GROWTH ASSESSMENT OF *Nauclea diderrichii* DE WILD. AND TH. DUR. MERRILL PLANTATION IN FORESTRY RESEARCH INSTITUTE OF NIGERIA

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Abstract: This study examined the growth of *Nauclea diderrichii* plantation in Forestry Research Institute of Nigeria, Ibadan, Oyo State, Nigeria. Ten (10) plots of 10 by 20 m in dimension were randomly established using Simple Random Sampling Technique. Total enumeration was carried out and a total of 123 *Nauclea diderrichii* were measured. The parameters examined were Dbh and total height. The Dbh was measured at 1.3 m above the ground level using girthing tape while total height was measured with the use of Haga altimeter. Volume and basal area were also computed through the measured parameters (Dbh, Diameter at the middle and height). The result showed that plot 10 had the highest number of individual with 17 trees and the plot with the least number of individual is plot 3 with 7 trees. The result of this work showed that 7 years *Nauclea diderrichii* plantation had total volume and height of 1316.86 m and 91.75 mha^{-1} while basal area was 142.13 mha^{-1}. The value obtained for basal area is an indication of a well-stocked plantation.

Keywords: FRIN, growth, *Nauclea diderrichii*, plantation

Introduction

Principles of management and proper planning in natural resources are based on recognition of capacities and assessment of ecological potential (Seyedeh, 2014). Clear cutting and then planting with native and exotic tree species is the common management practice to reconstruction of degraded Forest ecosystems in the Nigeria. *Tectonia grandis, Gmelina arborea* Maple, oak, pine, ash are the common tree species have been used to thedifferent areas with variety of ecological characteristics (Mohammadnejad *et al*., 2010). *Nauclea diderrichii* De Wild. and Th.Dur. Merrill is a species of plant in the Rubiaceae family. It is found in Angola, Cameroon, Central African Republic, the Republic of the Congo, the Democratic Republic of the Congo, Ivory Coast, Gabon, Liberia, Mozambique, Nigeria, Sierra Leone, and Uganda. Its natural habitat is subtropical or tropical moist lowland forests. It is threatened by habitat loss. The wood of this tree is known as Bilinga, or sometimes Aloma in Germany and Opepe in Yoruba. It is dense and resistant to fungi and insects, and is used in marine construction. It grows to around 35 to 48 m tall, and 1 to 2 m in diameter at breast height and threatened by habitat loss (IUCN, 2016). Artificial forest plantation comprises of the both exotic and indigenous species such as Teak and Gmelina which are massive (FAO, 2010).

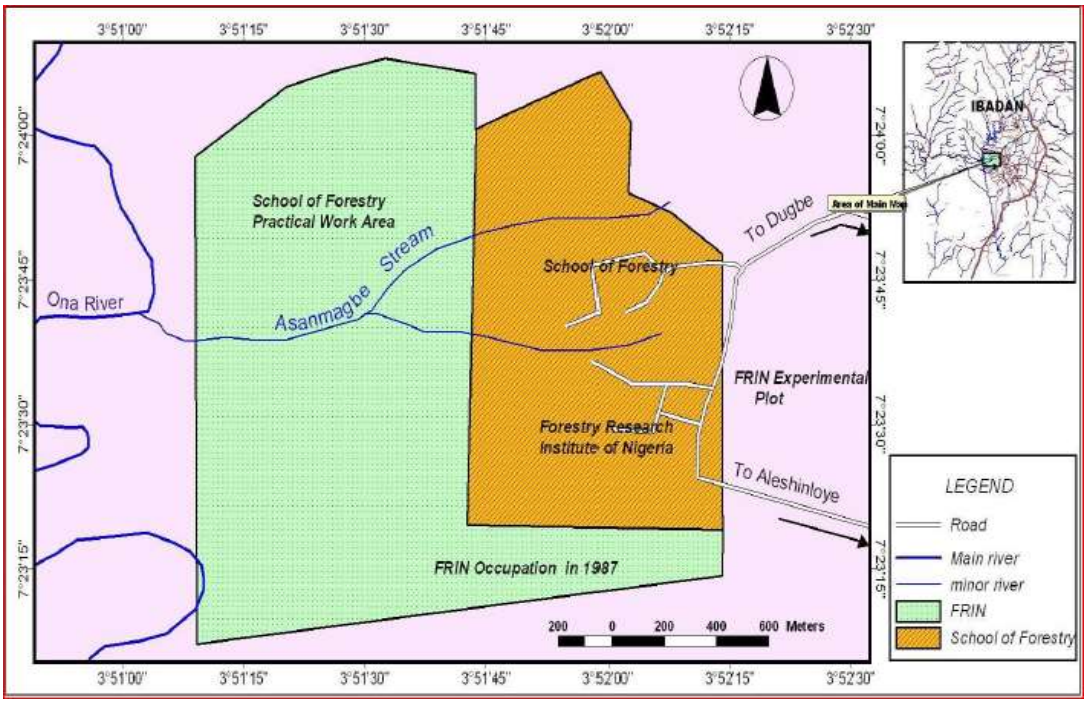
A plantation provides an extreme example of an even-aged structure. Two-aged stands are often, but not always, a result of human intervention and may be a temporary condition as management works towards developing an even-aged or uneven-aged stand. Structure within these stands will often have patchy or partial over story canopies with a well-defined second story, or layer, of either pole timber or seedlings and saplings. Uneven-aged structure means a stand has three or more age classes. This type of structure is a result of increasing species, age- and size-class diversity within a stand. On the other hand plantations are useful in silviculture, agro-forestry and all other industrial sectors that depend on the trees. It is also helpful in restoration of biodiversity, ecosystem structure and functioning. Piotto (2007) proposed that the performance of planted native species of economic importance must be known to precisely prescribe appropriate species for enrichment planting for selecting potential species and predict their response.

