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Evaluation of *Pentaclethra macrophylla* (Benth.) early development from seed under different growth conditions

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Abstract

This study investigated the effects of different sowing media on *Pentaclethra macrophylla* (Benth.) seedlings growth. The study was laid out in 3×3 factorial experiment in a completely randomized design (CRD) with sowing medium and watering regime as the two factors. The three sowing media used were sterilized river-sand, topsoil and a mixture of both. The watering regimes were: early morning, twice daily (i.e. morning and evening) and evening. Twelve trays were assigned to each treatment (sowing medium) making 36 trays for the experiment. Eight seeds were sown in each of the trays. Number of seedlings that germinated from each germination tray was recorded. After five weeks of germination, seedling height, collar diameter, leaf area and leaf number were measured and counted on each of the seedlings. Data were analyzed using ANOVA (i.e. factorial experiment). The highest seedling emergence of 28.1% was obtained under the mixture of sterilized river-sand and topsoil. This was followed by the 27.1% in sterilized river-sand. The least germination percentage (17.7%) was recorded in topsoil. The result revealed that watering in the evening was the best for the propagation of *P. macrophylla*. There were significant variations among the mean seedling heights, collar diameters, leaf areas and leaf numbers under different sowing media and watering regimes ($P<0.05$). The interaction effects of sowing media and watering regimes on seedling mean heights, collar diameters, leaf areas and leaf number were also significant ($P<0.05$). The follow-up test results further showed that sterilized river-sand supported the best growth with the highest mean value of 18.8±2.7cm in seedling height, 22.6±4.2 cm^2 in leaf area and 1.84±0.6 cm in collar diameter. Watering in the evening yielded the best result with means of 15.7±1.3 cm, 22±4and 22.7±3.6cm^2 in seedling height, leaf number and leaf area respectively.

Keywords: *Emergence, seedling growth, sowing media, watering regime, performance*

Introduction

The rapid rate of forest loss and degradation across the tropics has continued to increase the fragmentation of many plant populations, and poses risk of species extinction. In Nigeria, as elsewhere, conservation of forest genetic resources is achieved through the protection of these resources in their natural habitat (*in situ*) or preservation of samples of the genetic diversity of endangered species away from their field habitat (*ex situ*) in facilities such as botanical

gardens, seed gene-banks, *in-vitro* gene-banks and field gene-banks (Owonubi and Otegbeye, 2004).

Pentaclethra macrophylla is a tropical tree with various uses. It is dehiscent and its habitat is usually the fore-stand border regions of savanna and forest (Keay, 1989). The tree is generally referred to as 'oil bean' tree. It is called *Apara apagha* (Yoruba), *Okpaghan* (Urhobo), *Okpagha* (Bini), *Ugba* (Igbo) and *Ugbe* (Esan) by the different ethnic groups in Nigeria (Keay, 1989). The parts used for medicinal purposes are leaves, bark and root. The main phyto-chemical constituents are saponin, tannin and paucine. The leaves are boiled with *Piper guineense* and a glass-full of wine and given twice daily for the treatment of fever, stomach-ache and it has been used as healing lotion for sores (Gill, 1992).

The seeds are of great delicacy in eastern Nigeria. It is prepared and eaten with stock fish. If domesticated, a large plantation of it can provide source of raw materials to support canned food industry. The flowers produced by this plant are attractive to bees (Paul, 2007). The species has been recommended for planting to increase honey production. The plant, when burnt gives off unpleasant smell, good charcoal and the ash from the seed pods is used as cooking salt. The seed also has up to 30-36% oil, which is rich in protein, suitable for soap and candle making (Paul, 2007).
The species usually grows in an elevation of 0-500 m in forest, in well-drained soils, and an annual rainfall of about 1500-2700 mm. It is distributed usually in West Africa from Angola to Senegal (Keay, 1989). The flowering period is January to May. The fruits (pods) are very persistent, 35-45 cm long, hard and woody, splitting open explosively and curling up, containing 8 (always 8?) flat glossy-brown seeds up to 7 cm long. The tree grows up to 21 m high with a girth of about 6 m, branching down and forming spreading crown. It is usually crooked with wide buttresses. The stem bark is grayish to dark-reddish brown, flaking off in irregular patches.

Pentaclethra. macrophylla is a popular food delicacy in Nigeria especially among Igbo ethnic group. It is rich in protein, which is obtained by a solid state fermentation of the seed (Enujiugha and Akanbi, 2005). It is an essential food item for various traditional ceremonies, where it is mixed with slices of boiled stock fish (*Ugba* and *Okporoko*). The natural fermentation of the seed, which at present is still done at the household level, renders the production nutritious, palatable and non-toxic (Enujiugha and Akanbi, 2005). Its production, like many African fermented foods, depends entirely on mixed fermentation by microorganisms from diverse sources.

