials.Therefore, it is necessary to improve seedling quality production techniques. Information about the influence of different light intensities on the germination and early growth of *T. tetraptera* will help to identify an appropriate and suitable light condition for propagating the species.

**Methodology**

**The Study Area**

The study was carried out at Department of Forest Resources Management's Nursery in Faculty of Agriculture, University of Ilorin. The nursery is geographically located on latitude 8°29'10.9"N and longitude 4°40'36.43"E. The climate of the site is characterized by both wet and dry seasons. The rainy season begins towards the end of April and last until October, while the dry season begins in November and ends in April (Olanrewaju, 2009). The temperature ranges from 33ºC to 35ºC from November to January, while from February to April, the value ranges between 34ºC and 37ºC. Days are very hot during the dry season, and the mean temperature is generally high throughout the year. The total annual rainfall in the area ranges from 990.3 mm to 1318 mm. The relative humidity ranges between 75% and 88% from May to October, while in the dry season, it ranges between 35% and 65% (Olanrewaju, 2009).

The soil type in Ilorin is a ferruginous tropical soil-type, existing on crystalline acidic rocks. The soil is uniform in terms of physical characteristics, the fertility of soils is variable and farming activities are enhanced in most parts of the study area. The soil has the tendency of being more productive if not for water deficiency, thus it demands for adequate water management to attain better productivity (Oriola *et al*., 2006).

The vegetation of University of Ilorin falls within the forest and savannah land with slight variations in terms of the nature of vegetation population and growth. This is so because it falls within the middle-belt region, between the northern savannah and southern forest belts of the country. The vegetation can also be classified as wooded savannah grassland because the original vegetation cover has been removed through anthropogenic activities such as clearing and cattle grazing, among others. The common trees are *Vitellaria paradoxa*, *Parkia spp., Afzelia africana, and Terminalia spp.* (Oriola *et al.*, 2010).

**Experimental Procedures**

Matured fruits of *Tetrapleura tetraptera* fruits were obtained from Oja-Oba, Ilorin, Kwara State. The fruits were cut open to extract the seeds. The extraction process was carefully done to avoid damage to the seeds. After the extraction, viability test was carried out using floatation method. Floated seeds were discarded while the ones that sank to the bottom of the container were air-dried. After drying, the seeds were pre-treated using 98% concentrated sulfuric acid for five minutes to break the seed dormancy. After pre-treatment, the seeds were rinsed thoroughly with running tap water. A total of 400 viable seeds were used for the experiment.

**Sowing Media Used**

Germination trays and polypots were filled with different sowing media, namely: sawdust of *Afzelia africana*, collected from sawmill, topsoil obtained from Ile-Apa, University of Ilorin, riversand collected from the University of Ilorin Damsite, and a mixture of topsoil and sawdust in the ratio of 2:1 was also used.

**Construction of Light Chamber**

Three light chambers used were constructed with wooden frame covered with one, two and three layers of dark nets representing 75%, 50% and 25% of sunlight, respectively (Agbo-Adediran, 2014; Iroko, 2019). An open space (Control I) representing 100% of sunlight and shade (Control II) were also used for the experiment. A 4×5 factorial experiment in randomized complete block design was adopted for the study layout. Sowing media and light intensity were the two factors at four and five levels, respectively.

**Germination Test**

Twenty germination trays were used. Each treatment has a total of four trays filled with the different sowing media. Two hundred seeds were sowed in each germination tray making it a total of 80 seeds per treatment and 400 seeds overall. Watering was carried out twice a day at 0.2 litre/tray (0.4 litre/tray/day). The seeds were considered germinated when the cotyledons became exposed. Germination count was taken daily for four weeks i.e. when no further visible germination occured.

**Growth Assessment**

Five largest and most vigorous seedlings (in terms of height and collar diameter) were selected from each germination tray and transplanted into polythene pots, arranged per original sowing media (that is, topsoil, sawdust, mixture of sawdust and topsoil in ratio 2:1 and riversand), to monitor the total height (cm), leaflet area ($cm^2$), collar diameter (mm) and number of leaflets. After transplanting, the seesdlings were taken care of for 24 weeks. The tending involved watering (ones daily) and weeding.

