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RESEARCH ARTICLES

Evaluation of Growth Performance of African Rose Wood Seedlings on Different Soil in Kaduna Northern Guinea Savanna Eco-Zone Nigeria

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ABSTRACT

Limited empirical studies have examined the nexus between soil properties survival and growth performance of *Pterocarpus erinaceous* under different soil and environmental conditions; this knowledge is however critical for the successful establishment of African rosewood plantations and general ecological balances in the forest ecosystem. Preliminary study was carried out on the growth performance of *Pterocarpus erinaceous* seedlings on different soil sources at the nursery of the Savanna Forestry Research Station situated in the Institute for Agricultural Research (I.A.R) farm Samaru, Kurumi Bomu village. Farm land soil were collected from Institute of Agricultural Research (I.A.R) farm Samaru at Kurumi Bomu village while forest soil and granulated iron stone soil were gotten within the Savanna Forest Research Station, plantations. The seedlings of four (4) weeks were gotten from Savanna Forest Research Station, and transplanted into these soil samples; replicated eight (8) times and readings were taken forth nightly for three (3) months. The experiment was laid using Complete Randomized Design method. Growth data were collected forth nightly and was subjected to Analysis of Variance (ANOVA) and Duncan Multiple Range Test. Result shows that there is significant ($P \leq 0.05$) difference in the height, stem diameter and number of leaf among the three (3) soil for the growth assessment. The growth rate recorded from the farm land soil is statistical higher ($P \leq 0.05$) in leaf width, plant height and stem diameter than the other two (2) soil while the growth parameters assessed are significantly lower ($P \leq 0.05$) in iron stone soil and Forest soil. It is recommended that soil from the farmland is the most suitable for raising and nurturing of *Pterocarpus erinaceous* in the nursery without additional of any plant nutrient media.

Key Words: Eco-zone, Guinea, nursery, plantation, Savanna, seedlings, soil

INTRODUCTION

African rosewood (*Pterocarpus erinaceous* Poir.) is a medium-size deciduous tree belonging to the Fabaceae family (Rabiou *et al.,* 2015; Obiri *et al.,* 2022). It is native to the semi-arid Guinneo-Sudano-Sahelian Forest zones of West Africa with presence in about 8 countries within the West African sub region due to its ability to thrive in a varied range of environmental conditions (Kossi *et al.,* 2019; Biaou *et al.,* 2023). Its superior wood qualities make it one of the most valuable and preferred timber species for the manufacture of valuable artifacts in Asia; China in particular stemming a rapidly increasing demand for its wood (Rabiou *et al.,* 2015;Anthionio & Antwi–Boasiako,2023). It has therefore emerged to become one of the most heavily traded tropical hardwood species on international markets and a major source of revenue and foreign exchange for many West African economies. The fruits, which take four months to mature, are disc-shaped, flat, and have winged margins. It is also central woody corky bulge containing several seeds. Unlike most legumes, *Pterocarpus erinaceous* fruit is indehiscent and is dispersed by wind. It also floats in water and can be water dispersed, Orwa *et al.,* (2009). Poor soil, multipurpose uses, exploitation without limit and lack of scientific knowledge on the suitable propagation methods and soil types is important regarding the increasing commercialization of their derivatives, added to an ineffective forest ecosystem management constitute one of the major cause of the decline of its population. The species population are mostly old and the transition from small size class to higher is low (Leakey, 1998). Apart from its contributions to national economies, *Pterocarpus erinaceous* provides many socioeconomic and cultural benefits to local communities who exploit it for timber and non - timber products (Rabiou *et al.,* 2015; Adjonou *et al.,* 2020; Obiri *et al.,* 2022;Biaou *et al.,*2023). However, despite its significant socioeconomic importance, recent rises in global demand and commercial value for its wood contributed to increased exploitation and consistent increase in its international trade (Dumenu & Bandoh, 2016; Johnson *et al.,* 2020). West Africa is currently the largest producer and supplier of African rosewood globally with large volumes of the exported timber sourced from illegal sources (Anthionio & Antwi – Boasiako, 2023). According to Dumenu & Bandoh (2016) African rosewood supply from Africa to China experienced a 700% increase since 2010. Kossi *et al.* (2019) also, reported that the West Africa region produced about 80% of the total volume of African rosewood exported to China in 2016. This high pressure exerted on the populations of *Pterocarpus erinaceous* makes it one of the most exploited, heavily traded, and threatened tropical hardwood species globally