Despite the socio-economic relevance of *P. macrophylla,* there is hardly any plantation of it, particularly in Imo State. Larger percentage of its collection still comes from the wild. If this trend continues, the values of the plant may be lost, considering the current rate of deforestation in Nigeria, wild forest fires and uncontrolled forest exploitation, among many ills. The only possible way to save this important endemic tropical tree species from possible extinction is through domestication as a very important species in the southern Nigeria for its contribution to household food security as well as medicinal values. It is a well-classified species in the eastern Nigeria as it is popularly known as *Ugba* among the Igbo-speaking people. However, most of its (seeds) extractions are done, uncontrollably, in the wild. Although literature is replete with history and theory of its growth conditions in other parts of the world (some of these should be cited), no practical cases or documentation exists on its

propagation in eastern Nigeria. As such, we are ignorant of its regeneration success. Moreover, the optimum conditions for its emergence and growth in this part of the country have not been verified. Therefore, this study evaluated seedling emergence of *P. macrophylla* under different growing conditions with a view to selecting the best medium for subsequent propagation(s).

Materials and Methods

The study was carried out at the nursery site of the Department of Forestry and Wildlife Technology, Federal University of Technology, Owerri, in south-eastern Nigeria. Three hundred (300) seeds of *P. macrophylla* were collected from matured mother trees of the species at *Mbano* village, a suburb of Imo State. The collected seed pods were broken and the seeds extracted and kept under ambient temperature condition for two days. The decarped seeds were subjected to viability test through the floatation method, in which case the seeds that floated in water after 24 hours of soaking were considered not-viable and discarded. A total of 36 germination trays were used for the germination experiment.

Topsoil was obtained from an exposed land in the botanical garden of the department of Forestry and Wildlife Technology from a portion not greater than fifteen centimeters (15cm) depth from the soil surface. River-sand was obtained from the *Otamwiri* River at the Federal University of Technology, Owerri. This river-sand was then sterilized by frying under extreme heat supply to remove organic matters.

The study was laid out in 3×3 factorial experiment in a Completely Randomized Design (CRD) with 12 replications. The treatments were three sowing media (top soil, river-sand and sterilized river-sand and topsoil) and 3 watering regimes, (morning, afternoon and evening). Twelve (12) germination trays each were assigned to the three sowing media and with the three levels of watering regimes. Eight (8) seeds were sown in each of the trays totaling sixty-four (64) seeds per treatment.

Data Collection and Analysis

The number of seedlings germinated in each of the sowing media was recorded noting the date of the first seedling emergence. The number of leaves was determined by counting. The plant height was measured with a meter ruler at the distance from the soil level to terminal bud while the leaf area was determined using leaf area meter. Collar diameter was measured using a veneer caliper on the last day of the experiment (on the 8^{th} week). The date of first seedling emergence was also noted. Data collected were subjected to Descriptive statistics such as frequency and percentage and Analysis of Variance (ANOVA) was also used to determine the effect of treatments on the parameters.

Results

The highest seedling emergence percentage of 28.13% was recorded for the mixture of sterilized river-sand and topsoil. This was followed by the 27.08% germination recorded under sterilized river-sand. The lowest seedling emergence percentage of 17.71% was obtained for the topsoil (Table 1).

Table 1. Germination rates under different sowing media

Medium	Seed sown	Number of emerged seeds	% seedling

			emergence
River-sand	96	26	27.08
Topsoil	96	17	17.71
Mixture of both	96	27	28.13

The result of ANOVA (3 × 3 factorial experiment) for seedling height growth under different sowing media and watering regimes is presented in Table 2. The result revealed that there were significant differences among the mean seedling height growths under different sowing media and watering regimes ($P < 0.05$). Similarly, the effect of interaction between sowing medium and the watering regime was significant ($P < 0.05$). The effects of the two factors (sowing medium and watering regime) were significant on leaf numbers ($P < 0.05$). Also, the interaction between the two factors was significant ($P < 0.05$). Similarly, the effects of the two factors as well as their interaction were significant were significant on collar diameters ($P < 0.05$). The result further revealed that there were significant differences among the mean leaf areas under different sowing media and watering regimes ($P < 0.05$). The interaction effect of the two factors was also significant on the leaf areas ($P < 0.05$) (Table 2).

