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Seedling Growth of *Tectona grandis* using Different Potting Mixture

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Authors' contributions

This work was carried out in collaboration among all authors. Author GEO designed the study and contributed in the development of the manuscript. Author CF performed the statistical analysis and wrote the first draft of the manuscript. Author CNO assisted in the design of the study and wrote the protocol. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This study evaluated the influence of 11 potting media compositions on seedling growth and development of *Tectona grandis*.
Study Design: The experiment was set up in a completely randomized design involving ten replicates.
Place and Duration of Study: The study was carried out at the Department of Forestry and Wildlife Management Nursery, University of Port Harcourt, Rivers State, Nigeria, between April 2019 and April 2020.
Methodology: Ten (10) seedlings per sowing media including topsoil, topsoil and cow dung (2:1, 3:1), topsoil and poultry dung (2:1, 3:1), topsoil and pig dung (2.1, 3:1), topsoil and sawdust (2.1, 3:1), topsoil and mushroom substrate (2.1, 3:1) were selected and transplanted into polybags. Growth parameters (seedling height, root collar diameter, leaf number and biomass (shoot dry weight (SDW), root dry weight (RDW) and total dry weight (TDW)) were determined and subjected to analysis of variance.
Results: Seedlings of *T. grandis* displayed significant differences ($p \leq 0.05$) in height, root collar diameter, leaf number and biomass. Among treatments, tallest seedlings were observed in mixture

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of topsoil and poultry dung (3:1), at months 1 to 3 and in mixture of topsoil and cow dung (3:1) at months 4 and 5, highest root collar diameter was observed in mixture of topsoil and poultry dung (3:1) and highest leaf number was recorded in mixture of topsoil and poultry dung (2:1 and 3:1) and topsoil and cow dung (2:1 and 3:1) at months 1 to 5. The highest SDW was evident in mixture of topsoil and poultry dung (2:1) while highest RDW and TDW were observed in mixture of topsoil and cow dung (3:1). Lowest height, diameter, leaf number and biomass were recorded in topsoil (control) at months 1 to 5.

Conclusion: The results revealed that among the tested mixtures, topsoil and poultry dung and topsoil and cow dung mixtures were the best for seedlings growth of *T. grandis.*

Keywords: Tectona grandis; potting mixtures; seedling growth; root collar; biomass.

1. INTRODUCTION

Tectona grandis, commonly known as teak is a large deciduous tropical hardwood tree species which belongs to the family Verbaneceae. The leaves are large and broad with large terminal panicles of small white flowers, which are distinctive [1]. *T. grandis* can attain a height of up to 30 m and a girth of 3 m. The bole is normally fluted with a bark that is grey to brownish and slash-pale brown. The leaves are 50 cm long and 30 cm broad, fruits are up to 18 mm in diameter while the wood is dark and golden in colour. *T. grandis* is used for very good timber for cabinet making, furniture, poles, beams, railway sleepers, roofs, planks, panels and numerous construction works [2]. The wood waste in the form of wood-shavings and sawdust is used for chip-boards, fibre-boards, and plastic boards [3]. Leaves are used to dye textile, particularly wool and cotton. In Java, Indonesia, the sawdust is burnt as incense [4].

Teak wood has anthelmintic qualities, making it useful against parasitic worms [5]. It has diuretic qualities and is thus used in the preparation of herbal medicines for enhancing the passage of urine [6] and anti-oxidizing properties, making it beneficial in preventing free radical damage in the body [7]. A plaster made from the powdered wood is a good remedy for splitting headaches [8].

Good container potting media management is essential for the production of high quality seedlings of *T. grandis* in Nigeria. Potting media composition type could have significant effects on the health growth and development of *T. grandis*. Different potting media compositions are being used for the supply of essential nutrients needed for the production of container-grown seedlings of *T. grandis* in forest nurseries in Nigeria. There has been no consistent potting media recommendation for the production of *T. grandis* in the country. As a result, excessive or insufficient potting material treatment may have a negative impact on the production and use of *T. grandis* seedlings.

There is a growing concern to decrease the application of inorganic fertilizers towards a more environmentally friendly application of organic manure in the production of seedlings worldwide. Application of inorganic manures in crop production could have adverse effects on the flora and fauna which play significant roles in the sustainability of the natural soil fertility. Secondly, indiscriminate use of organic manure could also have adverse effect on the soil and cause phyto-toxicity, if the appropriate application and ratio are not determined. These create the need for this study. The objective of this study is to evaluate the influence of potting media on early seedling growth and development of container-grown seedlings of *Tectona grandis*.