**Biomass Accumulation**

After 24 weeks of seedling development, the biomass accumulation was determined by selecting thirty seedlings, whose heights were closest to the mean height of the seedlings in each of the seedling groups (categorized by their originating sowing media). The selected seedlings were uprooted, carefully washed and sectioned into root, shoot and leaves and the fresh weights were taken. The sections were air-dried to constant weights, and the dried weights were taken. Total biomass accumulation was obtained by adding the biomasses of all the sections (i.e. root, stem and leaf).

**Data Collection and Analysis**

Data collection was based on germination percentage, trend of germination and early growth of the seedlings (biomass). Total germination was obtained by visual counting of the number of germinated seedlings from the first day of seedling emergence to when no further germination was observed. The mean germination rate was computed as using:

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$$MGP = \frac{x}{y} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where;
MGP =Mean germination percentage
x = number of germinated seeds per treatment,
y = number of seeds sown per treatment.

The growth assessment was carried out on the following parameters:

(i) Seedling height: This was done by placing a graduated measuring ruler and positioning it at the stem insertion and measuring to the apical meristem.
(ii) Number of leaflets: this was done by counting the number of developed leaflets.
(iii) Collar diameter: this was done using vernier calliper, by closing the jaws lightly at the seedling collar, and the reading was taken on the calibrated side.

Descriptive statistics such as percentage, graph, mean and standard deviation were used to summarize the computed variables information. Analysis of variance (4×5 factorial experiment in randomized complete block design) was carried out to comapare significant differences in seedling growths among sowing median and light intensities as well as the interactions of the two factors.

## Results

### Germination

*Tetrapleura tetraptera* seed germination occurred between 6 and 21 days of sowing, beyond this period, no further germination was observed. The highest number of seedling emergence was recorded between 8$^{th}$ and 14$^{th}$ day after sowing. The germination slowed after the second week of seedling emergence until the end of the third week, after which no further sprouting was observed.

Highest germination rate (95%) was recorded in seeds sown using sawdust under 100% light intensity and the least was recorded for topsoil under 100% light intensity. No germination occurred for seeds sown using riversand under 100% light intensity. The results showed that light intensity had a significant impactson the germination of *Tetrapleura tetraptera* seeds. Seeds sown under shade have the highest germination rates across thesowing media with 90% for riversand, 85% for topsoil and 75% for both sawdust and mixture of sawdust and topsoil with a mean of 81.2 ± 7.5% unlike the 100% light intensity, where only sawdust and the mixture of sawdust and topsoil thrived (below 50% on average). Germination rates under25%, 50% and 75% light were similar, with means of 57.5 ± 23.2, 57.5 ± 15.5 and 67.5 ± 10.4%, respectively (Table 1). Apart from the fact that no visible seedling emergence was observed inriversand under 100% light intensity, all seedlings that germinated in topsoil under 100% light intensity survived barely a week after germination. Considering the overall performance under different sowing media, sawdust was best having a cumulative germination rate (80%) with least result in riversand (Table 1).

**Table 1: Germination rates of *T.tetraptera*in different light intensities and sowingmedia**

| Light (%) | Medium | Seeds sown | No. of seeds germinated | % | Mean ± SD (%) |
|---|---|---|---|---|---|
| 100 | Topsoil | 20 | 5 | 25 | 48.8 ± 43.9 |
| | Sawdust | 20 | 19 | 95 | |

| | | | | | |
|---|---|---|---|---|---|
| | Mixture | 20 | 15 | 75 | |
| | Riversand | 20 | 0 | 0 | |
| 75 | Topsoil | 20 | 8 | 40 | 57.5 ± 23.2 |
| | Sawdust | 20 | 15 | 75 | |
| | Mixture | 20 | 16 | 80 | |
| | Riversand | 20 | 7 | 35 | |
| 50 | Topsoil | 20 | 10 | 50 | 57.5 ± 15.5 |
| | Sawdust | 20 | 15 | 75 | |
| | Mixture | 20 | 13 | 65 | |
| | Riversand | 20 | 8 | 40 | |
| 25 | Topsoil | 20 | 14 | 70 | 67.5 ± 10.4 |
| | Sawdust | 20 | 16 | 80 | |
| | Mixture | 20 | 11 | 55 | |
| | Riversand | 20 | 13 | 65 | |
| Shade | Topsoil | 20 | 17 | 85 | 81.2 ± 7.5 |
| | Sawdust | 20 | 15 | 75 | |
| | Mixture | 20 | 15 | 75 | |
| | Riversand | 20 | 18 | 90 | |

