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Physiological Response of *Tetrapleura tetraptera* (Schum. and Thonn.) Taub. to Soil Textural Class, Moisture and Light Intensity

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Abstract

Investigation was carried out on response of *Tetrapleura tetraptera* (Schum. and Thonn.) to soil, water and light with the view of its domestication and introduction to different ecological regions. The experiment was arranged in a factorial experiment of 3×3×3 in a completely randomized design (CRD) with three replicates. The factors were: soil textural class (Loamy sand, Sand and Sandy clay loam), watering regime (daily, twice a week and once a week) and light intensity (100%, 75% and 50%). Soil textural classes had significant influence on collar diameter, stem height, number of leaflets, root/shoot ratio and relative growth rate of *Tetrapleura* seedlings. Seedlings grown on loamy sand recorded the highest mean value- 2.28 mm for collar diameter, stem height- 12.9 cm, number of leaflets- 19.9, chlorophyll b- 0.34 mg mL^{-1}, leaf relative water content- 27.4% and relative growth rate- 0.037 mg g^{-1} day^{-1}. Watering regime had significant influence on the collar diameter of *Tetrapleura*. Seedlings watered daily recorded the highest mean value- 2.25 mm for collar diameter. Light intensity significantly influenced collar diameter and root/shoot ratio. Seedlings exposed to 100% light intensity recorded higher mean value for collar diameter- 2.28 mm and root/shoot ratio- 1.481 cm. The interaction between soil textural class and light intensity significantly affected collar diameter, stem height and number of leaflets. Higher mean value for collar diameter (2.47 mm) stem height (13.25 cm) and number of leaflets (21.16) were recorded while the interaction between soil textural class, light intensity and watering regime was significant for only number of leaflets. *Tetrapleura* exhibited some level of tolerance to different soil texture, drought and light intensity. Therefore, *Tetrapleura* has the potentials to be raised in different ecological zones characterized by difference in soil, rainfall and amount of sunshine.

Key Words: *Tetrapleura tetraptera*, soil textural class, watering regime, light intensity, domestication

Introduction

Tetrapleura tetraptera (Schum. and Thonn.) Taub. is a member of the Fabaceae family of flowering plants. It was formerly categorized as a Leguminosae and belong to the subfamily of Mimosodeae (Atawodi et al. 2014). It is commonly known as Aidan and Oshosho among the Yoruba and Igbo people of Nigeria respectively. *T. tetraptera* is a deciduous tree that can grow up to 20-25 m height with a girth of 1.5-3.0 m. It has a slender bole and is native to Benin, Burkina Faso, Cambodia, Chad, Cote d'Ivoire, Gambia, Guinea, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo and Uganda (Orwa et al. 2009). *Tetrapleura* has great potential to protect the environ-

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ment as well as provide valuable timber and non-timber products. One of the most recognized attributes of *Tetrapleura* is its application in medicine and nutrition. In traditional medicine, the Yorubas in southwestern Nigeria utilized the fruit for the management and/or control of arthritis and other inflammatory conditions, and adult onset type-2 *Diabetes mellitus* (Ojewole and Adewunmi 2004). Research undertaken by various scientists has demonstrated the effectiveness and potentials of *Tetrapleura* in the management and/or control of those ailments that were traditionally managed or control using *Tetrapleura* as well as other diseases such as malaria, schistosomiasis, kidney disorder and cardiovascular diseases (Adewunmi 2004; Ojewole and Aladesanmi 2007; Ekwenye and Okorie 2010; Odesanmi et al. 2010; Ajayi et al. 2011; Okoronko and Echeme 2012; Atawodi et al. 2014). Other benefits derived from *Tetrapleura* include food, Agroforestry, timber, energy etc.

However, despite the enormous benefits and potentials of *Tetrapleura*, it still remained uncultivated in Nigeria (Omokhua and Ukoimah 2008) while their population in the wild is endangered due to overexploitation (Aniedi et al. 2013). One of the major constrains militating against the establishment of large plantations of some forest tree species as well as its introduction to other ecological zones different from that which it is native to, is lack of adequate silvicultural information such as, suitable soil type, light and moisture requirement and the combined effects of these variables on the growth and development of plants.

Domestication of tree species that can withstand diverse environmental condition while yielding multiple benefits is crucial, as there is the likelihood of plants to be experiencing stress even outside the arid/semi arid region (Chaves et al. 2002). Therefore, there is need to understand individual plant response to limiting factors such as water, light and temperature as well as their combined effects on plant growths and development for continuous provision of goods and services despite unfavourable environmental condition. This necessitated the need to assess the suitability of *Tetrapleura* under different environmental conditions with the view of domesticating and introductiing the species to other ecological zones.