2. MATERIALS AND METHODS

2.1 Study Area

The research was conducted in the Forestry Nursery, which is located at the Department of Forestry and Wildlife Management, Faculty of Agriculture, University of Port Harcourt, Choba, Rivers State, at latitude 04°53' 38.3"N and longitude 00.6° 54'38"E.

2.2 Seed Collection

The fruits of *T. grandis* were collected from the Swamp Forest Research Station of the Forestry Research Institute of Nigeria, Benin, Edo State. The seeds were processed and mixed thoroughly to form a seed-lot. Only viable seeds were sown; seeds that sank after floatation for three hours were regarded as viable and used for the study, while the seeds that floated were discarded.

2.3 Potting Media Collection, Composition and Analysis

Topsoil was collected from the forest floor at the Institute of Agricultural Research and Development, University of Port Harcourt. Spent composition of mushroom, poultry manure, piggery manure and cow-dung were collected from the Demonstration farm of the Faculty of Agriculture, University of Port Harcourt. The composition of the potting media is displayed in Table 1. Sowing media were analysed to determine their physiochemical properties as shown in Table 2. The moisture content of the soil was determined using the gravimetric method [9]; bulk density by pipette method [10]; soil porosity was determined by mercury porosimetry [11]; pH as outlined by Jackson [12]; organic carbon using chromic acid wet oxidation method by Walkley and Black [13]; total nitrogen micro Kjeldhal Method [14]; available phosphorus by Spectrophotometric method [15] and available potassium by using Flame photometer method [12].

2.4 Experimental Design / Treatment Procedure

The experiment was laid in a completely randomized design (CRD) with 10 replicates. Three kg of *T. grandis* was sown in a nursery bed. The seeds were soaked in water for 24h to break dormancy and ensure faster and uniform germination before sowing. Watering was done daily. Ten (10) seedlings each of *T. grandis* at the two leaf stage were transplanted individually into the prepared polybags filled with the different potting media. Each of the polybags represented individual replicates. Polybags were watered daily with 250ml of water and weeded when necessary.

2.5 Growth Data Collection

Initial measurement on shoot parameters for all seedlings was done immediately after transplanting (one month after sowing) and monthly thereafter for four months. Measurement on seedling height was done from the substrate level to the tip of the youngest leaf using a meter rule; on root collar diameter was done at the root collar using a digital caliper and on leaf number was determined by directly counting the number of leaves.

2.6 Biomass Determination

Five seedlings were chosen for each treatment at the end of the experiment (5 months) and carefully removed from the pots and the root system exposed by carefully washing off the growth media from the roots, blotting surplus moisture from the plants was done with absorbent paper. Seedlings were then cut at the collar into shoot and root components and placed in a paper bag for drying. The shoot and root samples were dried in the oven at 70°C for two days (48 h) and reweighed to get the shoot dry weight (SDW) and root dry weight (RDW). Dry weights of the shoot and root were then added together to get the total dry weight (TDW) of seedlings per treatment.

2.7 Data Analysis

Average values and standard errors were determined with respect to potting media. Data collected on growth attributes were analysed using the Analysis of Variance (ANOVA) in SPSS statistical software (SPSS version 21.0, SPSS Inc.) to determine the variation among treatments. Duncan Multiple Range (DMR) test was used to separate means that were significant at 5% level of probability.

Table 1. Potting media composition

Media composition	Ratio (v/v)	Treatment
Topsoil	Control	T_1
Topsoil + Sawdust	2:1	T_2
Topsoil + Sawdust	3:1	T_3
Topsoil + Mushroom substrate	2:1	T_4
Topsoil + Mushroom substrate	3:1	T_5
Topsoil + Poultry manure	2:1	T_6
Topsoil + Poultry manure	3:1	T_7
Topsoil + Pig-dung	2:1	T_8
Topsoil + Pig-dung	3:1	T_9
Topsoil + Cow-dung	2:1	T_{10}
Topsoil + Cow-dung	3:1	T_{11}

3. RESULTS AND DISCUSSION

3.1 Potting Media Analysis

The result showed that mixtures of topsoil and poultry manure (2:1, 3:1) as well as topsoil and cow dung (2:1,3:1) have optimum physical properties (Table 2).

3.2 Mean Seedling Height

There were significant differences in the effect of potting media on seedling height of *T. grandis* (Table 3). Tallest seedlings were observed in mixture of topsoil and poultry dung (3:1) (13.65, 19.50 and 25.54 cm), followed by topsoil and poultry dung (2:1) (12.61, 18.63 and 24.91 cm) at months 1 to 3, and in mixture of topsoil and cow dung (3:1) at months 4 and 5 (35.50 and 43.56 cm) while lowest mean seedling height was recorded in topsoil (control) at months 1 to 5 (4.57, 6.70, 8.92, 10.94 and 12.93 cm respectively).