**Table 2: Summary of *T. tetraptera* germinations under different sowing media**

| Medium | Seeds sown | No. of seeds germinated | % |
|---|---|---|---|
| Topsoil | 100 | 54 | 54 |
| Sawdust | 100 | 80 | 80 |
| Mixture | 100 | 70 | 70 |
| Riversand | 100 | 46 | 46 |

## Early Growth

The results of ANOVA for seedling growth parameters under different light intensities and sowing media are presented in Table 3. The result revealed that there was a significant variation in mean leaflets area under different light intensity ($P < 0.05$). However, the variations in sowing media and the interaction between the sowing media and light intensity had not significant effects on leaflets area growths ($P > 0.05$). Meanwhile, there were significant variations in mean seedling heights, collar diameters and number of leaflets among the sowing media and light intensities ($P < 0.05$). Similarly, the effects of interactions between the two factors were also significant on seedling heights, collar diameter and leaflets number ($P < 0.05$).

**Table 3: ANOVA results for seedling growth parameters under different light intensities and sowing media**

| Parameter | SV | df | SS | MS | F | P |
|---|---|---|---|---|---|---|
| No. of leaflets | Light intensity | 4 | 2220.705 | 555.176 | 12.238 | 0.000 |
| | Sowing media | 3 | 9772.955 | 3257.652 | 71.807 | 0.000 |
| | Interaction | 10 | 4284.645 | 428.465 | 9.444 | 0.000 |

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| | | | | | | |
|---|---|---|---|---|---|---|
| | Error | 72 | 3266.400 | 45.367 | | |
| | Total | 89 | 19544.705 | | | |
| Collar diameter | Light intensity | 4 | 34.191 | 8.548 | 40.833 | 0.000 |
| | Sowing media | 3 | 34.196 | 11.399 | 54.453 | 0.000 |
| | Interaction | 10 | 13.570 | 1.357 | 6.482 | 0.000 |
| | Error | 72 | 15.072 | .209 | | |
| | Total | 89 | 97.029 | | | |
| Leaflets area | Light intensity | 4 | 172.600 | 43.150 | 6.520 | 0.000 |
| | Sowing media | 3 | 19.456 | 6.485 | 0.980 | 0.407 |
| | Interaction | 10 | 125.528 | 12.553 | 1.897 | 0.059 |
| | Error | 72 | 476.500 | 6.618 | | |
| | Total | 89 | 794.084 | | | |
| Height | Light intensity | 4 | 202.593 | 50.648 | 21.649 | 0.000 |
| | Sowing media | 3 | 378.127 | 126.042 | 53.876 | 0.000 |
| | Interaction | 10 | 89.241 | 8.924 | 3.815 | 0.000 |
| | Error | 72 | 168.444 | 2.340 | | |
| | Total | 89 | 838.405 | | | |

*N.B.: a = 0.05*

Table 4 presents the results of mean separations (LSD) for the seedling growth parameters under different sowing media. The mean seedling height in riversand and sawdust were not significantly different, but significantly different from that of topsoil as well as the mixture of sawdust and topsoil. However, there was no significant difference in the mean height values recorded in topsoil and the mixture of sawdust and topsoil. The seedling planted with topsoil had the highest mean seedling height of 15.03 ± 2.56 cm. The least mean height growth of 8.93 ± 2.26 cm was obtained in mixture of sawdust and topsoil.

In terms of leaflets number, topsoil produced seedlings with highest mean value of about 40 ± 19 leaflets per plant. The result revealed that there was a significant difference between the mean leaflet numbers under riversand and topsoil. Similarly, a significant difference existed between seedlings raised with topsoil and the mixture of sawdust and topsoil. However, there was no significant difference in the mean leaflet number produced by those raised with sawdust and the mixture. The result revealed that mean leaflet areas raised under riversand and the mixture differed insignificantly. However, the mean seedling leaflet areas under topsoil and sawdust significantly differed from those of riversand and the mixture. The seedlings raised with topsoil had highest mean leaflet area of 5.19 ± 1.69 cm$^2$.

