Biomass accumulated by *Entandrophragma angolense* (Welw.) C DC. seedlings under different light intensities and soil textural classes

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Abstract

Biomass accumulation may affect the carbon status of developing seedling through shift in photosynthesis “source” relative to the respiratory “sink” within the plants. This study investigated the influence of biomass accumulation under different light intensities (25%, 50%, 75% and 100%) and soil textural classes (clay, sandyloam, sandy, loamysand and loamy). The study was conducted in a 4 X 5 factorial experiment in Completely Randomized Design (CRD).

Interactions of light intensities and soil textural showed that seedlings grown using loamysand placed under 50% light intensity had the highest mean Leaf Dry Weight (LDW) of 2.29g while seedlings grown using sandy soil placed under 50% light intensity had the lowest mean leaf dry weight of 0.70g. Stem Dry Weight (SDW) of 1.80g was recorded in seedlings grown using loamysand placed under 25% light intensity while the lowest mean stem dry weight of 0.58g and seedlings grown using sandyloam placed under 50% light intensity had the highest mean Root Dry Weight (RDW) of 1.56g, seedlings grown using clay soil placed under 25% light intensity had the lowest mean root dry weight of 0.59g. Seedlings grown using sandyloam placed under 50% light intensity had the highest mean Total Dry Weight (TDW) of 4.89g and the least was recorded in clay soil placed under 25% light intensity. This reveals that *Entandrophragma angolense* seedlings preferred moderate light intgensities (50% light intensity) and sandyloam for optimum biomass production.

Keywords: *Entandrophragma angolense*, light intensity, soil textural classes, biomass accumulation and seedlings.

Introduction

Forest ecosystem can capture significant amount of Green House Gasses (GHG), particularly carbon dioxide (Co_2). In the recent decades, there is considerable interest in increased change in carbon content of the vegetation through the preservation of forests, reforestation, creation of forest farms and other land management method. A great number of studies have demonstrated the ability of forest species to store carbon in their biomass.

Entandrophragma angolense (Meliaceae) common name Mahogany, is most common in moist semi-deciduous forest, particularly in regions with an annual rainfall of 1600–1800 mm. However, it can also be found in evergreen forest. In East Africa, it occurs in lowland and mid-altitude rainforest, but sometimes also in gallery forest and thickets, up to 1800 m altitude. It strongly prefers well-drained localities with good water-holding capacity. The heartwood is pale pinkish brown to pale reddish brown, slightly darkening upon exposure to deep reddish brown, and distinctly demarcated from the creamy white to pale pinkish sapwood, which is up to 10cm wide.

Biomass accumulation may affect the carbon status of developing seedling through shift in photosynthesis “source” relative to the respiratory “sink” within the plants. Biomass accumulation also affects capture of light, nutrients and water for seedlings growth. In terms of classical plant growth analysis theory, plant Relative Growth Rate (RGR) is divided into two components. Net Assimilation Rate (NAR) that is the change in plant mass per unit leaf area per unit time and Leaf Area Ratio (LAR) which leaf area per unit plant mass (Evans, 1998).

Plant diversity in forests of the tropics zone however, not all species co-habit within the same spatio-temporal settings. Different in requirements for light, water and nutrients and in life history traits, as well as plant morphology and physiology give rise to variation in species successional status and abundance. The seedling stage is critical in forest trees because survival and performance at this phase will affect composition, structure and functioning of future forest ecosystem while the intensity often serves as an abiotic factor during establishment even shade-tolerant species may utilize forest gaps to promote regeneration from seed (Yahamoto, 2000; Bilek *et.al*, 2014; Zhu *et. al*., 2014). Comparisons of seed development of contrast species in uniform light condition can help elucidate underlying morphological and physiology traits important for growth and survival. Understanding how seedling of tree species perform relative to each other in a common environment will contribute to the knowledge of mechanism to maintain species diversity in forest communities and to inform forest management practices to emphasize multifunctional and biodiversity.

Materials and Method

The study was carried out at the Tree Improvement Nursery and Silviculture Nursery of the Department of Sustainable Forest management, Forestry Research Institute of Nigeria, Jericho Hill, Ibadan, Nigeria (FRIN).

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FRIN is located within longitude $07^0$23'18"N to $07^0$23'43"N and latitude $03^0$51'20"E to $03^0$51'43"E. Mean annual rainfall is about 1548.9 mm, falling within approximately 90 days. The mean maximum temperature is 31.9^0C, minimum 24.2^0C while the mean daily relative humidity is about 71.9% (FRIN, 2014).

