EFFECT OF PROVENANCE VARIATIONS ON THE GROWTH AND DEVELOPMENT OF *TERMINALIA IVORENSIS (A CHEV)*

Abstract

Indigenous tree species like *Terminalia ivorensis* has multiple uses; from timber products to medicinal condiments for treating different ailments. This species is self-incompatible. Thus, habitat protection is a key to its survival and sustenance. This study evaluated the effect of provenance variations on the growth and development of *T. ivorensis*. Three provenances of *T. ivorensis* were selected; FRIN Arboretum, Onigambari Forest Reserve and J1 Forest Reserve. Thirty (30) seedlings of *T. ivorensis* were selected and marked at each provenance for assessment of growth parameters for a period of twelve weeks. The growth parameters included: seedling height, collar diameter, leaf count and leaf area. Also, soil samples were collected from each provenance to test for nutrient composition. Results showed that J1 Forest Reserve had best performance across the growth parameters assessed with 10.4 cm plant height, 2.02 mm collar diameter, 11 leaves count and 20.5 cm^2 leaf area respectively. This growth parameter result differs significantly from the other two provenances. This was also attributed to the nutrient offered by J1 Forest Reserve with 1.18% and 2.20% of organic carbon and organic matter in the soil respectively. Also, the available phosphorus which is involved in photosynthesis, respiration, energy storage and transfer, cell division and enlargement as well as promotion of root formation was about 15.7mg/kg in the soil and is considered high because it is higher than the critical level of 8.50mg/kg. J1 Forest Reserve is recommended as the best provenance for raising *T. ivorensis* amongst assessed natural habitats.

Keyword: provenance, parameter, terminalia, ivorensis, collar, leave

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Introduction

Terminalia ivorensis belongs to the family combretaceae and it is an important timber species recognized in Nigeria with its various uses. This tree species if protected from logger can attain heights of up to 50 m and girth of 500cm. It has been biologically stated that *T. ivorensis* is self-incompatible; the flowers are bisexual, its selection and breeding started in the 1960s in Africa. Orwa *et al.*, (2009) stated that the trees with superior growth rate and stem form have been selected and clone, banks have been established in this species and the interval between the opening of the leaf buds and flowering is 3-4 weeks where the flowers are fertilized by insects. Fruiting, which begins in December, is abundant from January to March (Orwa *et al*., 2009). It also plays a major role in increasing soil fertility where fall off leaves are decomposed and add more nutrients to the soil (Norgrove and Hauser, 2002); it is widely used for medicinal purposes in Africa (Masoko *et al*., 2005).

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The trees sapling usually requires 4 - 5years before attaining 1-1.5 m height, compared to other indigenous timber species with fast growth. For example, even *T. superba* from the same genus could attain 1.8 m in height within one year (Osei-Begyina, 2007). This species is used for construction and other timber-based uses. It also can be used for reforestation and afforestation species especially where wood-base timber are needed as well as for forest ecosystem replenishment (Jones and Averre, 2000). It occurs naturally in evergreen and moist semi-deciduous forests ecosystem, where large trees are most common in low density localities or lowlands (Ibe *et al*., 2015). It is most abundant in the transition zone between humid semi-deciduous and evergreen forests. It is found in rainforest ecosystem but predominantly it's a tree of seasonal forest zones (Orwa *et al*., 2009). *Terminalia ivorensis* is an emergent in the upper storey of seasonal forest but sometimes loses its vertical growing leader resulting in considerable variation in height of mature trees. Regeneration is often sparse, but locally, secondary forests can be dominated by young trees of *T. ivorensis*.

As one of the principal timber species of West Africa countries, *T. ivorensis* is widely harvested from natural forest and has been introduced into many other tropical countries as a promising timber plantation species. It is also grown as a shade tree in cocoa plantations in Nigeria (Ibe *et al*., 2015). It has been reported that the species is threatened by habitat loss and poor regeneration, and attempts at plantation growth have generally failed through frequent diebacks. The species has also been classified as 'vulnerable' by the IUCN (Ibe *et al*., 2015). Despite these facts, plantation of *T. ivorensis* is still scarce in the country. With so much emphasis today on ecosystem management and maintenance of natural forests, sustainable artificial regeneration of tree species for large-scale plantation development has become expedient to meet up with wood-based need in the country as well as environmental sustenance in a world of climate change effects where oil exploration has led to serious deforestation and degradation of several valuable forest species. However, not much work has been done on *T. ivorensis* in Nigeria. Although, some indigenous tree species like *P. biglobosa* and *T. superb* etc. do not experience much difficulty during germination, but *T. ivorensis* germinate with great difficulty ((Ibe *et al*., 2015).

