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Evaluation of *Pterocarpus mildbraedii.* Harm Performance under Different Growth Conditions

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Abstract

Growth response of *Pterocarpus mildbraedii* under different sowing media and fertilizer applications was evaluated. The experiment was laid out in a completely randomized design (CRD). Forty-eight trays were filled with each of the sowing media (garden topsoil, river-sand and sawdust). Each of the trays was sown with ten seeds making 480 seeds per medium. Five weeks after germination, seedlings were pricked-out and potted using 16 cm-poly pots. The seedlings were allowed to grow for another six weeks. Thereafter, they were transplanted to the field, at 5 m espacement. After the seedlings were established in the field, manures were applied on all the seedlings under each of the sowing media using two manures (i.e. Poultry droppings and cow dung) as well as NPK (15: 15: 15) with zero-fertilizer application as the control. Data were collected on germination and early seedling growth parameters eight weeks after. Data analysis involved descriptive statistics, one-way analysis of variance (ANOVA), t-test and regression analysis for establishing relationship among growth parameters. Follow-up test was carried out on significant result. *Pterocarpus mildbraedii* germinated in 3 to 17 days. The germinations peaked on the 4th day in river-sand and topsoil, and on the 11th day in sawdust. Germination was highest in sawdust (43.3%) and least in topsoil (37.1%). The results showed that leaf number were not significantly different among the sowing media ($P > 0.05$) with an average of 4 leaves per plant. However, there were significant differences in collar diameters, seedling heights and leaf areas among the treatments ($P < 0.05$) with highest mean values in sawdust. Poultry droppings improved seedling height growth by 2.50 cm, 1.75 cm and 1.2 cm in river-sand, sawdust and topsoil, respectively after eight weeks of planting. The best height prediction equation for *P. mildbraedii* seedling was $Ht = 7.77 + 6.25CD – 0.0517LA + 0.373LN$ ($R^2 = 0.59$; RMSE = 1.679). Height was the best predictor of collar diameter as in $CD = 0.258 + 0.0765Ht$ ($R^2 = 0.51$; RMSE = 0.192). There were no suitable predictors for leaf area and leaf number.

Keywords: Early growth, increment, sowing media, manure, parameter prediction

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Introduction

Pterocarpus mildbraedii, locally known as *Oha ojii* in eastern Nigeria, belongs to the family *Papilionoideae* (Keay, 1989). It is a semi-deciduous tree with a rounded crown, and can grow 15-25 m tall, or a little more. The long straight bole can be up to 60 cm in diameter. It occurs in lowland rainforest, dry evergreen and riverine forests, up to 1250 m altitude, in Sierra Leone, Nigeria, Liberia, Ghana, Cameroon, Equatorial Guinea and Tanzania (Bosch, 2004). The leaf of *P. mildbraedii* is one of the vegetables consumed widely in *Igbo* land of Nigeria (Chinma and Igyor, 2007), and has been recommended for consistent use to prevent diabetics (Durugbo, 2013). It is a good source of beneficial chemicals having antioxidant, hypocholesterolemic, chemoprotective and anti-bacterial properties (Ujowundu *et al*., 2010).

Due to intense consumption and deforestation, *P. mildbraedii* faces the risk of extinction (Adelaja and Faidi, 2008). There is paucity of information on the development and growth conditions of *P. mildbraedii*, since little effort has been made for domesticating the species. Nevertheless, no sustainable strategy has been adopted to ensure its conservation. Sadly, most of these valuable non-timber species of which *P. mildbraedii* is a part are lost on annual basis due to high deforestation and urbanization rates (Adelaja and Faidi, 2008). Hence, having adequate knowledge of the conditions for propagation of *P. mildbraedii* will enhance conservation of the species. It has been said that manuring helps to improve the growth of seedlings so as to shorten their period in the nursery as well as rotation length (Nwoboshi, 2000). It has also been noted that the qualities of seedlings are usually influenced by the composition of the growing media (Baiyeri, 2003; Baiyeri and Mbah, 2006). Therefore, it is imperative to ascertain the best growing media and fertilizer application for *P. mildbraedii* in order to ensure optimum growth performance.