With respect to the collar diameters, the highest mean collar diameter of 3.89 ± 1.46

mm was recorded for seedlings in topsoil. There was no significant difference between the mean collar diameter of the seedlings raised under sawdust and the mixture of sawdust and topsoil. However, the mean seedling collar diameter value recorded under riversand significantly differed from those of topsoil, sawdust and the mixture.

**Table 4: Follow-up result for the seedling growth parameters under different sowing media**

| Sowingmedia | Growth parameters | | | |
|---|---|---|---|---|
| | Height (cm) | Collar diameter (mm) | No. of leaflets | Leaflet area (cm$^2$) |
| Sawdust | $10.47 \pm 1.9^{a}$ | $2.18 \pm 0.55^{a}$ | $12 \pm 6^{a}$ | $3.36 \pm 3.94^{a}$ |
| Topsoil | $15.03 \pm 2.6^{c}$ | $3.89 \pm 1.46^{c}$ | $40 \pm 19^{c}$ | $5.19 \pm 1.69^{b}$ |
| Mixture | $8.93 \pm 2.3^{b}$ | $2.33 \pm 0.56^{a}$ | $13 \pm 6^{a}$ | $3.57 \pm 2.21^{ab}$ |
| Riversand | $10.40 \pm 2.6^{a}$ | $2.73 \pm 0.63^{b}$ | $21 \pm 9^{b}$ | $4.46 \pm 3.48^{ab}$ |

*N.B.: Means with the same alphabet as superscript are not significantly different from each other in each column*

The Follow-up result for the seedling growth parameters under different light intensities are presented in Table 5. The seedling raised under 25% light had the highest mean seedling height of 12.69 ± 3.65 cm. The least mean height growth of 8.02 ± 2.56 cm was obtained under 100% light. The mean seedling height in 25% light intensity and shade were not significantly different, but significantly different from the mean height recorded for 50%, 75% and 100% light intensities. For leaflets number, 25% light intensity produced seedlings with highest mean value of about 29 ± 23 leaflets per plants. The seedlings planted under 100% light intensity produced the least number of leaflets with a mean of about 11 ± 2 leaflets per plant. The result showed that there was no significant difference between the mean leaflet numbers under shade and 75% light intensity.

The result revealed that there is a significant difference between the mean seedling leaflets areas under different light intensities. Seedling raised under shade had highest mean leaflet area of 5.94 ± 1.25 cm$^2$. The seedlings grown under 100% light intensity had the lowest mean leaflet area of 1.35 ± 2.03 cm$^2$. In term of collar diameter, the collar diameter was highest under 25% light intensity (3.59 ± 1.44 mm). There was no significant difference between the mean collar diameter of the seedlings raised under shade and 100% light intensity. However, the mean seedling collar diameter value recorded under 50% and 75% light intensities were significantly different from each other as well as other light intensities.

**Table 5: Seedling growth parameters under different light intensities**

| Light intensity | Growth parameters | | | |
|---|---|---|---|---|
| | Height (cm) | Collar diameter (mm) | No. of leaflets | Leaflet area (cm$^2$) |
| | Mean ± SD | | | |
| 100% | $8.02 \pm 2.56^{a}$ | $2.06 \pm 0.27^{a}$ | $10.70 \pm 2.16^{a}$ | $1.35 \pm 2.03^{a}$ |
| 75% | $11.12 \pm 2.38^{c}$ | $3.19 \pm 0.81^{c}$ | $23.30 \pm 13.63^{b}$ | $2.69 \pm 1.19^{ab}$ |

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| | | | | |
|---|---|---|---|---|
| 50% | 9.17 ± 2.73[b] | 2.57 ± 0.64[b] | 14.45 ± 13.39[a] | 4.01 ± 3.88[bc] |
| 25% | 12.69 ± 3.65[d] | 3.59 ± 1.44[d] | 28.70 ± 22.91[c] | 5.00 ± 3.57[cd] |
| Shade | 12.68 ± 1.98[d] | 1.87 ± 0.37[a] | 19.35 ± 4.39[b] | 5.94 ± 1.25[d] |