There is however a dearth of information on the best conditions for the propagation of the species. With deliberate efforts being made by the Nigeria Government to conserve some valuable indigenous tree species both *in-situ* and *ex-situ*, efforts have been made without much success recorded. If germination of this tree species encountered difficulty then alternative knowledge for raising timber species like *T. ivorensis* would go a long way in encouraging its plantation establishment.

Consequently, it is pertinent to ascertain the best provenance of growing *T. ivorensis* to ensure better performance of the species. This study is aimed at assessing the effect of provenance variation on the growth and development of *Terminalia ivorensis*.

Study Area

This study was carried out in three *T. ivorensis* provenances which are: Onigambari Forest Reserve which lies approximately between latitude 7° 7' 60" N and longitude 3° 49' 60" E; Forestry Research Institute of Nigeria (FRIN) Arboretum lies approximately between latitude 7° 23' 28.68" N and longitude 3° 51' 46.08" E; and J1 Forest Reserve lies approximately between latitude 7° 0' 0" N and longitude 4° 15' 0" E respectively. The climatic condition of these three provenances is dominated by rainfall ranging from 1200 mm to 1500 mm annually and average temperature 35°C, and the average relative humidity ranges between 80 – 85 % (FRIN 2018)

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Methods

Ninety uniform seedlings of *T. ivorensis* were identified and marked for measurement of growth performance in a period of 12 weeks (3 months). The uniformity of the seedlings were determined by selecting seedlings with height 8.0 cm, collar diameter of 1.0 mm and 7 leaves count stage. Each seedling was marked and the coordinator of the location recorded with a GPS receiver. Thirty (30) seedlings were selected from each provenance (i.e. Onigambari Forest Reserve, FRIN Arboretum and JI Forest Reserve). Also, soil sample was collected with soil auger at each provenance to determine nutrient composition of the three provenances. Growth parameters (seedling height, collar diameter, leaf count and leaf area) were measured for three months. Seedling height was measured using graduated metric ruler; collar diameter was measured with vernier calliper, leaf count was done visually and leaf area was determined using formula adopted by Clifton-Brown and Jones, (1997).

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Experimental Design and Data Analysis

Randomise Complete Block Design (RCBD) was adopted as experimental design since there are two sources of variations. Variation due to provenance as treatment and growth parameter as block since the objective of the study is to assess effect of provenance variation on the growth and development of *T. ivorensis*. The data collected were analysed with Analysis of Variance (ANOVA)

Results and Discussions

The result from the ninety seedling selected for this study were collated and the mean from each parameter were reported see Table 1 below. J1 Forest Reserve had the highest plant height with 10.4 cm (0.104m), followed by Onigambari Forest Reserve with 9.11 cm (0.901m) and FRIN Arboretum had the least plant height with 8.45 cm (0.805m). Also, the leaf area; 20.5 cm^2 was offered by J1 Forest Reserve, Onigambari Forest Reserve followed closely with 20.2 cm^2 and 19.2 cm^2 was recorded for FRIN Arboretum (see Table 1) for details on collar diameters and leaf count results.

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Table 1: Results of Growth Parameter Grouped as Treatments and Blocks

Treatment/ Block	Onigambari Forest Reserve	FRIN Arboretum	J1 Forest Reserve
I. Plant height (cm)	9.11	8.45	10.4
II. Collar diameter (mm)	1.14	1.93	2.02
III. Leaf count (visual)	10	9	11
IV. Leaf Area (cm^2)	20.2	19.2	20.5

There were significant differences among the different provenances @ $P > 0.05$ (i.e. Onigambari Forest Reserve, FRIN Arboretum and J1 Forest Reserve) as well as the growth parameters (plant height, collar diameter, leaf count and leaf area) as adopted for this study see Table 2 below for details.