Materials and Methods

This study was carried out at the Botanical Garden of the Department of Forestry and Wildlife Technology, Federal University of Technology Owerri, Nigeria, centered on latitude 5^{o}29’0”N and longitude 7^{o}2’0”E in Imo state, south-eastern Nigeria. The mean annual rainfall is between

1,250 and 3000 mm with a relative humidity of up to 90% (Adeyemi *et al*., 2016). The temperatures are between 25^{o}C and 35^{o}C (Adeyemi *et al*., 2016). The experiments were laid out in a completely randomized design (CRD). The effects of sowing media and fertilizer treatment on seedling emergence and early growth were evaluated. One hundred and forty-four (144) germination trays were used for the study. Each of the trays was sown with ten (10) seeds making forty-eight (48) trays for each of the sowing media (i.e. topsoil, river sand and sawdust of *Garcinia kola*) and 1440 seeds in all.

Data Collection

The germination trays were visited on daily basis to ascertain the time and period of seedling emergence. The number of seeds germinated was recorded daily. Growth parameters such as seedling height, collar diameter, number of leaves and leaf area, were assessed, three weeks after seedling emergence. The seedling height was measured from the medium level (i.e. at the basal position) to the tip of plant. Every visible leaf on the plant was counted; including the tips of new leaves just beginning to emerge. Leaf area meter was used for leaf area measurement. The collar diameter was measured using vernier caliper.

Five weeks after germination, seedlings were pricked out into 16 cm (height) × 9 cm (diameter) polythene pots with due considerations to the sowing media. The seedlings were allowed to stabilize in the polythene pots for four weeks before transplanting to the field, at 5 m espacement (i.e. 5 m x 5 m spacing) and 15 cm depth, for fertilizer applications. After the seedlings established in the field, fertilizer application was carried out on all the seedlings under each of sowing media using two manures (i.e. poultry droppings and cow dung) as well as NPK (inorganic fertilizer) with zero-fertilizer application as control. Eight weeks after the initial measurement, seedling growth parameters were re-measured on all the seedlings under different sowing media and fertilizer applications.

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Statistical Analysis

Data were analyzed using descriptive statistics such as percentages and graphs, one-way analysis of variance (ANOVA) and simple linear regression.

Results and Discussion

Table 1 presents *P. mildbraedii* germination rates under the three sowing media. The germinations occurred between the 3 and 17 days after sowing with the highest germination percentage recorded under sawdust, having 43.3% with least (37.1%) in topsoil. For river-sand and topsoil, the germination peaked on the 4th day after sowing, while highest germination was recorded in sawdust on the 11th day after sowing. With respect to the number of days expended for seedling to emerge, seeds sown in river-sand and topsoil started emerging in three (3) days with average of 10 days in both cases. However, those sown in sawdust started emerged in four (4) days with an average germination days of 11 (Table 1).

Table 1: Germination rates of *P. milbraedii* under the three sowing media

Medium	Seeds sown	No. germinated	Germination	Average days	Range (day)	Peak (day)
River sand	480	204	42.2%	10	3 – 17	4th
Sawdust	480	208	43.3%	10	4 – 17	11th
Topsoil	480	178	37.1%	11	3 – 17	4th

Figure 1 shows the germination trends of *P. milbraedii* under different sowing media. The result shows that the first seedling emergence occurred in topsoil and sterilized river-sand after 3 days and the last was recorded on 17th day. With regards to sawdust, the first germination occurred after 4 days of sowing and the last was recorded on the 17th day after sowing. The result also shows that the highest number of seedling emergence occurred in topsoil with 52 seedlings and in sterilized river-sand with 36 seedlings, both on the 4th day. While the highest number of seedling emergence occurred under sawdust on the 11th day of sowing with 43 seedlings.