(Rabiou *et al.,* 2015; Adjonou *et al.,* 2020) These anthropogenic pressures in addition to the eminent threat of climate change raise concerns on the sustainability of African rosewood in many African countries where climate impacts are very prominent (Biaou *et al.,* 2023; Adjonou *et al.,* 2020; Imarhiagbe *et al.,* 2022).The present trend of *Pterocarpus erinaceous* exploitation and global trade has raised serious concerns about its sustainability with many advocating the need to adopt appropriate measures to protect the species from the eminent threat of anthropogenic disturbance (Dumenu & Bandoh, 2016; Adji *et al.,* 2021). These advocacies have influenced major trading countries in West Africa to impose harvesting and export bans in recent years (Dumenu & Bandoh, 2016; Adjonou *et al.,* 2020; Adji *et al.,* 2021; Christine *et al.,* 2021). Conservation efforts for the species have ranged from the imposition of intermittent harvesting and export bans, restoration of natural stands, plantation establishment, and adsorption of export quotas, community sensitization, and imposition of minimum felling limits in many West African countries. (Kossi *et al.,* 2019; Dumenu & Bandoh, 2016). This was followed by the registration and enlistment of the species in Annex II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and change of conservation status to globally endangered on the red list of the International Union for Conservation of Nature (IUCN) (Dumenu & Bandoh, 2016). Anthionio & Antw –Boasiako (2023) however, argued that despite these challenges, the current commercial value of *Pterocarpus erinaceous* presents a huge prospect for economic transformation and livelihood improvement under appropriate conservation strategies in many African countries whose economies are largely natural resources dependent. It also has the potential for ecological balances in the fragile savanna ecosystems despite the imminent threats of climate change (Dumenu & Bandoh, 2016; Adji *et al.,* 2021; Obiri *et al.,* 2022;Biaou *et al.,*2023) There is therefore an urgent need to develop strategies for the sustainable management of this species. In response to these calls, many have recognized population restoration through the establishment of African rosewood plantations as a strategic measure to restore the rapidly declining population and ensure the sustainable management of the species (Adji *et al.,* 2021). However, many authors have argued that the success of these interventions requires an in-depth understanding of the species biology, ecology, survival, and growth performance (Biaou *et al.,*2023) Also, species-site matching has been widely recognized to be crucial for tree survival, growth, and general success of reforestation program (Adjonou *et al.,* 2020; Dimobe *et al.,* 2022). However, limited empirical studies have examined the nexus between soil properties and survival; and growth performance of *Pterocarpus erinaceous* under different environmental conditions (Ansah *et al.,* 2023) this knowledge is

however critical for the successful establishment of African rosewood plantations and general ecological balances in the forest ecosystem. Despite its importance, there is limited supply of *Pterocarpus erinaceous* to meet the demand of the people. Therefore, there is need for large scale production of *Pterocarpus erinaceous* on a most suitable soil source. The objective of the study is to evaluate the growth performance of *Pterocarpus erinaceous* on different soil sources.

MATERIALS AND METHODS

Study area

The study was conducted in Savanna Forestry Research Station nursery situated in the Institute for Agricultural Research (I.A.R) farm Samaru in Kurumi Bomu village. Located at Latitude 12°13'and 11°11'N / Longitude 8°39' and 7°38' E and 686m above sea level (Figure 1). It is located in Sabon – Gari Local Government Area of Kaduna State. The vegetation in the local Government Area is the Northern Guinea Savannah woodland type, characterized by short scattered drought resistant trees with undergrowth of grass that serves as fuel for bushfires in the long dry season with mean annual rainfall of 1000mm – 1500mm, temperature of 25.6°C (78.1°F), precipitation of 1,117.6mm and humidity of 69% respectively (Sodimu *et al.,* 2021)

Treatments and experimental design

The experiment consisted of three (3) soil types namely: Forest soil, Iron stone soil and farm land soil. That was laid in a Completely Randomized Design (CRD) method and each treatment was replicated eight (8) times. The forest soil were collected from Savanna Forest Research Station, plantation; Farmland soil were collected from Institute of Agricultural Research (I.A.R) farm Samaru at Kurumi Bomu village while the Granulated iron stone were collected from Savanna Forest Research Station, plantation.