Generally, the height and diameter growth are influenced by a combination of genetic potential (DeLong, 1991; Bi and Turvey, 1994; Leiffers and Stadt, 1994; Comeau and Sachs, 1996), and physiological and morphological responses to environmental factors (Vogt *et al*., 1983; Cole and Newton, 1987; Harrington *et al*., 1991; Kelty *et al*., 1992; Simard and Heineman, 1996; Davis 1998; Mustard and Harper, 1998; Makinen, 1998; Wang, 1998). Cremer *et al.* (1982) and Nykanen *et al.* (1997), reported that height:diameter ratios as a gauge for susceptibility to snow and wind damage for many years. According to Opio *et al*. (2000) height to diameter ratio (HDR) has been proposed as an alternative competition index to be used in determining the vigour and `free growing' status of crop trees. Brunig (1974) and Faber (1975) showed that the relationships between height:diameter ratios and incidence of damage have been very strong. For every tree species height and diameter profile and survival rates varied from site to site, climatic factors and for other conditions which species is performing better is essential to know. Makela *et al.* (2000); Sievanen (1993); Landsberg and Waring (1997); Valentine *et al*. (1997); Bartelink (1998); Albrektson and Valinger (1985); Hashim (2005) and Piotto *et al.* (2003) have evaluated the performance of the different tree plantations by some simple measurement and statistics. The aim of the statistical forest inventory is to provide comprehensive information about the status and dynamics of forests for strategic and management planning.

Materials and Methods

Study area

The research was carried out in Forestry Research Institute of Nigeria (FRIN) Ibadan Oyo State, located between latitude 03°51 20"E to 03°51 43"E and longitude 07°23 18"N to 07°23 43"N(Nurudeen *et al*., 2017). The dry season is usually from November through March and is characterized by dry harmattan wind. The wet season on the other hand usually starts from April to October with occasionally strong winds and thunderstorms. Mean annual rainfall is approximately 1548.9 mm, falling within 90 days. The rainfall pattern is bimodal with peak around (June and July) and September to October. Mean total annual rainfall is 420.06 mm in about 109 days (Ariwaodo *et al*., 2012). Relative humidity is 74.6%. The mean maximum and minimum temperature are 39 and 24.3°C, respectively while the mean daily relative humidity is about 71.9% (FRIN, 2015).The vegetation on both sides of the stream which is an important watershed can be described as a near-natural plant community with few record of anthropogenic disturbance. Topography is undulating with underlying ferruginous sandy loam soils on crystalline rocks of undifferentiated pre-Cambian basement complex.