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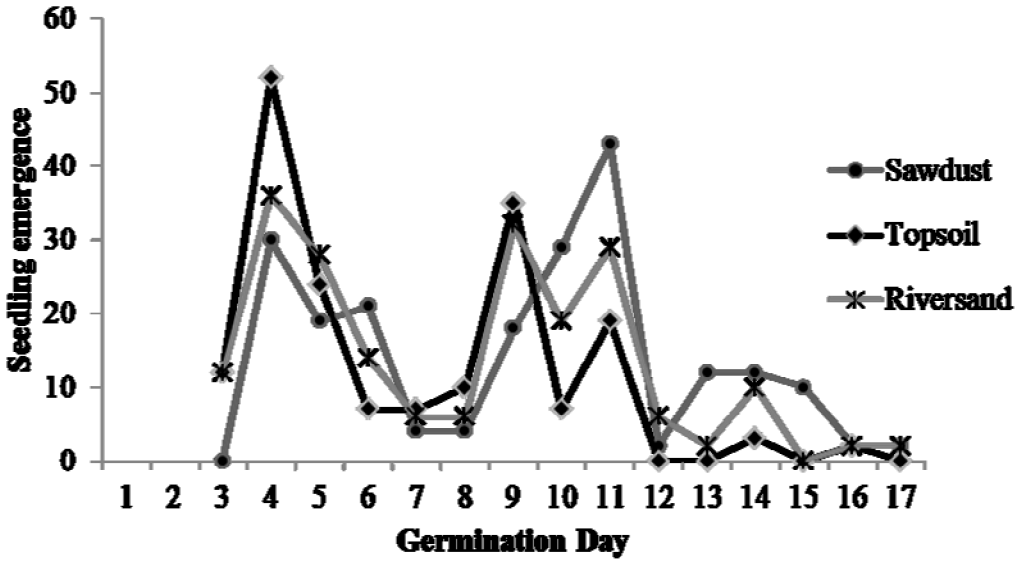


Figure 1: *Pterocarpus mildbraedii* emergence under different sowing media

The result of ANOVA for the numbers of leaves showed that there was no significant difference among the three sowing media ($P > 0.05$). However, there were significant differences in mean collar diameter, seedling height and leaf area among the treatments ($P < 0.05$). The highest mean height growth (9.60 ± 1.65 cm) was recorded in sawdust and the least (8.38 ± 1.76 cm) was recorded in river-sand. With respect to leaf areas, the highest mean (25.41 ± 8.20 cm^2) was recorded in sawdust and least (18.00 ± 6.66 cm^2) was in river-sand. The result for seedling collar diameter revealed that seedlings raised in sawdust produced the highest mean (1.09 ± 0.10 cm) with the least (1.01 ± 0.15 cm) was in river-sand. The mean number of leaves of about 4/plant was recorded in sawdust, river-sand and topsoil. Considering the height growth, values under sawdust and topsoil were not significantly different. However, mean height value under river-sand significantly differed from those of sawdust and topsoil (Table 2).

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Table 2: Mean values for seedling growth parameters under different sowing media

Media	Mean value			
	Height (cm)	Collar diameter (cm)	Leaf area (cm^2)	Leaf number
River sand	8.38 ± 1.76^b	1.00 ± 0.15^b	18.00 ± 6.66^b	4.03 ± 0.77^a
Sawdust	9.60 ± 1.65^a	1.09 ± 0.10^a	25.41 ± 8.20^a	4.09 ± 0.84^a
Topsoil	9.45 ± 2.00^a	1.08 ± 0.10^a	23.94 ± 9.90^a	3.78 ± 1.09^a
LSD value	**0.74**	**0.37**	**0.051**	**3.41**

NB.: means with the same alphabet as superscript in the same column are not significantly different

The result of ANOVA revealed that there were no significant differences in seedling heights, collar diameter, leaf areas and number of leaves among the treatments (including the control) since $P > 0.05$. The results of the LSD test for the seedling growth parameters for different fertilizer treatment under sawdust are presented in Table 3. The seedlings that received cow dung were highest in height values (23.85 ± 2.55 cm) with control having the least mean height growth (21.50 ± 0.91). The result for collar diameter showed that NPK produced seedlings with the highest mean collar diameter of 2.23 ± 0.21 cm, while the least mean collar diameter was recorded in control (1.80 ± 0.23). The result for leaf area revealed that seedlings treated with cow dung had highest mean leaf area value of 30.63 ± 6.42 cm^2, and the least mean seedling leaf area was recorded under control (23.82 ± 5.12 cm^2). With respect to number of leaves, poultry droppings produced seedlings with the highest mean of about 10 leaves per plant. This was followed by the seedlings treated with cow dung, NPK and control with a mean number of leaves of about 9 leaves per plant.