Materials and Methods

Study site

The experiment was conducted at the Screen house of the Department of Forest Resources Management, Faculty of Agriculture and Forestry, University of Ibadan, lying on approximately latitude 7°28' N and longitude 3°52' E and altitude 277 m above sea level. The climate is the West African monsoon with dry and wet season. The dry season usually starts from November – March, while the rainy season starts from April to October. Annual rainfall is about 1300 mm while mean annual temperature ranges between a maximum of 34°C and a minimum of 22°C (Akinyele 2010).

Experimental design and treatments

Three different soil textural classes namely; Loamy sand, Sand and Sandy clay loam were collected using texture by feel method (Presley and Thien 2008) from three different locations within Ibadan, Oyo state. The soils samples were taken to the Soil Science Laboratory, Department of Agronomy, University of Ibadan, for particle size analysis using Bouyoucos (Hydrometer) method (Bouyoucos 1951) to confirm its actual textural classes (Table 1). Two (2) light chambers constructed with wooden frame covered with one and two layers of green nets representing 75% and 50% of natural sunlight respectively and an open space (control) representing 100% of natural sunlight were used. Four (4) polythene pots of 25×13 cm size were filled with each of the soil textural class which was replicated three (3) times and randomly allocated to the three (3) light chambers and the open space (control). Each treatments combination has 12 polythene pots, 108 per light chambers and the open space (control) i.e. a total of 324 polythene pots in all. Germination bed was prepared on which 750 seeds pretreated with H_2SO_4 for 20 minutes were sown. Two (2) weeks after the commencement of germination, 324 seedlings of rela-

Table 1. Particle size analysis showing distribution and textural class of soil samples

Soil Sample (ST)	% Clay	% Sand	% Silt	Textural Class
1	12.8	3.4	83.8	Loamy sand
2	6.8	1.4	91.8	Sand
3	21.8	7.4	70.8	Sandy clay loam

tively uniform growth were transplanted from the germination bed to the polythene pots. The polythene pots were watered once daily for a week for the transplanted seedlings to establish well after which they were subjected to varying light intensity and different watering regime. The seedlings were watered once daily, twice a week and once a week depending on the treatment combination over a period of 16 weeks the experiment lasted.

Early growth and Physiological assessment

Four (4) seedlings were randomly sampled from each of the treatment combinations from which the following parameters were assessed;

Collar Diameter (mm)

Collar diameter was measured using electronic vernier caliper.

Stem Height (cm)

The stem height was measured from the soil level to the apex with the aid of a centimeter rule.

Number of leaflets

The numbers of leaflets were counted through physical count.

Root length (cm)

The root length was measured with the aid of a centimeter rule.

Root/Shoot ratio (cm)

The root-shoot ratio was calculated using the measurement from the stem height and root length.

Relative growth rate (mg g^{-1} day^{-1})

Relative growth rate by dry weight (RGR_{DW}) mg g^{-1} day^{-1} was calculated using the formula of Gbadamosi (2014) shown below.

$$RGR = \frac{In(\text{dry weight at end}) - In(\text{dry weight at start})}{\text{Duration of the experiment (Days)}}$$

Chlorophyll content (mg mL^{-1})

Leaflets with fully expanded leaves from each treatments combination that were previously used for other parameter assessment were used. 0.50 g of leaves tissue was grinded in 2 mL of absolute acetone (80%) using mortar and pestle. The leaves tissues were then diluted with 10 mL of acetone and thoroughly shaken to achieve homogenization after which it was filtered to obtain the extract. The samples were then read against acetone blank using Unico spectrophotometer model 1201 at 645 nm (chlorophyll a)–663 nm (chlorophyll b) wavelength. Chlorophyll a, b and total chlorophyll content was calculated according to Arnon's (1949) equations given as follows;

$$\text{Chl a (mg mL}^{-1}) = \frac{[12.7(A663)\ \ 2.69(A645)]}{100 \times W} \times V$$

$$\text{Chl b (mg mL}^{-1}) = \frac{[22.9(A645)\ \ 4.68(A663)]}{100 \times W} \times V$$

$$\text{Chl total (mg mL}^{-1}) = \frac{[20.2(A645)\ \ 8.02(A663)]}{100 \times W} \times V$$

Where A = Absorbance at wavelengths 645 nm and 663 nm
V = Final volume of chlorophyll extract in 80% Acetone
W = Fresh weight of tissue extract.