Source: Ariwaodo *et al.* (2012)
Fig 1: The map showing FRIN Headquarter

Sampling techniques and data collection

One age series of *Nauclea diderrichii* plantation was used for this experiment which is the plantation that was established in 2011. Simple Random Sampling was used to establishing 10 plots of 10 by 20 m in size with the spacing of 4 m interval. A total area of 2000 m^2 was sampled. It was based on model used by Onyekwelu (2007) and Salami (2017). Total area of land surveyed was 3.5 ha and sampling intensity was 5.7%. Data were collected on Diameter at breast height (Dbh) cm, total height (m) and these were used to compute basal area (m^2) and volume (m^2).Tree height: height of each tree species was measured at 20 m from the base of the tree for easy access to the crown of the tree using Haga altimeter. Diameter at breast height of each tree species were measured using girthing tape from the ground level to where 1.3 m is located at the tree and it was recorded. All trees in each plot were identified and measured. Within each selected plots, information on total number of species per plot of all living trees were recorded

Data analysis

Community structure analysis

The following community assessment variables were determined to analyze the plantation structure:

Basal area estimation

Basal area is the common term used to describe the average amount of an area occupied by tree stems. It is defined as the total cross sectional area of all stems in a stand measured at breast height. The basal area of all tress in the sample plots were calculated using this formula:

$$B.A = \frac{\pi D}{4} \quad \text{.....equ 1}$$

Where BA= Basal Area (m^2); D= DBH (cm), π=3.142

Volume estimation

The volume of all trees in the sample plots were calculated using this formula:

$$V = B.A\ x\ H \quad \text{.....eqn 2}$$

Where B.A is basal area and H is the height of the trees.

From Fig. 1, the height ranged mostly between 6 – 10 m with 121 trees while the height class of 1 – 5 m and 11 – 15 m had only one tree each.

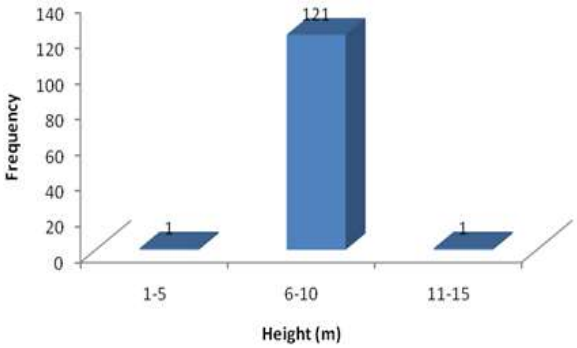


Fig. 1: Height class distribution

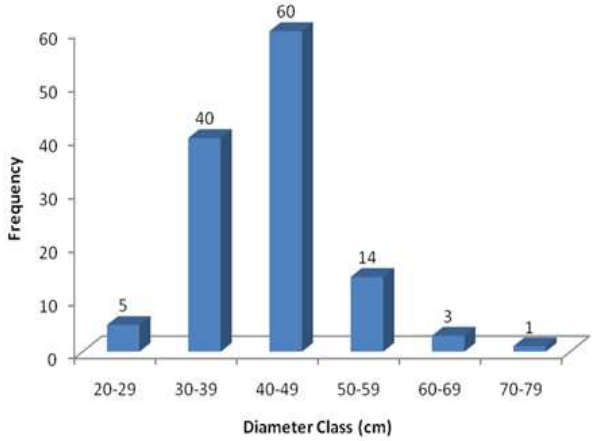


Fig. 2: Diameter class distribution

Results and Discussion

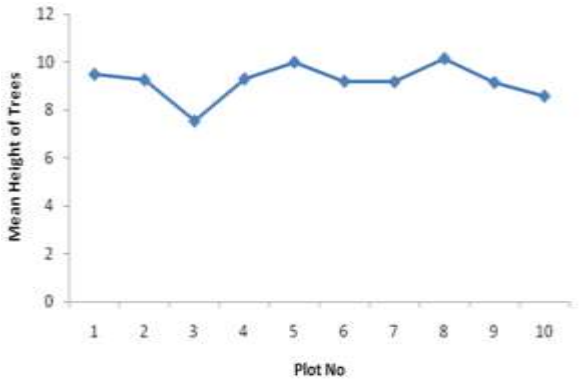


Fig 3: Mean height/plot

The graph showed that plot 8 has the highest mean height of trees of 10.4 m, followed by plot 5 with 9.99 m and the least is plot 3 with 7.53 m (Fig. 3). From Fig. 4, it can be deduced that plot 1 had the highest basal area of about 20.16 m^2, followed by plot 8 of about 18.41 m^2 and plot 3 had the least basal area of 11.40 m^2.