Table 2. ANOVA table for seedling growth parameters in different sowing media and watering regimes

Parameter	SV	df	SS	MS	F	P-value
Height	Sowing medium	2	681.8	340.9	17.942	0.000
	Watering regime	2	230.7	115.4	6.074	0.003
	Interaction	4	314.7	78.7	4.142	0.017
	Error	27	514.0	19.0		
Leaf number	Sowing medium	2	330.3	165.1	6.5	0.010
	Watering regime	2	1173.5	586.7	23.098	0.000
	Interaction	4	684.0	171.0	6.732	0.025
	Error	27	686.2	25.4		
Collar diameter	Sowing medium	2	4.771	2.386	18.787	0.000
	Watering regime	2	2.379	1.190	9.370	0.000
	Interaction	4	4.176	1.044	8.220	0.011
	Error	27	3.419	0.127		
Leaf area	Sowing medium	2	1001.5	500.8	22.062	0.000
	Watering regime	2	448.0	224.0	9.868	0.000
	Interaction	4	719.8	180.0	7.930	0.000
	Error	27	612.3	22.7		

$\alpha = 0.05$

The results of mean separations (LSD tests) for the seedling growth parameters under different sowing media are shown in Table 3. The seedling raised with sterilized river-sand had highest mean seedling height of 18.8 ± 2.7 cm. The least mean height growth of 8.5 ± 1.0 cm was obtained in topsoil. The mean seedling height growth in river-sand was significantly different from the value recorded for topsoil as well as the mixture of river-sand and topsoil. However, there was no significant difference in the mean height values recorded in topsoil and the mixture.

With respect to the leaf number, the mixture produced seedlings with highest mean value of about 16 ± 3 leaves per plant. The seedlings raised in topsoil produced the least number of

leaves with a mean of about 10 ± 3 leaves per plant. The result further revealed that there was a significant difference between the mean leaf numbers under river-sand and topsoil. In the same vein, a significant difference existed between seedlings raised with topsoil and the mixture of river-sand and topsoil. However, there was no significant difference in the mean leaf number produced by plants raised with river-sand and the mixture.

The result revealed that seedlings raised with river-sand had highest mean leaf area of 22.6 ± 4.2 cm^2. The seedlings grown under topsoil recorded the lowest mean leaf area of 10.4 ± 2.1cm^2. There was no significant difference between the mean leaf area values of the seedlings raised under river-sand and the mixture. However, the mean seedling leaf area value recorded under topsoil significantly differed from those of river-sand and the mixture. With respect to the collar diameter, the result revealed that there were significant differences among the mean seedling collar diameters under different sowing media. The highest mean collar diameter of 1.84 ± 0.6 cm was recorded for seedlings in river-sand. With the least of 0.95 ± 0.4cm recorded for topsoil.

Table 3. Seedling growth parameters under different sowing media

Sowing media	Mean ± SD			
	Height (cm)	**Leaf number**	**Leaf area (cm^2)**	**Collar diameter (cm)**
River-sand	18.8 ± 2.7^a	15.7 ± 1.3^a	22.6 ± 4.2^a	1.84 ± 0.6^a
Top soil	8.5 ± 1.0^b	9.7 ± 2.5^b	10.4 ± 2.1^b	0.95 ± 0.4^b
Mixture of both	11.4 ± 0.9^b	16.4 ± 3.2^a	20.3 ± 2.0^a	1.39 ± 0.6^c
$LSD_{0.05}$	**3.648**	**4.218**	**3.987**	**0.296**

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

Table 4 presents the seedling growth parameters under different watering regimes. The result revealed that there was no significant difference in the mean height values of seedlings that received water in the morning and those watered twice daily (morning and evening). Nevertheless, a significant variation existed between those watered in the morning and evening and those watered only in the evening. The seedlings that were watered only in the evening produced the highest seedling height of 15.7 ± 3.3cm. The least height (9.6 ± 1.3 cm) was obtained from the seedlings watered twice daily (i.e. morning and evening).

For the mean leaf number, the result showed that those watered only in the evening produced plant with the highest leaf number of 22 ± 4 leaves per plant. The trays that received water only in the morning and twice daily (morning and evening) produced seedlings with leaf number of about 10 ± 1 leaves per plant. The LSD result revealed that there was no significant difference in mean leaf numbers between those watered in the morning and those watered twice daily. However, significant differences existed between those watered only in the morning and those watered in the evening, as well as between those watered twice daily and those that received water only in the evening.

The result for the leaf area showed that there was no significant difference between the seedlings watered in the morning and those that received water twice daily (morning and evening). However, there was a significant difference in leaf areas between seedlings watered in the morning and those watered in the evening. Similarly, the plants watered twice daily (morning and evening) and those that received water only in the evening significantly differed. The trays watered only in the evening produced seedlings with highest leaf area of

22.7 ± 3.6 cm^2 with the least mean leaf area of 14.7 ± 2.6 cm^2 recorded under seedlings watered only in the morning.