Chlorophyll a/b ratio was derived by dividing the value of chlorophyll a by the value of chlorophyll b

Leaf Relative Water Content (LRWC)

Leaflets from each treatments combination that were previously used for the assessment of other parameters were used to determine the leaf relative water content. The leaflets were weighed immediately to obtain the fresh weight. The leaflets were then placed in a beaker containing water and allowed to stayed overnight in the dark, so as to become fully turgid. Leaflets were then re-weighed, to obtain turgid weight, and dried at 70 ± 1°C for 24 h to obtain dry weight. Leaf relative water content was then calculated using the formulae of Li et al. (2011) given as;

RWC (%) = (FW − DW)/(TW − DW) × 100,
Where FW = Fresh weight DW = Dry weight TW = Turgid weight

Data analysis

The data obtained from the parameters assessed were subjected to analysis of variance (ANOVA) ($p < 0.05$) using STATISTICA package. Mean separation where applicable was done using Fisher's least significant difference (LSD).

Results

Collar diameter (mm)

Soil textural class, watering regime, light intensity and the interaction between watering regime and light intensity had significant effect on collar diameter. The interaction between soil textural class and watering regime, watering regime and light intensity as well as the interaction between soil textural class, watering regime and light intensity did not have any significant effect on collar diameter of *Tetrapleura*. However, interaction between soil textural class and light intensity significantly affected collar diameter (Table 2). Seedlings grown on loamy sand, watered daily, exposed to 100% light intensity and the interaction between loamy sand and exposure to 100% light intensity recorded the highest mean value of 2.28 mm, 2.25 mm, 2.28 mm and 2.46 mm respectively (Table 3).

Stem Height (cm)

Stem height had significant effect on soil textural class and the interaction between soil textural class and light intensity. Watering regime, light intensity, the interaction between soil textural class and watering regime, the interaction between watering regime and light intensity as well as the interaction between soil textural class, watering regime and light intensity had no significant effect on the stem height (Table 3). Seedlings grown on loamy sand has the highest mean value of 12.9 cm. The interaction between Loamy sand and exposure to 100% light intensity recorded the highest mean of 13.25 cm (Table 2).

Number of leaflets

The analysis of variance performed on number of leaflets ($p < 0.05$) showed the number of leaflets to be significantly affected by soil textural class, the interaction between soil textural class and light intensity as well as the interaction between soil textural class, watering regime and light intensity. Watering regime, light intensity as well as the interaction between watering regime and light intensity did not significantly affect the number of leaflets (Table 3). Loamy sand recorded the highest mean value of 19.923 while plants grown on loamy sand and exposed to 100% light intensity have the highest mean value of 21.16. For the interaction between soil textural class, watering regime and light intensity, plants grown on loamy sand, watered once a week and exposed to 100% light intensity recorded the highest mean value of 23.16 (Table 2).

Root length (cm)

Soil textural class, watering regime and light intensity did not have significant effect on root length. The interactions between soil textural class and watering regime, soil textural class and light intensity, watering regime and light intensity and the interaction between soil textural class, watering regime and light intensity did not significantly affect the root length of *Tetrapleura* (Table 3).

Table 2. Summary of Analysis of variance F -values for the early growth and physiological response of *Tetrapleura tetraptera* subjected to some environmental factors

Source of variation	DF	*CD*	*SH*	*NL*	*RL*	*R/S*	*CHL* a	*CHL* b	*CHL* a/b	*TCHL*	*LRWC*	*RGR*
Soil textural class	2	6.431*	30.456*	58.091*	0.433ns	6.325*	2.428ns	0.399ns	0.79ns	0.765ns	0.667ns	10.443*
Watering regime	2	5.824*	0.066ns	1.595ns	2.013ns	0.481ns	2.793ns	0.241ns	2.319ns	0.125ns	0.112ns	0.446ns
Light intensity	2	14.625*	2.332ns	0.938ns	0.07ns	4.895*	0.945ns	0.092ns	0.008ns	0.375ns	1.333ns	2.555ns
Soil×Water	4	0.628ns	0.492ns	0.174ns	1.641ns	2.064ns	0.625ns	1.236ns	0.608ns	0.777ns	0.658ns	1.424ns
Soil×Light	4	4.227*	2.892*	3.517*	0.321ns	1.394ns	1.805ns	1.09ns	2.479ns	0.282ns	0.305ns	0.528ns
Water×Light	4	1.218ns	1.398ns	1.099ns	0.191ns	0.256ns	1.409ns	2.117ns	2.499ns	1.029ns	0.474ns	2.059ns
Soil×water ×light	8	1.37ns	1.075ns	2.166*	-	-	-	-	-	-	-	-

*and ns, Significant and not significant $p < 0.05$.