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Table 3: Mean values for *P. mildbraedii* seedlings growth parameters for different fertilizer applications under sawdust

Fertilizer	Mean value			
	Height (cm)	Collar diameter (cm)	Leaf area (cm^2)	Leaf number
Cow dung	23.85 ± 2.55^a	2.18 ± 0.28^a	30.63 ± 6.42^a	9.25 ± 1.90^a
NPK	22.75 ± 2.36^a	2.23 ± 0.20^a	27.20 ± 5.37^a	9.00 ± 3.27^a
Poultry dropping	23.63 ± 1.19^a	2.05 ± 0.25^a	28.09 ± 5.03^a	9.50 ± 3.12^a
Control	21.50 ± 0.91^a	1.80 ± 0.25^a	23.82 ± 5.12^a	9.00 ± 1.15^a
LSD value	**2.86**	**3.80**	**0.37**	**8.34**

NB.: means with the same alphabet as superscript in the same column are not significantly different

The results of ANOVA for seedling growth parameters under different fertilizer applications for topsoil revealed that there were no significant differences in mean seedling heights, collar diameters and leaf areas among the treatments ($P > 0.05$). However, the effects of different manures were significant on number of leaves ($P < 0.05$). The results of the LSD test for the seedling growth parameters for different fertilizer treatment under topsoil are presented in Table 7. The seedlings that received poultry droppings recorded highest mean seedling height (22.38 ± 1.83 cm), with least value (19.55 ± 1.64) under control experiment. The result for collar diameter showed that cow dung produced seedlings with the highest mean collar diameter (2.03 ± 0.05 cm) with least mean value in control (1.68 ± 0.22 cm). With respect to the leaf area, seedlings treated with poultry droppings had highest mean (31.74 ± 6.34 cm^2) with the least mean seedling leaf area (25.57 ± 3.35 cm^2) recorded under the control. The result for the number of leaves showed that the poultry dropping and cow dung produced seedlings with the highest mean value of about 9 leaves per plant. This was followed by the seedlings treated with NPK and control with a mean number of leaves of about 7 leaves per plant. The effects of cow dung and poultry droppings on number of leaves were not significantly different. Likewise, NPK did not produce a result significantly different from that of the control (Table 4).

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Table 4: Mean value for *P. mildbraedii* seedlings growth parameters for different fertilizer applications under topsoil

Fertilizer	Mean value			
	Height (cm)	Collar diameter (cm)	Leaf area (cm^2)	Leaf number
Cow dung	21.25 ± 1.71^a	2.03 ± 0.05^a	28.15 ± 2.69^a	9.00 ± 0.82^b
NPK	21.55 ± 1.91^a	1.83 ± 0.24^a	26.85 ± 2.40^a	6.75 ± 0.96^a
Poultry dropping	22.37 ± 1.83^a	2.00 ± 0.16^a	31.74 ± 6.34^a	9.25 ± 1.26^b
Control	19.55 ± 1.64^a	1.68 ± 0.22^a	25.57 ± 3.35^a	6.50 ± 1.29^a
LSD value	**2.69**	**1.66**	**0.28**	**6.07**

NB.: means with the same alphabet as superscript in the same column are not significantly different

The results of ANOVA for seedling growth parameters under different fertilizer applications for river-sand revealed that there were no significant differences in mean seedling heights, leaf numbers and leaf areas among the treatments ($P > 0.05$). However, there was a significant difference in the mean collar diameter among the treatments ($P < 0.05$). The results of the LSD test for the seedling growth parameters for different fertilizer treatments under sawdust are presented in Table 5. The seedlings that received poultry droppings recorded highest mean seedling height (22.00 ± 1.59 cm) with control as the least in mean height (17.60 ± 1.27 cm). The result for collar diameter showed that poultry droppings produced seedlings with the highest mean collar diameter of 1.90 ± 0.12 cm, with control as the least (1.53 ± 0.05 cm). With respect to leaf area, the result showed that seedlings treated with poultry droppings had highest mean leaf area (33.54 ± 2.82 cm^2) while the least mean value (24.50 ± 3.91 cm^2) was recorded in the control experiment. The result for the leaf number revealed that cow dung produced seedlings with the highest mean value of about 10 leaves per plant with the least of 5 leaves per plant recorded in control experiment. The effects of cow dung and NPK on collar diameter growth were not significantly different from that of control. However, poultry dropping produced a result significantly different from NPK, cow dung and control (Table 5).