3.3 Root Collar Diameter

There were significant differences in the effect of Potting media on the root collar diameter of *T. grandis* (Table 4). Highest root collar diameter of *T. grandis* was observed in mixture of topsoil and poultry dung (3:1) at months 1 and 5 (2.25 and 12.28 mm), in topsoil and cow dung (3:1) at months 2 and 4 (4.68 and 8.85 mm) and in topsoil and poultry dung (3:1) and topsoil and cow dung (3:1) at month 3 (6.67 mm) while lowest root collar diameter was recorded in topsoil (control) at months 1 to 5 (1.71, 3.62, 5.47, 7.16 and 9.35 mm respectively).

3.4 Mean Seedling Leaf Production

There were significant differences in the effect of potting media on the seedling leaf production of *T. grandis* (Table 5). The highest mean seedling leaf number of *T. grandis* was recorded in mixture of topsoil and poultry dung (2:1 and 3:1) and topsoil and cow dung (2:1 and 3:1) at months 1 and 2 (10.0 and 12.0), topsoil and cow dung (3:1) at month 3 (15.2), topsoil and poultry dung (3:1) at month 4 (18.2) and in topsoil and poultry dung (3:1) and topsoil and cow dung (2:1) at month 5 (21.4) while lowest leaf number was recorded in topsoil (control) at months 1 to 5 (5.8, 7.8, 9.8, 12.2 and 14.0 cm respectively).

3.5 Biomass

There were significant differences on the effect of potting media on the plant (Table 6). Highest SDW was evident in mixture of topsoil and poultry dung (2:1) (25.01), followed by topsoil and cow dung (3:1) (24.90), highest RDW was observed in mixture of topsoil and cow dung (3:1) (8.86), followed by topsoil and cow dung (2:1) (8.75), highest TDW was observed in mixture of topsoil and cow dung (3:1) (33.52), followed by topsoil and poultry dung (2:1) (33.44) and topsoil and cow dung (2:1) (33.42) while lowest SDW, RDW and TDW (9.39, 3.29 and 12.68 respectively) were shown in topsoil (control).

Table 2. Physical and chemical properties of potting media

Parameter	Water content (%)	Bulk density (g/cm^3)	Porosity (%)	pH	Organic carbon (%)	Total N (%)	Available P (mg/kg)	Potassium (cmol)
T1	38	0.38	30	4.6	12.08	0.8	5	0.02
T2	36	0.54	32	7.4	23.14	0.9	6	0.03
T3	37	0.98	36	7.5	23.26	0.8	6	0.03
T4	54	1.01	39	8.2	23.17	1.3	7	0.05
T5	57	1.04	42	7.8	23.64	1.4	7	0.06
T6	69	1.44	74	7.9	23.82	3.6	8	0.08
T7	68	1.49	75	7.5	23.95	3.9	8	0.09
T8	72	1.20	59	7.6	22.17	2.4	7	0.06
T9	76	1.22	60	7.4	22.18	2.3	6	0.06
T10	68	1.37	64	7.7	23.94	3.8	8	0.08
T11	65	1.42	65	7.5	23.96	3.8	8	0.09

Table 3. Effect of potting media on mean seedling height of *T. grandis*

	Seedling height (cm) (monthly)				
Treatments	**1**	**2**	**3**	**4**	**5**
T1	4.57±0.18^{g}	6.70±0.12^{j}	8.92±0.12^{i}	10.94±0.16^{g}	12.93±0.30^{h}
T2	8.27±0.08^{d}	12.32±0.05^{e}	16.56±0.07^{de}	20.78±0.04^{de}	24.57±0.10^{e}
T3	8.26±0.07^{d}	12.75±0.04^{d}	16.76±0.05^{d}	21.39±0.12^{d}	24.48±0.13^{e}
T4	7.80±0.09^{e}	11.66±0.07^{g}	15.89±0.03^{f}	19.92±0.15^{e}	23.85±0.21^{f}
T5	7.71±0.09^{e}	12.01±0.15^{f}	16.35±0.09^{e}	21.89±0.82^{d}	23.94±0.10^{f}
T6	12.61±0.06^{b}	18.63±0.09^{b}	24.91±0.07^{b}	31.71±0.23^{c}	36.52±0.15^{d}
T7	13.65±0.09^{a}	19.50±0.10^{a}	25.54±0.10^{a}	33.74±0.70^{b}	37.51±0.32^{c}
T8	6.90±0.15^{f}	10.00±0.17^{i}	12.78±0.25^{h}	15.90±0.25^{f}	18.38±0.10^{g}
T9	8.24±0.12^{d}	10.56±0.14^{h}	13.24±0.22^{g}	16.59±0.08^{f}	18.48±0.10^{g}
T10	10.56±0.09^{c}	15.66±0.06^{c}	20.77±0.05^{c}	35.18±0.39^{a}	42.43±0.26^{b}
T11	10.78±0.04^{c}	15.86±0.06^{c}	21.06±0.09^{c}	35.50±0.43^{a}	43.56±0.15^{a}
P value	0.000	0.000	0.000	0.000	0.000