Experimental Design

Two hundred seedlings with good vigour and relatively uniform growth were randomly selected and transplanted into medium sized (10 X 18cm) poly pot filled with 2 kg of the prepared soils and these were exposed to different light intensities: 100%, 75%, 50% and 25% of full day light. Each soil textural class was replicated 10 times under each light intensity chambers. A total of fifty seedlings were placed under each light intensity chamber. Seedlings put under light screening intensive chambers with one layer of mesh net is for 75% of light intensity, those under cages with double layer of mesh net stand for 50% light intensity, those under light screening chambers with triple layers stand for 25% light intensity while those in the open field were exposed to 100% light intensity (Akinyele, 2007 and Agbo-Adediran, 2014). Light intensity within and outside the light screening chamber was measured with a light meter.

For biomass estimation, mean height of the seedlings of each soil textural classes were calculated and one seedling whose height is closest to the mean height was selected for destructive sampling at every four weeks for 16 weeks. The selected seedling from each treatment was carefully uprooted by separating the seedling from the soil, washed and sectioned into root, stem and leaves. Estimations of stem length and root length of each seedling was obtained using meter tape and sensitive weighing balance was used to obtain the initial (fresh) weight of leaves, stem and root. After taking the fresh weight, seedling components (leaf, stem and root) were taken to the analytical laboratory of the Department of Sustainable Forest Management, FRIN, placed in the oven and dried at 70°C until a constant weight is obtained. Since 100% of each component was dried in the oven, the dry weight of each component was taken as their biomass. Seedling total biomass was then obtained by summing the biomass of the various components.

Data collection and analysis

The data collected was subjected to Analysis of Variance and the means were separated using Duncan Multiple Range Test (DMRT) procedure.

Results and Discussion

Effect of light intensities on the biomass accumulation of *E. angolense* seedlings

Leaf Dry Weight (LDW)

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The mean seedlings Leaf Dry Weight (LDW) for light intensities ranged from 1.12 to 1.43 g with the highest mean LDW (1.43g) is observed in seedlings placed under 75% Light Intensity (LI) and the lowest mean LDW (1.12g) was recorded in seedlings placed under 25% LI (Table 1). Analysis of Variance (ANOVA) indicated that there were significant differences ($p \leq 0.05$) in the LDW of seedlings of *E. angolense* placed under different light intensities (Table 4).

Stem Dry Weight (SDW)

The mean seedlings Stem Dry Weight (SDW) for light intensities ranged from 0.83 to 1.12 g with the highest mean SDW (1.12g) was in seedlings placed under 100% LI and the lowest mean SDW (0.83g) from the seedlings placed under 25% LI (Table 1). ANOVA indicated that there were no significant effect ($p>0.05$) of light intensities on the SDW of *E. angolense* seedlings (Table 4).

Root Dry Weight (RDW)

The mean seedlings Root Dry Weight (RDW) for light intensities ranged from 0.94 to 1.21 g with the highest mean RDW from seedlings placed under 100% LI and the lowest mean RDW from the seedlings placed under 25% LI (Table 1). ANOVA indicated that there was no significant effect ($p>0.05$) of light intensities on the RDW of *E. angolense* seedlings (Table 4).

Total Dry Weight (TDW)

The mean seedlings Total Dry Weight (TDW) for light intensities ranged from 2.90 to 3.58 g with the highest mean TDW (3.58g) was in seedlings placed under 75% LI and the lowest mean TDW (2.90g) was in seedlings placed under 25% LI (Table 1). ANOVA indicated that was no significant effect ($p>0.05$) of light intensities on the TDW of *E. angolense* seedlings (Table 4).

Effect of soil textural classes on the biomass accumulation of *E. angolense* seedlings

Leaf Dry Weight (LDW)

Seedlings grown using loamy-sand had the highest mean Leaf Dry Weight (LDW) of 1.55 g while seedlings grown using sandy soil had the least with 0.93 g (Table 2). Analysis of Variance (ANOVA) indicated that there was significant difference ($p \leq 0.05$) in the LDW of seedlings of *E. angolense* grown with different soil textural classes (Table 4).

Stem Dry Weight (SDW)

Seedlings grown using sandy-loam had the highest mean Stem Dry Weight (SDW) of 1.39 g while seedlings grown using clay soil had the least with 0.72 g (Table 2). ANOVA indicated that there was significant difference ($p \leq 0.05$) in the SDW of seedlings of *E. angolense* grown using soil textural classes (Table 4).