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Table 5: Mean values for *P. mildbraedii* seedlings growth parameters for different fertilizer applications under river-sand

Fertilizer	Mean value			
	Height (cm)	Collar diameter (cm)	Leaf area (cm^2)	Leaf number
Cow dung	19.38 ± 0.75^{a}	1.65 ± 0.17^{ab}	28.52 ± 3.89^{a}	9.50 ± 3.11^{a}
NPK	20.10 ± 4.37^{a}	1.80 ± 0.25^{ab}	32.31 ± 6.33^{a}	8.50 ± 2.65^{a}
Poultry dropping	22.00 ± 1.59^{a}	1.90 ± 0.12^{a}	33.54 ± 2.82^{a}	9.25 ± 0.50^{a}
Control	17.60 ± 1.27^{a}	1.53 ± 0.05^{ab}	24.50 ± 3.91^{a}	5.00 ± 3.38^{a}
LSD value	**3.69**	**4.02**	**0.25**	**6.77**

NB.: means with the same alphabet as superscript in the same column are not significantly different

The results of ANOVA for comparing seedling growth increment for the different fertilizer application under the three growth media showed that under river-sand, mean seedling height was not significantly different among the treatment since $P > 0.05$. However, there was significant difference in the mean collar diameter ($P < 0.05$). Under the sawdust, mean seedling heights and collar diameters were not significantly different among the treatment ($P > 0.05$). The result also showed that mean seedling heights and collar diameters were not significantly different among the treatment ($P > 0.05$) in topsoil. The results mean separation (LSD test) for the seedling growth increment under different fertilizer treatments in river-sand, sawdust and topsoil are presented in Table 11. Under river sand, the seedlings that received poultry droppings had highest the mean height increment (2.70 ± 2.13 cm) with control having the least mean height increment (0.20 ± 0.14). With respect to collar diameter, poultry droppings and NPK produced seedlings with the highest mean collar diameter increment (0.38 ± 0.09 cm), with least value (0.10 ± 0.00 cm) recorded under the control experiment. For height, there was no significant difference in means among the treatment. The effects of poultry droppings and NPK on collar diameter were not significantly different. Likewise, cow dung did not produce a result significantly different from that of the control.

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For sawdust, the seedlings that received NPK had the highest mean seedling height increment (3.25 ± 2.06 cm) while the control produced seedlings with the least mean height increment (1.38 ± 1.11 cm). Collar diameter result showed that NPK produced seedlings with the highest mean collar diameter increment of 0.48 ± 0.09 cm, with control as the least (0.20 ± 0.08 cm). The seedlings that received poultry droppings recorded highest mean seedling height increment of 2.50 ± 1.53 cm under topsoil with the control as the least in mean height increment (1.30 ± 0.42). The result for collar diameter showed that poultry droppings produced seedlings with the highest mean collar diameter increment (0.25 ± 0.24 cm), while the least value was recorded in control experiment (0.13 ± 0.05 cm) as shown in Table 6.