Means with the same letter within a column do not differ at 5% probability

Table 4. Mean seedling root collar diameter (mm) under different treatments of potting media in *T. grandis*

	Seedling root collar diameter (mm) (monthly)				
Treatments	**1**	**2**	**3**	**4**	**5**
T1	1.71±0.03^{d}	3.62±0.02^{f}	5.47±0.03^{d}	7.16±0.02^{d}	9.35±0.02^{e}
T2	2.02±0.01^{c}	4.03±0.02^{e}	6.06±0.02^{c}	8.05±0.02^{c}	11.15±0.03^{c}
T3	2.02±0.03^{c}	4.05±0.02^{de}	6.13±0.03^{c}	8.10±0.02^{c}	11.18±0.04^{c}
T4	1.97±0.02^{c}	4.04±0.02^{de}	6.03±0.02^{c}	8.00±0.03^{c}	11.11±0.03^{c}
T5	2.02±0.01^{c}	4.08±0.02^{de}	6.11±0.06^{c}	7.99±0.02^{c}	11.17±0.06^{c}
T6	2.12±0.02^{b}	4.48±0.03^{b}	6.63±0.06^{a}	8.69±0.04^{b}	12.19±0.05^{ab}
T7	2.25±0.03^{a}	4.64±0.03^{a}	6.67±0.08^{a}	8.80±0.03^{ab}	12.28±0.03^{a}
T8	2.15±0.02^{b}	4.12±0.03^{cd}	6.08±0.03^{c}	8.04±0.02^{c}	10.11±0.02^{d}
T9	2.11±0.01^{b}	4.17±0.02^{c}	6.08±0.05^{c}	8.06±0.02^{c}	10.12±0.03^{d}
T10	2.21±0.02^{a}	4.55±0.05^{b}	6.50±0.04^{b}	8.84±0.03^{a}	12.12±0.04^{b}
T11	2.24±0.03^{a}	4.68±0.04^{a}	6.67±0.05^{a}	8.85±0.13^{a}	12.16±0.03^{b}
P value	0.000	0.000	0.000	0.000	0.000

Means with the same letter within a column do not differ at 5% probability

Table 5. Seedling leaf production under different treatments of potting media in *T. grandis*

	Seedling leaf production (monthly)				
Treatments	**1**	**2**	**3**	**4**	**5**
T1	5.8±0.13^{c}	7.8±0.13^{c}	9.8±0.13^{d}	12.2±0.13^{d}	14.0±0.00^{c}
T2	8.0±0.00^{b}	10.0±0.00^{b}	12.0±0.00^{c}	14.2±0.13^{b}	16.1±0.10^{b}
T3	8.0±0.00^{b}	10.0±0.00^{b}	12.0±0.00^{c}	14.1±0.18^{b}	16.0±0.00^{b}
T4	8.0±0.00^{b}	10.0±0.00^{b}	12.0±0.00^{c}	14.0±0.00^{bc}	16.2±0.13^{b}
T5	8.1±0.00^{b}	10.0±0.00^{b}	12.0±0.00^{c}	14.0±0.00^{bc}	16.2±0.13^{b}
T6	10.0±0.00^{a}	12.0±0.00^{a}	14.4±0.27^{b}	18.0±0.00^{a}	21.0±0.26^{a}
T7	10.0±0.00^{a}	12.0±0.00^{a}	14.4±0.27^{b}	18.2±0.13^{a}	21.4±0.22^{a}
T8	8.0±0.00^{b}	10.0±0.00^{b}	12.0±0.00^{c}	14.0±0.00^{bc}	16.0±0.00^{b}
T9	8.0±0.00^{b}	10.0±0.00^{b}	12.0±0.00^{c}	13.7±0.13^{c}	16.0±0.00^{b}
T10	10.0±0.00^{a}	12.0±0.00^{a}	14.8±0.33^{ab}	18.0±0.00^{a}	21.4±0.27^{a}
T11	10.0±0.00^{a}	12.0±0.00^{a}	15.2±0.33^{a}	18.0±0.00^{a}	21.1±0.28^{a}
P value	0.000	0.000	0.000	0.000	0.000