With respect to collar diameter, the result revealed that there was a significant difference in mean collar diameters of plants grown in trays that received water in the morning and those that were watered twice daily. However, the seedlings raised in trays that received water in the morning and those that were watered only in the evening did not differ significantly. Similarly, the trays watered twice daily and those watered only in the evening did not produce significantly different mean values. The highest collar diameter value of 1.70 ± 0.7 cm was recorded under the trays that received water only in the morning, and the least collar diameter of 1.07 ± 0.4cm was recorded in plants grown under trays watered twice daily.

Table 4. Seedling growth parameters under different watering regimes

Watering regime	Mean ± SD			
	Height (cm)	**Leaf number**	**Leaf area (cm^2)**	**Collar diameter (cm)**
Morning	13.5 ± 2.8^{abc}	10 ± 2^{a}	14.7 ± 2.6^{a}	1.70 ± 0.7^{ac}
Morning and Evening	9.6 ± 1.3^{b}	10 ± 1^{a}	15.9 ± 3.1^{a}	1.07 ± 0.4^{b}
Evening	15.7 ± 3.3^{c}	22 ± 4^{b}	22.7 ± 3.6^{b}	1.42 ± 0.4^{bc}
$LSD_{0.05}$	**ns**	**7.306**	**6.906**	**ns**

N.B.: Means with the same alphabet as superscripts are not significantly different from each other in each column; ns – not significant

Discussion

The highest emergence rate recorded in the mixture of topsoil and river sand may be due to the fact that some soil conditions such as air passages, nutrients and microbial activities, play supportive roles in the germination of the species. This corroborates the findings of Agboola and Etejere (1991), who noted that soil conditions, probably moisture, pH, nutrients and microbial activities play supportive role in germination of tropical forest trees. However, in the contrary, Okunomo *et al.* (2004) reported that highest germination percentage was recorded under topsoil for *Dacryodes edulis* and *Persea americana seeds* respectively, citing the presence of adequate nutrients for germination and growth in topsoil. With regards to the watering regimes, evening appeared to be the best for *P. macrophylla*, probably because the available water contents of the different media has varied effects on the germinability of the seeds with optimal utility in the evening hours. This is in agreement with the work of Keever and Cobb (1985) and Beeson (1992), who independently stated that plant growth can be increased significantly if irrigation is applied in the evening. In general, plants irrigated in the evening produced the heaviest plants with the greatest water utilization efficiency. The previous studies suggest that presumably sufficient daily irrigation to be applied only during early morning hours, growth would be significantly reduced compared to plants irrigated later in the evening. The relatively high temperature experienced in the day time causes the soil to lose water as a result of the evapo-transpiration of the soil water. This could be the reason for the lower yield recorded from seedlings watered in the morning compared to the higher yield recorded in seedlings watered in the evening. The effect of temperature has been attested to by Tisdale and Nelson (1975), who noted that temperature directly affects the plants functions of photosynthesis, respiration, cell wall permeability, absorption of water and nutrients transpiration, enzyme activity and protein coagulation.

It could be suggested that the best sowing medium for the propagation of *P. macrophylla* is sterilized river-sand as this significantly favoured the seedling height, leaf area and collar diameter growths. Watering of *Pentaclethra macrophylla* seedlings in the evening had better growth performance. This is in line with the report of Ikojo *et al.* (2005) on *Brachystegia eurycoma* seedlings by. The reduced rate of evaporation of soil water experienced in the evening also helped in the performance of the seedlings watered in the evening. The seedlings were able to obtain more moisture and soil nutrients, which might have aided seedling development.

Seedlings watered twice daily yielded the smallest seedling height, leaf number, leaf area and collar diameter. Increased efforts to prevent drought stress may lead to excessive irrigation. This was observed in the seedlings watered both in the morning and evening. The results were poor compared to those watered either in the morning or late in the evening. Topsoil has a high water-retention properties and do not drain quickly when compared to the other sowing media used in this study. This result agreed with the findings of Sakio (2005), that flooding reduces the total dry weight increment in some plant species. In flooding condition, available oxygen in the soil is usually low thus, limiting nutrient absorption for species not adapted to this condition. According Predick *et al.* (2009), growth of flood-intolerant species is often depressed in flooding condition. *Pentaclethra macrophylla* may not be a choice species for planting in flooded areas as seedlings in this study were observed to be stunted and number of leaves and leaf expansion were very poor. This is in line with the findings of Kozlowski (1997). This response might have reflected the species habitat and growth pattern as suggested by Sakio (2005). Topsoil receiving the same watering regime as sterilized river-sand and a mixture of topsoil and river- sand, is more flooded as a result of the high water retaining capacity of the soil.

Conclusion

This study has shown that the sterilized river-sand exhibited superior performance over the two other sowing media in terms of *P. macrophylla* seedling growth parameters studied. The species performed better when watered once daily, preferably in the evening (6:30 pm) and it exhibits poor growth in excessive watering conditions at the early stage of development. This reflects the capability of this species to cope with drought stress.

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