Table 6: Mean values for *P. mildbraedii* seedlings growth increments for different fertilizer applications under three sowing media

Media	Parameter	Mean values				
		Cow dung	NPK	Poultry droppings	Control	**LSD**
River-sand	Height (cm)	1.45 ± 0.76^{a}	2.50 ± 1.63^{a}	2.70 ± 2.13^{a}	0.20 ± 0.14^{a}	**2.11**
	CD (cm)	0.18 ± 0.09^{a}	0.38 ± 0.09^{b}	0.38 ± 0.09^{b}	0.10 ± 0.00^{a}	**0.13**
Sawdust	Height (cm)	2.85 ± 1.41^{a}	3.25 ± 2.06^{a}	3.13 ± 0.38^{a}	1.38 ± 1.11^{a}	**2.09**
	CD (cm)	0.43 ± 0.22^{a}	0.48 ± 0.09^{a}	0.33 ± 0.09^{a}	0.20 ± 0.08^{a}	**0.21**
Topsoil	Height (cm)	2.48 ± 1.05^{a}	1.55 ± 0.48^{a}	2.50 ± 1.53^{a}	1.30 ± 0.42^{a}	**1.92**
	CD (cm)	0.23 ± 0.08^{a}	0.20 ± 0.08^{a}	0.25 ± 0.24^{a}	0.13 ± 0.05^{a}	**0.20**

NB.: means with the same alphabet as superscripts under each row are not significantly different; CD - collar diameter

Table 7 presents linear relationships (models) among *P. mildbraedii*'s growth parameters. The most suitable seedling height prediction equation is of the form: *Ht = 7.77 + 6.25CD - 0.0517LA + 0.373LN* (R^2 = 0.59; RMSE = 1.679). The best collar diameter model (model 6) is of the form: *CD = 0.258 + 0.0765Ht* (R^2 = 0.51; RMSE = 0.192). The result further showed that there was neither suitable model for leaf area prediction nor leaf number, going by their very low modeling efficiencies (R^2). However, all the models presented were significant ($P < 0.05$) as shown in

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Table 12. Table 13 present the result for the validations of the presented models. All the models presented have low bias values, and there were no significant differences in the mean observed and predicted values for the dependent variables (P > 0.05) in all cases (Table 8).

Table 7: Linear relationships among *P. mildbraedii* growth parameters in 5 months after germination

SN	Model	R^2	RMSE	P
1	Ht = 8.70 + 6.67CD	0.51	1.795	0.000
2	Ht = 17.5 + 0.137LA	0.07	2.475	0.065
3	Ht = 16.9 + 0.524LN	0.24	2.231	0.000
4	Ht = 7.77 + 6.25CD - 0.0517LA + 0.373LN	0.59	1.679	0.000
5	Ht = 9.18 + 7.18CD - 0.0508LA	0.51	1.821	0.000
6	CD = 0.258 + 0.0765Ht	0.51	0.192	0.000
7	CD = 1.15 + 0.0261LA	0.24	0.237	0.000
8	CD = 1.53 + 0.0432LN	0.14	0.254	0.008
9	LA = 13.6 + 11.3CD - 0.305Ht	0.25	4.460	0.002

NB.: a = 0.05; R^2= coefficient of determination; RMSE = root mean square error; CD = collar diameter; Ht = height; LA = leaf area; LN = leaf number

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Table 8: Model validation results

SN	Model	Obs.	Pred.	Bias	t	P
1	Ht = 8.70 + 6.67CD	21.29	21.29	0.00	0.01	0.99
2	Ht = 17.5 + 0.137LA	21.29	21.32	-0.03	0.06	0.96
3	Ht = 16.9 + 0.524LN	21.29	21.29	0.00	0.01	0.99
4	Ht = 7.77 + 6.25CD - 0.0517LA + 0.373LN	21.29	21.25	0.04	0.09	0.93
5	Ht = 9.18 + 7.18CD - 0.0508LA	21.29	21.32	-0.03	0.05	0.96
6	CD = 0.258 + 0.0765Ht	1.89	1.89	0.00	0.01	0.99
7	CD = 1.15 + 0.0261LA	1.89	1.88	0.01	0.23	0.82
8	CD = 1.53 + 0.0432LN	1.89	1.89	0.00	0.10	0.92
9	LA = 13.6 + 11.3CD - 0.305Ht	28.44	28.43	0.01	0.01	0.99