Table 3. Mean early growth and physiological responses of *Tetrapleura tetraptera* subjected to some environmental factors

Treatments	Mean										
	CD	*SH*	*NL*	*RL*	*R/S*	*CHL* a	*CHL* b	*CHL* a/b	*TCHL*	*LRWC*	*RGR*
Soil textural class											
Loamy sand	2.282^{a}	12.898^{a}	19.929^{a}	22.011^{a}	0.964^{b}	0.121^{a}	0.342^{a}	0.454^{a}	0.463^{a}	27.444^{a}	0.037^{a}
Sandy clay loam	2.213^{b}	10.571^{b}	13.061^{c}	22.456^{a}	1.516^{a}	0.126^{a}	0.306^{a}	0.427^{a}	0.431^{a}	25.111^{a}	0.030^{b}
Sand	2.157^{b}	11.073^{b}	15.457^{b}	23.544^{a}	1.079^{b}	0.161^{a}	0.33^{a}	0.574^{a}	0.497^{a}	22.111^{a}	0.036^{a}
Watering regime											
Daily	2.250^{a}	11.144^{a}	15.929^{a}	20.889^{a}	1.143^{a}	0.153^{a}	0.321^{a}	0.52^{a}	0.474^{a}	26.111^{a}	0.035^{a}
Twice a week	2.240^{a}	11.529^{a}	15.714^{a}	22.844^{a}	1.137^{a}	0.153^{a}	0.314^{a}	0.599^{a}	0.468^{a}	24.556^{a}	0.035^{a}
Once a week	2.148^{b}	11.451^{a}	16.804^{a}	24.278^{a}	1.279^{a}	0.107^{a}	0.342^{a}	0.337^{a}	0.448^{a}	24.0^{a}	0.033^{a}
Light intensity											
100%	2.284^{a}	12.284^{a}	15.699^{a}	23.0^{a}	1.481^{a}	0.136^{a}	0.318^{a}	0.493^{a}	0.453^{a}	28.667^{a}	0.035^{a}
75%	2.259^{a}	11.588^{a}	16.585^{a}	22.367^{a}	1.022^{b}	0.123^{a}	0.324^{a}	0.477^{a}	0.447^{a}	24.889^{a}	0.032^{a}
50%	2.106^{b}	11.810^{a}	16.162^{a}	22.664^{a}	1.056^{b}	0.154^{a}	0.336^{a}	0.486^{a}	0.490^{a}	21.111^{a}	0.036^{a}
Soil×Light											
Loamy sand×100%	2.465^{a}	13.254^{a}	21.158^{a}								
Loamy sand×75%	2.262^{b}	12.739^{a}	20.168^{a,b}								
Loam sand×50%	2.121^{e}	12.702^{a}	18.461^{b,c}								
Sandy clay loam×100%	2.237^{b,c}	10.745^{b,c}	12.357^{e}								
Sandy clay loam×75%	2.268^{b}	10.154^{c}	13.543^{e}								
Sand clay loam×50%	2.133^{c,e}	10.025^{c}	13.284^{e}								
Sand×100%	2.150^{b,e}	11.983^{a,b}	13.584^{e}								
Sand×75%	2.248^{b}	11.212^{a,b}	16.045^{d}								
Sand×50%	2.071^{e}	10.813^{b,c}	16.741^{c,d}								
LSD (0.05)	*0.628*	*1.387*	*4.099*	*3.910*	*1.377*	*0.053*	*0.096*	*0.288*	*0.122*	*10.673*	*0.004*

Note: *CD*, Collar diameter (mm); *SH*, Stem height (cm); *NL*, Number of leaflets, Root length (cm); *R/S*, Root/shoot ratio (cm); *TCHL*, Total chlorophyll (mg mL^{-1}); *LRWC*, Leaf relative water content (%); *RGR*, Relative growth rate (mg g^{-1}).

Root/Shoot ratio (cm)

Root/shoot ratio was found to be significantly affected by soil textural class and light intensity while watering regime, the interaction between soil textural class and watering regime, the interaction between soil textural class and light intensity, the interaction between watering regime and light intensity did not significantly affect the roots/shoots ratio of *Tetrapleura* (Table 3). Sandy clay loam has the highest mean value of 1.516. For light intensity, plants exposed to 100% light intensity has the highest mean value of 1.481 (Table 2).