Soil sample collection

The two (2) soil samples (farmland and forest soils) were collected using soil auger at 10cm depth while the iron stone soil was collected and grinded with a mortar to fine particles, then each soil samples were thoroughly mixed together to form a uniform sample10g of each soil were packed and labelled for laboratory analysis and the rest are then filled into polythene pots to commence the experiment. The seedlings of four (4) weeks were gotten from Savanna Forest

Research Station, and transplanted into these soil samples and readings were taken forth nightly for three (3) months.

Growth data parameters assessment

The growth data parameters were taken forth nightly for three (3) months. The height (cm) of the plant was assessed, measuring from the base of the plant to the apex. The average was computed and recorded; the number of leaves was counted, computed and recorded; the stem of the plant was assessed using a veneer caliper and was recorded. The number of the nodes were counted and then recorded. However, at the end of the terminal experiment, the plant was up rooted, the number of the longest root as well as the total number of root were counted and recorded.

Soil and statistical analysis

The three (3) soil types collected bulked, packed and labelled separately into white zip locked bag for analysis of its chemical properties at the soil science laboratory of Ahmadu Bello University Zaria, Nigeria. The data collected were analyzed using ANOVA at P≤0.05 probability level and the means with significant difference were separated using Duncan multiple range test (DMRT) at (P≤0.05).

RESULTS AND DISCUSSION

The data recorded for the evaluation of growth performance on *Pterocarpus erinaceous* seedlings for three (3) months on the three (3) different soil sources are presented in the following table below.

Table 1. Influence of soil type on number of leaves of *Pterocarpus erinaceous*

Treatments	2WAP	4WAP	6WAP	8WAP	10WAP	12WAP
Forest Soil	5.00^{ab}	4.38	4.25^{a}	4.25^{a}	4.2.5^{a}	4.25^{a}
Iron stone	4.38^{b}	3.38	3.00^{b}	3.00^{b}	3.00^{b}	3.00^{b}
Farmland soil	5.13^{a}	4.13	4.50^{a}	4.50^{a}	4.50^{a}	4.50^{a}
SE ±	0.23	0.59	0.23	0.23	0.23	0.23

i. *Means in the same column followed by unlike letters are significantly different at P≤0.05 Level of probability using Duncan's Multiple Range Test (DMRT).*

ii. *WAP = Weeks after planting.*

Number of Leaves of *Pterocarpus erinaceous* plant as influenced by different soil sources were significant (P≤0.05) at all the sampling intervals except at 4 weeks after planting. At 2 weeks after planting, farm land soil produced significantly higher number of leaves than all other soil types but statistically comparable to plants grown in forest soil. Least significant number of leaves resulted from plants grown in iron stone soil. At 6 to 12 weeks after planting, forest soil and farm land soil maintained consistent significantly (P≤0.05) higher number of leaves than iron stone soil. This observation is in consonance with the work of (Sodimu, 1998;Usharani *et al.,* 2019) that Farm land soil are good soil media source for nurturing *Pterocarpus erinaceous* seedlings.

Table 2. Influence of Soil type on Plant Height of *Pterocarpus erinaceous*

Treatments	2WAP	4WAP	6WAP	8WAP	10WAP	12WAP
Forest Soil	14.02^{a}	14.47^{a}	14.85^{a}	15.42^{a}	15.75^{a}	16.43^{c}
Iron stone	12.44^{b}	12.78^{b}	13.30^{c}	13.80^{c}	14.21^{b}	14.72^{b}
Farmland soil	14.28^{a}	14.64^{a}	15.00^{a}	15.76^{b}	16.24^{ab}	16.43^{a}
SE ±	0.70	0.67	0.65	0.66	0.66	0.67

i. *Means in the same column followed by unlike letters are significantly different at P≤0.05 level of probability using Duncan's Multiple Range Test (DMRT).*

ii. *WAP= Weeks after planting*.

Plant height of *Pterocarpus erinaceous* as influenced by different soil were significant (P≤0.05) higher in farmland soil than other two (2) Soil. The least significant (P≤0.05) growth of *Pterocarpus erinaceous* occur in the iron stone soil (Usharani *et al.,* 2019) reported that *Pterocarpus erinaceous* planted on farmland soil grew better than all other soil types and in contrary to the work of (Sodimu, 1998) that tree height of teak (*Tectona grandis*) planted on granulated iron stone soil does better in height than other soil.