Root Dry Weight (RDW)

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Seedlings grown using sandy-loam had the highest mean Root Dry Weight (RDW) of 1.44 g while seedlings grown using clay soil had the least with 0.70 g (Table 2). ANOVA indicated that there was significant difference ($p \leq 0.05$) in the RDW of seedlings of *E. angolense* grown using soil textural classes (Table 4).

Total Dry Weight (TDW)

Seedlings grown using sandy-loam had the highest mean Total Dry Weight (TDW) of 4.36 g while seedlings grown using clay soil had the least with 2.54 g (Table 2). ANOVA indicated that there was significant difference ($p \leq 0.05$) in the TDW of seedlings of *E. angolense* grown using different textural classes of soils (Table 4).

Table 1: Mean Separation for the Effect of Light Intensities on the Biomass accumulated by *E. angolense* Seedlings

Light Intensity	LDW	SDW	RDW	TDW
100%	1.13 ± 0.11b	1.12 ± 0.10a	1.21 ± 0.10a	3.46 ± 0.28a
75%	1.43 ± 0.12a	1.09 ± 0.13a	1.07 ± 0.13a	3.59 ± 0.24a
50%	1.42 ± 0.09a	0.99 ± 0.14a	1.11 ± 0.11a	3.52 ± 0.22a
25%	1.12 ± 0.14b	0.83 ± 0.11a	0.94 ± 0.12a	2.89 ± 0.23a

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

Table 2: Mean Separation for the Effect of Soil Textural Classes on the Biomass Accumulated by *E. angolense* Seedlings

Soil	LDW	SDW	RDW	TDW
Clay	1.12 ± 0.11^{b}	0.72 ± 0.11^{c}	0.70 ± 0.14^{c}	2.54 ± 0.27^{c}
Sandyloam	1.52 ± 0.11^{a}	1.39 ± 0.11^{a}	1.44 ± 0.14^{a}	4.35 ± 0.27^{a}
Sandy	0.93 ± 0.11^{b}	0.99 ± 0.11^{ab}	1.00 ± 0.14^{ab}	2.92 ± 0.27^{bc}
Loamysand	1.55 ± 0.11^{a}	0.87 ± 0.11^{ab}	1.03 ± 0.14^{abc}	3.45 ± 0.27^{b}
Loamy	1.26 ± 0.11^{ab}	1.07 ± 0.11^{b}	1.22 ± 0.14^{ab}	3.55 ± 0.27^{b}

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

Interaction effect of light intensities and soil textural classes on the biomass accumulation of *E. angolense* seedlings

Leaf Dry Weight (LDW)

Interactions of light intensities and soils showed that seedlings grown using loamy-sand placed under 50% LI had the highest mean Leaf Dry Weight (LDW) of 2.29 g while seedlings grown using sandy soil placed under

50% LI had the lowest mean LDW of 0.70 g (Table 3). Analysis of Variance (ANOVA) indicated that there was no significant interaction effect (p>0.05) of light intensities and soil textural classes on the LDW of *E. angolense* seedlings (Table 4).

Stem Dry Weight (SDW)

Interactions of light intensities and soils showed that seedlings grown using sandy-loam placed under 50% LI had the highest mean Stem Dry Weight (SDW) of 1.80 g while seedlings grown using loamy-sand placed under 25% LI had the lowest mean SDW of 0.58 g (Table 3). ANOVA indicated that there was no significant interaction effect (p>0.05) of light intensities and soil textural classes on the SDW of *E. angolense* seedlings (Table 4).

Root Dry Weight (RDW)

Interactions of light intensities and soils showed that seedlings grown using sandy-loam placed under 50% LI had the highest mean Root Dry Weight (RDW) of 1.56 g while seedlings grown using clay soil placed under 25% LI had the lowest mean RDW of 0.59 g (Table 3). ANOVA indicated that there was no significant interaction effect (p>0.05) of light intensities and soil textural classes on the RDW of *E. angolense* seedlings (Table 4).

Total Dry Weight (TDW)

Interactions of light intensities and soil textural classes showed that seedlings grown using sandy-loam placed under 50% LI had the highest mean Total Dry Weight (TDW) of 4.89 g while seedlings grown using clay soil placed under 25% LI had the lowest mean TDW of 2.05 g (Table 3). ANOVA indicated that was no significant interaction effect (p>0.05) of light intensities and soil textural classes on the TDW of *E. angolense* seedlings (Table 4).