NB.: CD = collar diameter; Ht = height; LA = leaf area; LN = leaf number

Generally, *P. mildbraedii* seeds have very high germination percentage going by the result of this study. Among the three sowing media, sawdust was relatively the best. The higher germination rate recorded under sawdust may be due to the fact that organic matter and organic carbon was higher in sawdust (of *Garcinia kola*) and less topsoil and river-sand. Higher concentration of organic carbon in sawdust has been noted by Okoli *et al.* (2015) compared to other sowing media, though not of identified tree species. This is in consonance with the study by Omokhua *et al*. (2015), who reported highest germination percentage for *Terminalia ivorensis* in sawdust. The result however disagrees with the work of Dickens (2011), who recorded apparent high germination percentage of *Irvingia wombulu* in river-sand. The difference may be as a result of uniqueness of the respective plants studied, just as the seeds of *Irvingia* and *P. mildbraedii* differ in physiological and biochemical properties and growth responses and requirements. It was

observed during the study that the leaves of the plant were attacked by a species of pest *Achatina fulica*, two weeks after seedling emergence by feeding on the leaves, thereby casing defoliation. This may be due to the fact that the leaves are edible and of course very succulent at that tender age. However, the application of table salt (NaCl) around the seedlings as a control measure proved very effective in preventing further attacks by decimating the advancing pest.

All the manures applied improved the growth of *P. milbraedii* seedlings in one way or the other as all the measured parameters were greater with marked differences under the three fertilizer treatments (poultry droppings, cow dung and NPK), but to different extents, compared to that of the control, having zero-fertilizer inclusion. This is in line with the findings of Adeyemi *et al*. (2016), who noted positive effects of different manures on *Garcinia kola* seedlings were greater than the control. Among all the fertilizers applied, poultry dropping was the most positively impactful as it produced the highest mean effects on growth of *P. mildbraedii* seedlings. This may be due to the fact that the manure had the highest rate of mineralization and assimilation than others, thereby quickening the nutrient uptake in plants, resulting in speedy development. For instance, poultry droppings improved seedling height growth by 2.50 cm, 1.75 cm and 1.2 cm in river-sand, sawdust and topsoil, respectively compared to zero-fertilizer application (control) in eight weeks. This result corroborates the work of Mahantappa *et al*., (2011), who noted significantly maximum seedling growth in poultry manure compared to other eleven different fertilizer treatments tried on *Pterocarpus santalinus*.

Collar diameter is good predictors of height. Although some other parameters have predictive ability to estimate height growth, their contributions to explaining the seedling height growths are inadequate to serve as single predictors. Most of the developed models were good going by their modeling efficiency and small RMSE and bias values. A low value of RMSE is an indication of good fit and suggests a good predictive ability of such models (Adekunle *et al*., 2004). The result further showed that there was neither suitable model for leaf area prediction nor number of leaves. This disagrees with the works of Zhang and Pan (2011), Pompelli *et al*., (2012) and Souza and Habermann (2014), who independently recorded suitable models for

predicting leaf area. This could be due to the fact of species growth variations, or higher maturity of the species in question than those considered in the current study.

The model validation result, which involved testing the developed models and comparing the results with the real (observed) data, revealed that there were no significant differences in mean observed and the predicted values. This is in line with the works of Dau and Chenge (2016), Adeyemi and Ugo-mbonu (2017), who noted that observed data were not significantly different from that predicted values for the dependent variables.

Conclusion

The result of this study has shown that sawdust (of *Garcinia kola*) was the best for propagating *Pterocarpus mildbraedii* seeds, going by the results of this study as reflected in growth parameters measured. In general, seeds of *P. mildbraedii* germinated within a short period of time, between 3 to 17 days after propagation. The early seedling emergence is probably due to the fact that the seeds were removed from the pods before sowing. With regards to fertilizer application, fertilization significantly improved *P. mildbraedii* seedling growth and development with poultry droppings producing the highest net growth effects. There was no die-back after fertilization, implying that none of the manures applied had negative effects on the seedlings. Hence, poultry manure is recommended for future propagation of the species, and for other species having similar growth attributes and responses. Most of the developed growth models were good going by their modeling efficiencies and small bias values. However, only $Ht = 7.77 + 6.25CD - 0.0517LA + 0.373LN$ and $CD = 0.258 + 0.0765Ht$ were tested suitable for *P. mildbraedii* seedling height and diameter predictions.

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