Stem diameter of *Pterocarpus erinaceous* plant in table 3 above shows no significant (P ≥0.05) different at all the sampling interval for all the treatment. At 2 to 8 WAP forest soil and farm land soil maintained consistent significantly higher stem diameter than the iron stone soil. However, at 2 WAP, the iron stone soil was the highest followed by the forest soil while the farmland soil was the lowest. At 12 WAP, the forest soil was the highest at (4.95) followed by the farmland soil at (4.46) and the least was the iron stone soil at (4.41). The above result did not agree with the work of (Sodimu, 1998) that ironstone soil gives better growth of stem diameter of young seedlings.

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Table 3. Influence of soil type on stem diameter of *Pterocarpus erinaceous*

TREATMENT	2WAP	4WAP	6WAP	8WAP	10WAP	12WAP
Forest Soil	2.89[a]	3.30[b]	3.99[b]	4.42[a]	4.81[a]	4.95[a]
Iron stone	2.94[a]	3.09[b]	3.39[b]	3.88[b]	4.28[b]	4.41[b]
Farmland soil	2.70b	2.98[a]	3.43[b]	4.00[b]	4.31[b]	4.46[b]
SE ±	0.12	0.10	0.12	0.12	0.12	0.12

i. *Means in the same column followed by unlike letters are significantly different at P≤0.05 level of probability using Duncan's Multiple Range Test (DMRT).*
ii. WAP= Weeks after planting.

Table 4. Influence of soil type on leaf width of *Pterocarpus erinaceous*

TREATMENT	2WAP	4WAP	LEAVEWIDTH 6WAP	8WAP	10WAP	12WAP
Forest Soil	43.97[b]	62.8[b]	70.02[b]	71.48[b]	79.51[b]	0.00
Iron stone	49.82[a]	58.38[c]	61.44[c]	66.01[c]	69.02[c]	0.00
Farmland soil	45.84[ab]	26.53[a]	87.92[a]	91.90[a]	97.49[a]	0.00
SE ±	2.32	4.66	4.59	4.31	4.25	0.00

i. *Means in the same column followed by unlike letters are significantly different at P≤0.05 level of probability using Duncan's Multiple Range Test (DMRT)*
ii. *ii WAP= Weeks after planting.*

Leaf width of *Pterocarpus erinaceous* plant influenced by different soil were significant (P≤0.05) at all the sampling period from the 2 to the 12 WAP. *Pterocarpus erinaceous* plant on the farm land soil maintained the highest leaf width of the three (3) treatment, next was the plant in the forest soil while the least was the iron stone. These is in agreement with the work of (Usharani *et al.,* 2019) that nutrients composition of farmland soil gives good leave width when compared with other soil.

Table 5. Chemical properties of the soils use in the experiment

Soil	Soil pH	Ca	Mg	N	K	P
Iron stone	5.7	1.50	0.88	1.23	0.87	1.73
Farmland soil	6.0	2.40	1.41	1.05	0.43	8.28
Forest soil	6.35	4.80	2.82	1.58	0.70	2.12

Table 5 shows the chemical properties of the three (3) types of soil used in the experiment, two (2) of the three (3) soil (Farmland soil and Ironstone soil) were

slightly acidic while the forest soil closely neutral. The forest soil had the highest calcium (Ca) content followed by the farmland soil and the iron stone soil was the least, the forest soil had the highest magnesium(Mg) content next was the farmland soil and the least was the iron soil. The iron stone had the highest potassium (K) content followed by the forest soil and the farmland was the least. The farmland soil had the highest phosphorus (P) content followed by the forest soil while the iron stone was the least.

CONCLUSION

It is an evident from the result of this study that significant difference occurs among the three (3) soil in raising of *Pterocarpus erinaceous* in all the parameters assessed. The most suitable soil for the growth performance of *Pterocarpus erinaceous* is farmland soil while the least suitable soil is the granulated iron stone soil. This result implies that farmland soil has the highest nutrient capacity and soil pH for the growth and development of the seedlings. Based on the above results *Pterocarpus erinaceous* can be best raised using farmland soil without additional of any other potting media. Although, the other two (2) soil (granulated iron stone and forest soil) can be used in the absence of farm land soil but additional plant nutrient media like organic or inorganic fertilizers may be needed for optimum growth and development of the plant.

AUTHORS CONTRIBUTIONS

Akintunde Isiaka SODIMU: Investigation; data curation; writing-original draft; software / formal analysis; writing-review part, and editing.
Muhammed Fatima RASHEED: Conceptualization; validation,
David BAYO : Methodology, and editing

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