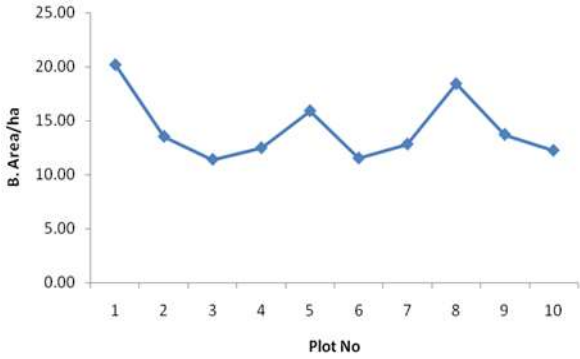


Fig. 4: Mean B.Area/Plot

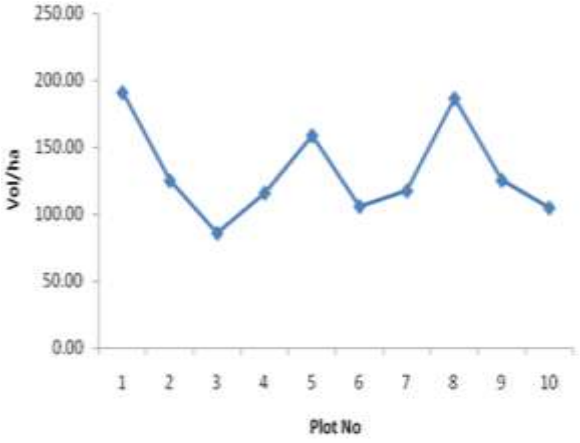


Fig 5: Mean tree Vol/plot

The above graph showed the mean tree volume of each plot in the plantation (Fig. 5). It indicates that plot 1 had the highest volume/ha of 191.11 m^3, followed by plot 8 which had the volume of 18.66 m^3 and plot 3 had the least volume of 85.81 m^3.

Floristic composition

The results of this study showed that *Nauclea diderrichii* plantation in Forestry Research Institute of Nigeria is a repository of standard mono-plantation. One hundred and twenty three (123) stands of *Nauclea diderrichii* were reported in Forestry Research Institute of Nigeria plantation which below the value of 296 ha and 323 ha observed by Adekunle and Olagoke (2007) and Aigbe *et al.* (2014) in Obanla Natural Forest and Afi Forest Reserve, respectively. The floristic distribution of this plantation was found to be relatively high. This is a pointer to the fact that this plantation can still recover its primary genetic resources if properly monitored. Table 1 showed that the plot with the highest number of individuals was plot 10 with 17 trees and the lowest was plot 3 with 7 individuals. However, the genetic resources were relatively high compared with values obtained in a degraded Gambari Forest Reserve in South western Nigeria (Nurudeen *et al.,* 2017; Salami and Akinyele, 2018a). Aigbe *et al.* (2014) reported 387 stems ha^{-1} in Strict Nature Reserve (SNR) of Akure Forest, Nigeria. Lu *et al.* (2010) obtained a total of 105 species that belong to 32 families in the evergreen forest of Andaman Giant, India. An average stands density of 422 stems/ha was reported for Borneo rainforest by Small *et al.* (2005).

Table 1: Mean DBH, mean height, Basal area/ha and volume/ha of the plot in the study area

Plot No	No of Ind.	Av. dbh (cm)	Av. Height (m)	B.A./ha	Vol./ha
1	12	50.66	9.48	20.16	191.11
2	10	41.49	9.25	13.52	125.08
3	7	38.09	7.53	11.40	85.81
4	11	39.85	9.29	12.47	115.88
5	12	44.99	9.99	15.90	158.83
6	15	38.29	9.19	11.52	105.84
7	15	40.39	9.17	12.81	117.51
8	13	48.41	10.14	18.41	186.66
9	11	41.78	9.14	13.71	125.32
10	17	39.46	8.57	12.23	104.82
Total	**123**	**423.41**	**91.75**	**142.13**	**1316.86**
Mean		**42.33**	**9.17**	**14.21**	**131.69**

Source: Field survey (2018)