Table 3: Mean Values for the Interaction Effect of Light Intensity and Soil Textural Class on the Biomass Accumulated by *E. angolense* Seedlings

Light Intensity	Soil	LDW	SDW	RDW	TDW
100%	Clay	0.89 ± 0.23	0.76 ± 0.22	0.78 ± 0.28	2.43 ± 0.53
	Sandyloam	1.18 ± 0.23	1.70 ± 0.22	1.43 ± 0.28	4.31 ± 0.53
	Sandy	1.14 ± 0.23	1.12 ± 0.22	1.17 ± 0.28	3.42 ± 0.53
	Loamysand	1.22 ± 0.23	0.92 ± 0.22	1.12 ± 0.28	3.26 ± 0.53
	Loamy	1.22 ± 0.23	1.13 ± 0.22	1.53 ± 0.28	3.87 ± 0.53
75%	Clay	1.31 ± 0.23	0.89 ± 0.22	0.63 ± 0.28	2.83 ± 0.53
	Sandyloam	1.99 ± 0.23	0.89 ± 0.22	1.54 ± 0.28	4.42 ± 0.53
	Sandy	1.00 ± 0.23	1.19 ± 0.22	1.11 ± 0.28	3.31 ± 0.53

	Loamysand	1.58 ± 0.23	0.87 ± 0.22	0.80 ± 0.28	3.25 ± 0.53
	Loamy	1.27 ± 0.23	1.58 ± 0.22	1.26 ± 0.28	4.10 ± 0.53
50%	Clay	1.41 ± 0.23	0.63 ± 0.22	0.82 ± 0.28	2.85 ± 0.53
	Sandyloam	1.53 ± 0.23	1.80 ± 0.22	1.56 ± 0.28	4.89 ± 0.53
	Sandy	0.70 ± 0.23	0.65 ± 0.22	0.82 ± 0.28	2.17 ± 0.53
	Loamysand	2.29 ± 0.23	1.11 ± 0.22	1.38 ± 0.28	4.77 ± 0.53
	Loamy	1.17 ± 0.23	0.75 ± 0.22	0.95 ± 0.28	2.87 ± 0.53
25%	Clay	0.87 ± 0.23	0.59 ± 0.22	0.59 ± 0.28	2.05 ± 0.53
	Sandyloam	1.37 ± 0.23	1.18 ± 0.22	1.25 ± 0.28	3.81 ± 0.53
	Sandy	0.89 ± 0.23	0.99 ± 0.22	0.91 ± 0.28	2.79 ± 0.53
	Loamysand	1.10 ± 0.23	0.58 ± 0.22	0.83 ± 0.28	2.50 ± 0.53
	Loamy	1.38 ± 0.23	0.82 ± 0.22	1.14 ± 0.28	3.34 ± 0.53

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

Table 4: ANOVA Result for the Effect of Different Light Intensities and Soil Textural Classes on the Biomass Accumulation of *E. angolense* Seedlings

Variable	SV	Df	SS	MS	F	Sig.
LDW	LI	3	1.33	0.44	2.91	0.05*
	S	4	3.30	0.83	5.42	0.00*
	LI * S	12	3.39	0.28	1.85	0.07^{ns}
	Error	40	6.10	0.15		
	Total	59	14.12			
SDW	LI	3	0.76	0.25	1.80	0.16^{ns}
	S	4	3.08	0.77	5.45	0.00*
	LI * S	12	3.31	0.28	1.95	0.06^{ns}
	Error	40	5.65	0.14		
	Total	59	12.80			
RDW	LI	3	0.53	0.18	0.75	0.53^{ns}
	S	4	3.63	0.91	3.90	0.01*
	LI * S	12	1.20	0.10	0.43	0.94^{ns}
	Error	40	9.31	0.23		
	Total	59	14.66			
TDW	LI	3	4.44	1.48	1.66	0.19^{ns}

S	4	22.82	5.71	6.42	0.00*
LI * S	12	12.47	1.04	1.17	0.34^{ns}
Error	40	35.56	0.89		
Total	59	75.29			

significant at (p≤0.05) ns- not significant (p>0.05)

Conclusion

This study reveals that *Entandrophragma angolense* seedlings preferred moderate light intensities (50% light intensity) and sandyloam for optimum biomass production. *Entandrophragma angolense* can be raised under any of the light intensities in the nursery and have the ability of surviving when planted under tree canopies for enrichment planting programme.

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