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Table 2: Tests of Between-Subjects Effects (ANOVA Table)

Dependent Variable: Data

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	509.172[a]	5	101.834	361.154	.000
Intercept	1259.725	1	1259.725	4467.595	.000
Provenance	3.671	2	1.836	6.510	.031
G. parameter	505.501	3	168.500	597.584	.000
Error	1.692	6	.282		
Total	1770.590	12			
Corrected Total	510.864	11			

a. R Squared = .997 (Adjusted R Squared = .994)

The mean of the different provenances (treatments) were separated using Least Significant Difference (LSD). The result showed that there were significant differences between the means ($P > 0.05$). J1 Forest Reserve mean differed significantly from both FRIN Arboretum and Onigambari Forest Reserve. Although, FRIN Arboretum and Onigambari Forest Reserve means were not significantly different from each other ($P > 0.05$) (see Table 3) below for details.

Table 3: Least Significant Differences (Multiple Comparisons)

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
FRIN Arbo	JI FR	-1.3350*	.37548	.012	-2.2538	-.4162
	Onigambari	-.4675	.37548	.260	-1.3863	.4513
JI FR	FRIN Arbo	1.3350*	.37548	.012	.4162	2.2538
	Onigambari	.8675	.37548	.060	-.0513	1.7863
Onigambari	FRIN Arbo	.4675	.37548	.260	-.4513	1.3863
	JI FR	-.8675	.37548	.060	-1.7863	.0513

Based on observed means.
The error term is Mean Square (Error) = .282.
*. The mean difference is significant at the 0.05 level.

Soil Analysis

Soil sample obtained from different provenances were subjected to laboratory analysis. The result shows variation across the nutrients composition of the provenance which resulted in the variations in the growth parameters.

Onigambari Forest Reserve

Table 4 below showed the laboratory analysis of soil sample collected from Onigambari Forest Reserve. The soil analysis showed that the textural class of the soil is sandy-loam. Both the organic carbon and organic matter in the soil were low with 0.88% and 1.51% respectively; this is because organic matter was above the critical level of 2.00 as reported by Agboola and Ayodele, (1985). Nitrogen which helps in the formation of amino-acids and the building of protein is necessary for plant cell division. However, based on the result, total nitrogen available in the soil is 0.07% which is below the critical level of 0.15% (Agboola and Ayodele, 1985). Also, the inadequacy of nitrogen had an effect on the growth of Onigambari Forest Reserve seedlings by causing a decrease in their growth and also chlorosis which could be seen in the collar diameter of the seedlings. The available phosphorus which is involved in photosynthesis, respiration, energy storage and transfer, cell division and enlargement is about 2.16% in the soil which is considered low because it is below the critical level of 8.50% (Agboola and Ayodele, 1985).

Though, micronutrients are high with Iron (Fe) having 14mg/kg, which is above the critical level of 3.50mg/kg, which is important in the production of chlorophyll, and also component of many enzymes associated with the energy transfer and fixation of lignin formation (Agboola and Ayodele, 1985). Zinc (Zn) is essential for protein synthesis and growth regulation had a positive effect on the seedlings in terms of leaf production and leaf area.38.2mg/kg was obtained and it's above the critical level of 1.0mg/kg (Agboola and Ayodele, 1985).

Table 4: Nutrients Compositions of Onigambari Forest Reserve

S/N	Soil Properties	Value
1	Total organic carbon	0.88%
2	Total organic matter	1.51%
3	Total Nitrogen	0.07%
4	Phosphorus	2.16mg/kg
5	Magnessium	3.33mol/kg
6	Zinc	38.2mg/kg
7	Iron	14mg/kg