*N.B.: Means with the same alphabet as superscript are not significantly different from each other in each column*

## Biomass Accumulation

The highest mean biomass accumulation of 2.12 ± 0.59 g for stem was recorded for seedling raised with topsoil under 25% light intensity, followed by 1.13 ± 0.13 g for seedling raised with topsoil under 50% light intensity (Table 6). The least mean biomass accumulation of 0.01 ± 0.05 g was recorded for seedling raised with the mixture of sawdust and topsoil under 100% light intensity. For the leaf biomass, seedlings raised with topsoil under 25% light intensity was the highest in terms of leaf biomass (0.95 ± 0.09 g). The least leaf biomass accumulation was recorded in plants raised with sawdust and the mixture of sawdust and topsoil under 100% light intensity. The highest mean biomass accumulation of 5.00 ± 1.81 g for root was also recorded in seedlings raised with topsoil under 25% light intensity, followed by 2.46 ± 0.75 g for seedling raised with topsoil under 50% light intensity, with the least mean root biomass (0.08 ± 0.03 g) recorded in seedlings raised with sawdust under 100% light intensity.

The highest total biomass accumulations were recorded in seedlings raised with topsoil having 8.06 ± 2.49 g, 4.41 ± 1.10 g and 2.81 ± 0.46 g under 25%, 50% and 75% lights, respectively. The lowest biomass accumulation was recorded in seedlings under 100% light intensity with biomass values of 0.14 g and 0.27 g for sawdust and the mixture of sawdust and topsoil, respectively. Seedlings raised with riversand also performed well for all the light intensities, but only under shade.

**Table 6: Biomass accumulation**

| Light intensity | Sowing media | Mean Biomass (g) | | | |
|---|---|---|---|---|---|
| | | Stem | Leaf | Root | Total |
| 100% | Sawdust | 0.06±0.02 | 0.00± 0.00 | 0.08±0.03 | 0.14±0.05 |
| | Sawdust and Topsoil | 0.10±0.05 | 0.00± 0.00 | 0.17±0.05 | 0.27±0.10 |
| 75% | Topsoil | 0.63 ± 0.12 | 0.74 ± 0.09 | 1.44 ± 0.25 | 2.81±0.46 |
| | Sawdust | 0.10 ± 0.02 | 0.08 ± 0.11 | 0.20 ± 0.05 | 0.32±0.18 |
| | Sawdust and Topsoil | 0.11 ± 0.04 | 0.01 ± 0.00 | 0.21 ± 0.22 | 0.33±0.26 |
| | Riversand | 0.15 ± 0.03 | 0.06 ± 0.02 | 0.27 ± 0.06 | 0.48±0.11 |
| 50% | Topsoil | 1.13 ± 0.13 | 0.82 ± 0.22 | 2.46 ± 0.75 | 4.41±1.10 |
| | Sawdust | 0.13 ± 0.02 | 0.02 ± 0.01 | 0.23 ± 0.03 | 0.38±0.06 |
| | Sawdust and Topsoil | 0.15 ± 0.05 | 0.02 ± 0.01 | 0.35 ± 0.06 | 0.52±0.12 |
| | Riversand | 0.22 ± 0.05 | 0.17 ± 0.06 | 0.76 ± 0.08 | 1.15±0.19 |
| 25% | Topsoil | 2.12 ± 0.59 | 0.95 ± 0.09 | 5.00 ± 1.81 | 8.07±2.49 |
| | Sawdust | 0.15 ± 0.03 | 0.04 ± 0.02 | 0.39 ± 0.23 | 0.58±0.28 |

| | | | | | |
|---|---|---|---|---|---|
| | Sawdust and Topsoil | 0.12 ± 0.06 | 0.06 ± 0.03 | 0.23 ± 0.07 | 0.41±0.16 |
| | Riversand | 0.25 ± 0.06 | 0.15 ± 0.06 | 0.78 ± 0.12 | 1.18±0.24 |
| Shade | Topsoil | 0.27 ± 0.01 | 0.47 ± 0.11 | 0.26 ± 0.02 | 1.00±0.14 |
| | Sawdust | 0.08 ± 0.03 | 0.07 ± 0.01 | 0.12 ± 0.04 | 0.27±0.08 |
| | Sawdust and Topsoil | 0.15 ± 0.03 | 0.09 ± 0.01 | 0.16 ± 0.01 | 0.40±0.05 |
| | Riversand | 0.26 ± 0.06 | 0.23 ± 0.05 | 0.31 ± 0.16 | 0.80±0.27 |