Table 2: Growth parameters of the study area

Parameters	Mean	Min	Max
Dbh (cm)	42.33	20.6	72
Height (m)	9.17	7.53	10.14
B. Area (m^2)	14.21	11.40	20.16
Vol. (m^3)	131.69	85.81	191.11

Source: Field survey (2018)

Diameter class distribution pattern of plantation

There were higher numbers of stems per hectare in the diameter classes of 40-49 cm with population sizes of 60 trees in plantation. Diameter ranges of 30 – 39 cm had 40 trees/ha, while the diameter class of 70-79 cm had 1 tree/ha in plantation. Lesser number of stems per hectare was recorded in diameter classes of 70 – 89.9 cm in study area. It implies that higher number of the trees was wildlings and they were not merchantable (Salami and Akinyele, 2018a). Conversely, Salami and Akinyele (2017 and 2018b) discovered highest number of trees for diameter class 10-19.9 cm (27.93%) at Gambari Forest. Also, Oduwaiye and Ajibode (2005) reported the highest number of trees for diameter class of 11-30 cm followed by those of between 0-10 cm at Gambari Forest Reserve. Oduwaiye *et al.* (2002) revealed that all the plots accessed had the largest class of diameter below 10 cm at the Okomu Permanent Sample Plot.

Community structure indices

The growth variables obtained at the study area were in Table 2. Total volume and height were 1316.86 and 91.75 m ha while basal area was 142.13 mha^{-1}. The mean Dbh and height

encountered is an indication that most of the trees encountered in the study area were above minimum merchantable size of 48 cm stipulated by logging policy of south western Nigeria. The results showed that Plot 1 had the highest Dbh 50.66 9 cm, followed by plot 8 which had the value of 48.41 cm and the least is plot 3 with 38.09 cm. Plot 8 had highest height of 10.14 m and the lowest is plot 3 of 7.53 m. Table 1 also showed that plot 1 had the highest basal area of 20.16 m^2, followed by plot 8 which had 18.41 m^2 and the least is plot 3 which had 11.40 m^2. Plot 1 had the highest volume value of 191.1 m^3, followed by plot 8 which had the volume value of 186.66 m^3 and least volume value of 85.81 m^3. Table 2 above showed that the Dbh ranged from 20.6 cm to 72.0 cm with the mean value of 42.33 cm while its height ranged from 7.53 to 10.14 m and with the mean value is 9.17 m. Basal area ranged from 11.40 to 20.16 m^2 and mean value of 14.21 m^2, its volume ranged from 85.81 to 191.11 m^3 with mean value of 131.69 m^3. The value obtained for basal area is an indication of a well-stocked plantation (Alder and Abayomi, 1994). However, lower mean Dbh was recorded compared to Omo Forest Reserve and Gambari Forest Reserve with the mean Dbh of 1.46 and 0.77 m, respectively (Salami and Akinyele, 2018b). Conversely, Salami and Akinyele (2017) discovered highest volha^{-1} (306.62) and (145.32) in Omo Forest Reserve and Gambari Forest Reserve, respectively.

Conclusion and Recommendations

From the result of the experiment, it was observed from the study that the average Dbh, height, basal area and volume were 42.33 cm, 9.17 m, 14.21 m^2, 131.69 m^3, respectively. Though the plantation is still young, the result obtained can well serve as a baseline for other studies and provides valuable information on the growth trend pattern of *Nauclea diderrichii* in the plantation. It will also help to promote a basis for further investigations on the relationship between volume and other growth parameters. It is hoped that this study will be of value to forest managers, policy makers.

Based on the research which showed that *Nauclea diderrichii*are threatened and already going into extinction, it is therefore recommended that, more research work on the *Nauclea diderrichii* plantation should be carried out to have robust baseline information for further studies. More plantation should be established and also more indigenous tree species of economic importance especially *Nauclea diderrichii* which can be used as a source of seed collection, tree improvement and research purpose should be planted. It is believed that this study will provide a basis for further data collection management at Forestry Research Institute of Nigeria. Therefore all categories of regression models generated in this study with good fit are recommended for tree volume estimation in plantation of *Nauclea diderrichii*at Forestry Research Institute of Nigeria, Ibadan South Western Nigeria.

Conflict of Interest

Authors declare that there is no conflict of interest related to this study.

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