J1 Forest Reserve

The Table 5 below showed the laboratory analysis of soil sample collected from J1 Forest Reserve. The analysis revealed that the textural class of the soil is sandy-loam. Both the organic carbon and organic matter in the soil are high with 1.18% and 2.20% respectively, this is because organic matter is above the critical level of 2.00 (Agboola and Ayodele, 1985). Nitrogen which helps in the formation of amino-acids and the building of protein is necessary for plant cell division. However, based on the result below, total nitrogen available in the soil is 0.06% which is below the critical level of 0.15%, thereby having an effect on the growth of plants by causing stunted growth and chlorosis which was vividly seen among the seedlings of J1 forest reserve through th0e growth of parameters assessed. The available phosphorus which is involved in photosynthesis, respiration, energy storage and transfer, cell division and enlargement, which also promotes root and formation is about 15.7mg/kg in the soil and is considered high because it is higher than the critical level of 8.50mg/kg (Agboola and

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Ayodele, 1985). In relation to the growth of the seedlings, it helped in boosting the growth of the seedlings in the terms of stem diameters when compared to the seedlings from other provenances.

Also, Iron (Fe), which is involved in the production of chlorophyll, which is also a component of many enzymes associated with the energy transfer and fixation of lignin formation in plants is available as 3.75mg/kg which is considered high because it is above the critical level of 3.50mg/kg (Agboola and Ayodele, 1985). Zinc which took part in the regulation of growth among the seedlings of its provenance and essential for protein synthesis as well as growth regulation is about 17.0mg/kg in the soil which is above the critical level of 8.50mg/kg (Agboola and Ayodele, 1985).

Table 5: Nutrients Compositions of J1 Forest Reserve

S/N	Soil Properties	Value
1	Total organic carbon	1.18%
2	Total organic matter	2.20%
3	Total Nitrogen	0.06%
4	Phosphorus	15.7mg/kg
5	Magnessium	7.6mol/kg
6	Nitrogen	0.76mol/kg
7	Zinc	17mg/kg
8	Iron	73.5mg/kg

FRIN Arboretum

Table 6 below showed the laboratory analysis of soil sample collected from FRIN Aboretum. The soil analysis revealed that the textural class of the soil is sandy-loam. Both the organic carbon and organic matter in the soil are low with 0.38% and 0.65% respectively and this organic matter is above the critical level of 2.00% (Agboola and Ayodele, 1985). Total Nitrogen which helps in the formation of amino-acids is 0.03% which is below the critical level of 2.00%. Based on the performance of the seedlings from this provenance, the inadequacy of nitrogen had a serious effect on the growth of plants in terms of leaf area, collar diameter and plant height when compared to the seedlings of other provenances. Phosphorus (P) which is involved in photosynthesis, respiration, energy storage and transfer is high about 7.90% in the soil which is below the critical level of 8.50% (Agboola and Ayodele, 1985).

Iron (Fe), which helps in the production of chlorophyll also attributed to the seedlings growth in terms of collar diameter. Copper (Cu), which is available as 18mg/kg, is above the critical level of 3.50mg/kg helped in providing necessary carbohydrate and nitrogen metabolism and it also on the other hand help preventing wilting plants. Also, Zinc (Zn) which is essential for protein synthesis and growth regulation had a positive effect on the seedlings by enhancing their growth in terms of leaf area and leaf production is about 71.6mg/kg in the soil which is above the critical level of 8.50mg/kg (Agboola and Ayodele, 1985).

Table 6: Nutrients Compositions of FRIN Arboretum

S/N	Soil Properties	Value
1	Total organic carbon	0.38%
2	Total organic matter	0.65%
3	Total Nitrogen	0.03%
4	Phosphorus	7.896mg/kg
5	Magnessium	13.35mol/kg
6	Zinc	19.8mg/kg
7	Iron	71.6mg/kg

Conclusions and Recommendations

There are variations in growth parameters of seedlings from the three provenances assessed for this study. This can be seen and correlated with soil sample analysis results from the provenances. The result of the soil analysis showed that J1 Forest Reserve had the highest nutrients and this resulted in the growth parameter been the best for the *Terminalia ivorensis* seedlings. There were significant differences amongst the provenances as well as growth parameters investigated.

As a result of means separation, J1 Forest Reserve differed significantly from the other two provenances and is recommended as the best provenance for raising *Terminalia ivorensis.* Therefore, for growth and development of *Terminalia ivorensis*on large scale J1 Forest Reserve is the best in the where this species is found in southwestern, Nigeria.

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