## Discussion

The result has showed that shade had significant impacts on seedling emergence of *T. tetraptera* seedling as it resulted in highest germination rates across the different sowing media investigated. This shows that seeds would germinate more readily at low or reduced light intensity. This corroborates the finding of Hartmann *et al*. (2017), who noted positive impact of shade on germination rates. This may be attributed to reduced impact of heat, which could be dehydrating. Thereby slows biochemical processes that enhance germination since evapotranspiration is reduced. The reduced germination percentages observed in higher light internsities may be due to the heating effects of light on the seeds resulting from dehydration. However, early seedling development was inhibited by shade due to lack of solar energy for the production of photosynthate. Nevertheless, moderate amount of light (at 25%) was required to drive home a desired process. This is in consonant with the reports of Aderounmu (2010) and Onyekwelu *et al*. (2012), who observed the importance of light intensity during early growth for most tropical tree species, since it enhances photosynthesis and food manufacture. However, it does not agree with the work of Oyedeji (2012), Bolanle-Ojo (2014) and Iroko (2019), who reported no significant variations in seedling growth parameters of three tropical species (*Dalium guineense*, *Artocarpus heterophyllus* and *Khaya senegalensis*) under different light regimes. Other inherent characteristics and, perhaps, adaptive features of those tree species might be responsible for the outcome.

Ability of the topsoil in supporting better seedling growths and biomass accumulation may be a result of more organic matter contents of the medium, which was able to supply better nutrients responsible for seedling growthand biomass accumulation compared to sterilized riversandor sawdust. This is supported by the findings of Cirtain (2009), Tirado-Corbalá and Slater (2010),Oyinlola and Jinadu (2012) and Usman *et al*. (2013), who observed thathigher nutrient contents associated with topsoilwere responsible for higher growth in tree seedlings.The poor performance of *T. tetraptera* seedlings under shade and direct sunlight shows that the species neither be raised under a full-shade nor direct sunlight. However, a moderately low light intensity offers a better opportunity for propatation of the species. The consequential effects of growing the species under heavy shade or direct sunlight include slow growth, poor seedling establishment and eventual death. This is in line with the observation of Onyekwelu *et al*. (2012), who noted poor performance of *Chrysophyllum albidum* and *Irvingia gabonensis* under forest canopy and the death of young *Chrysophyllum albidum* seedlings in the open sky. Also seedlings raised under controlled light intensities (25, 50 and 75%) have higher biomass accumulation compared to those raised under total shade. This may be due to slowing of photosyntate accumulation in plant tissue due to reduced photosynthetic activities under shade. This corroborates the work of Bolanle-Ojo (2014), who reported a significant effect of light intensity on biomass of *Kigelia africana* seedlings.

## Conclusion

Thestudy has shown that *T. tetraptera* performed excellently well under shade, in terms of germination. However, shade hindered good performance of the seedlings in the first 24 weeks of development. Consequently, the species required a moderate light intensity of about 25% for a good performance at the early stages of development. Therefore, a better growth results would be achieved, when raised under moderately-lowlight conditions. Growing *T. tetraptera* seedlings with topsoil together with an exposure to little amount of light resulted in optimal performance. This implies a good relationship between the sowing media and a moderate level of light intensity for *T. tetraptera* seedlings.

However, since the study was only on early growth assessment, it might be necessary to conduct a post-nursery development studies to make a more robust recommendation for propagation on a large-scale. This is because the later-stage development of the species might be influenced by several unknown limiting factors. Hence, there is need for further study on the plant over a wide range of field conditions and a long period of time. Also, for *T. tetraptera* seedlings to give a good performance, it is advisable to plant it using topsoil, since it is very rich inorganic matter that would provide plant with the required nutrients needed for growth and development. The plant also need a low light condition to perform well, since too much sunlight increased the temperature of the leaves, which in turn leads to rapid water and transpiration losses, resulting in decreases in the production of photosynthates.

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