Relative growth rate (mg g^{1} day^{-1})

The analysis of variance ($p < 0.05$)) carried out on the relative growth rate indicated a significant difference on the relative growth rate of *Tetrapleura* subjected to different soil textural class. However, there were no significant differences in the relative growth rate of *Tetrapleura* subjected to watering regime and light intensity as well as their interactions (Table 3). Seedlings grown on Loamy soil has the highest mean value of 0.037 (Table 2).

Chlorophyll contents (mg mL^{-1})

The analysis of variance ($p < 0.05$) for chlorophyll a, b, a/b ratio and total chlorophyll, all indicated that there was no significant difference among the treatments (Table 3). *Tetrapleura* seedlings grown on sand recorded highest mean value of 0.497 for total chlorophyll while those watered daily has the highest mean value of 0.474, Seedlings exposed to 50% light recorded the highest mean value of 0.49 (Table 2).

Leaf relative water content (LRWC)

Analysis of variance ($p < 0.05$) on leaf relative water content revealed that there was no significant difference for all the treatments (Table 3). However, the mean value indicated that seedlings grown on loamy sand recorded the highest mean value of 27.444. Plants watered daily recorded the highest mean value of 26.111 while plants exposed to 100% light have the highest mean value of 28.667 (Table 2).

Discussion

Loamy sand is best for growing *Tetrapleura*. However, other textural classes (Sandy clay loam and Sand) also recorded impressive growth performances and could be used for raising *Tetrapleura* seedlings. The high nutrients contents associated with soil possessing loam characteristics (Oyinlola and Jinadu 2012) may be responsible for the observed result. This result is in accordance with the findings of Tirado-Corbalá and Slater (2010), Tabari (2012) and Usman et al. (2013) who reported better growth parameters of different plants grown on loamy soil. *Tetrapleura* seedlings performed well irrespective of the moisture stress they were subjected to. Therefore, *Tetrapleura* seedlings may be suitable for arid environment. Similar result was reported by Sneha et al. (2012) who reported a non significant difference in collar diameter of *Tectona grandis* subjected to water stress. Elhadi et al. (2013) also reported a similar result when five tropical trees were exposed to varying level of irrigation while Olajide et al. (2014) recorded a non significant difference on the height growth of *Dialium guineense* when subjected to different watering regime. However, a contrary result was observed by LI et al. (2011) and Tabari (2012) who reported that frequency of moisture application to significantly affect relative water content and stem height respectively. These variations may be attributed to the difference in species of plants, plants developmental stage, environmental factors (Kang et al. 2013) and inherent plant genetic makeup.

Tetrapleura seedlings performed well under both high and low light intensities. Exposure of seedlings to 100% light intensity recorded better performance for most of the parameters assessed even though there was no significant difference. However, the treatments mean recorded for chlorophyll contents though insignificant indicates that seedlings exposed to the lowest light intensity recorded the highest mean value of chlorophyll a, b, total and a/b following similar pattern observed by many researchers (Goncalves et al. 2001; Kitajima and Hogan 2003; Beneragama and Goto 2010; Reed et al. 2012) which indicate the adaptive response of *Tetrapleura* to reduce light. This is attributed to the need for shaded plants to increase chlorophyll concentration in order to enhance light capture (Sarijeva et al. 2007). Higher amount of chlorophyll b was recorded in all the different levels of light treatment compared to chlorophyll a consequently lower chlorophyll a/b. An increase in the concentration of chlorophyll b and thus their a/b ratio is typical of plants grown under shade (Glime 2007). This response is an indication of the shade tolerant ability of a plant (Boardman 1977). This implies that *Tetrapleura* is a shade tolerant species hence may perform better when raised in some levels of shade. Growing *Tetrapleura* seedlings on loamy sand together with exposure to high level of light intensity resulted in optimal performance. This indicates a better working relationship between the type of soil and amount of sunshine when growing *Tetrapleura* seedlings.

Conclusion

Tetrapleura seems to grow well on all the soil textural class used, varying level of watering regime applied and different levels of light intensity exposed to. Though some variation in performance were recorded, most of them were insignificant. This demonstrates the potentials of *Tetrapleura* to be raised in different ecological zones characterized by different soils, amount of rainfall and intensity of light. Therefore, it is recommended for domestication and introduction to other ecological zones different from its native area. However, since this research was only an early growth studies, this might not be adequate enough to categorically recommend it for domestication and introduction to different ecological zones. Hence, there is need for further research on the plant over a wide range of field condition over a period of time.

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