Means with the same letter within a column do not differ at 5% probability

Table 6. Biomass accumulation in *T. grandis* at 150 days after transplanting

	Plant biomass (g)		
Treatments	**SDW**	**RDW**	**TDW**
T1	9.39±0.08^{g}	3.29±0.05^{g}	12.68±0.11^{e}
T2	18.55±0.02^{e}	6.52±0.11^{c}	25.07±0.11^{c}
T3	18.50±0.07^{e}	6.55±0.11^{c}	25.06±0.10^{c}
T4	19.12±0.03^{d}	6.30±0.07^{de}	25.42±0.09^{b}
T5	19.23±0.17^{d}	6.47±0.09^{cd}	25.69±0.18^{b}
T6	25.01±0.23^{a}	8.63±0.04^{b}	33.44±0.18^{a}
T7	24.55±0.16^{c}	8.72±0.05^{ab}	33.27±0.13^{a}
T8	18.08±0.03^{f}	6.06±0.01^{f}	24.14±0.01^{d}
T9	18.16±0.04^{f}	6.14±0.01^{ef}	24.30±0.04^{d}
T10	24.66±0.12^{bc}	8.75±0.06^{ab}	33.42±0.10^{a}
T11	24.90±0.07^{ab}	8.86±0.05^{a}	33.52±0.16^{a}
P value	0.000	0.000	0.000

Means with the same letter within a column do not differ at 5% probability. Where SDW: Shoot Dry Weight, RDW: Root Dry Weight and TDW: Total Dry Weight

4. DISCUSSION

Seedling height, root collar diameter, leaf production and biomass of *Tectona grandis* were significantly affected by potting media compositions. Mixtures of topsoil and poultry dung and topsoil and cow dung resulted in significantly taller seedlings, thicker root collar diameter, more leaves and higher biomass. This is an indication that plant growth was clearly influenced by nutrient availability in the potting medium during propagation. A good potting media should contain appropriate macro and micro nutrients needed for good growth and development of plants. Mixture of topsoil and poultry dung and topsoil and cow dung seem to possess optimal physio-chemical characteristics including greater pore spaces which could have facilitated the availability of air and water within the soil; and organic carbon, nitrogen and phosphorus which are major nutrient required by plants for optimum growth. This may have contributed in no small measure to the observed good growth of *T. grandis* in this study. It was also observed that mixtures of topsoil and poultry dung and topsoil and cow dung with higher amount of amendment (3:1) displayed better nutrient and subsequent growth than the lower amount of amendment (2:1) with topsoil.

The study has shown that growth attributes can influenced by the type of potting medium used to raise the plants in the nursery. Nutrient availability plays a pivotal role in plants growth and development. They are important structure in plant for photosynthesis. Poorly developed plant attributes (height, collar diameter, leaves and biomass) could lead to poor photosynthate for metabolic activities.

Similar findings have been observed by [16], [17] and [18]. The authors noted that the physical, chemical and biological properties of potting media have influence on the growth and development of plants. Swetha et al. [19] opined that potting media with organic substrate recorded maximum plant height, number of leaves, leaf length and leaf area compared to the control with no organic substrate for *Agluonema* seedlings. Similar observations were reported by Kerkeni et al. [20] and Utobo et al. [21] who noted that potting medium combination had impact on the growth and development of *Capsicum annuum* and carrot varieties respectively. The finding is also in agreement with that of Popescu and Popescu [22] who reported that the type of organic manure and the mixture has considerable influence on the growth and development of *Petunia grandiflora* and *Nicotiana alata* and with that of [23] on native plant species in Greece.

Topsoil (control) consistently had the shortest seedlings, thinnest root collar diameter, fewest leaves and reduced biomass throughout the five months of study. The poor performance of topsoil alone implies that the potting medium was poor in nutrient availability as it contained lower quantity of organic carbon, available phosphorus and potassium, hence the poor growth and development of the different parameters studied.

5. CONCLUSION

The main reason for the application of potting media in seedling production is to provide nutrients and a suitable physical environment for the plants. The present study shows that seedling height, leaf production, root collar diameter and biomass accumulation were significantly influenced by potting media. The results revealed that among the tested mixtures, topsoil and poultry dung and topsoil and cow dung mixtures were the best for seedling growth of *T. grandis.* It could therefore be concluded that the addition of organic manure to the topsoil potting medium was responsible for improved growth in *T. grandis*. Hence, it is recommended to use mixture of topsoil and poultry manure and/or topsoil and cow dung when propagating this species.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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