Vol. 8. No. 1. 2018.

Contents available at:

www.crdeepjournal.org

International Journal of Environmental Sciences (ISSN: 2277-1948)

Full Length Research Article

Growth Assessment of young *Tectona grandis* (Linn F.) Plantation in Benin City, Nigeria

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ARTICLE INFORMATION

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Article history:
Received: 09-09-2018
Revised: 15-09-2018
Re Revised: 28-09-2018
Accepted: 25-10-2018
Published: 02-11-2018

Key words:
Plantation, *Tectona grandis*, trend, growth and yield.

ABSTRACT

Forestry like other business ventures requires effective management of its resources. Over time there is dearth of periodic information on stand conditions of forest plantation species in Nigeria. Hence, there is need to update quantifiable information on tree stands not only for management decision but also to depict the growth and productive capabilities of the tree stand. This study therefore was carried out on fifteen years old Tectona grandis plantation (1.8 hectares) located in Moist Forest Research Station, Benin City, Edo State, Nigeria. Total enumeration of the whole forest was carried out and the following variables were assessed: Stem height-St (m), diameter at breast height outer bark-dbh (cm) and diameters at the Base (Db), Middle (Dm) and Top (Dt). The data obtained were used to estimate basal area (BA), stem volume (Vol) and tree slenderness coefficient (TSC). Correlation matrix was used to assess relationship between the growth variables assessed. It was revealed that the mean dbh, St, BA, Vol and TSC were 22.57±1.35cm, 14.04±0.42m, 0.05±0.01m^2/ha, 1.64±0.12m^3/ha and 69.04±3.16 respectively. There were strong relationships between the growth variables (dbh and BA = 0.98, dbh and Vol = 0.95, etc). Management objectives targeting at utilizing this for pole production can utilize this plantation at this stage. The maximum stem height attained shows that it is of tropical species. Hence, sustainable management of this plantation is recommended for optimum growth and yield.

Introduction

Plantation forests play an important role in the limitation of natural forests depletion and in the satisfaction of population's firewood and timber needs (FAO, 2011). Well-known forest growth models are often based on very large (e.g., Buckman *et al*., 2006; Vanclay, 1994) or sophisticated databases (e.g., Landsberg *et al*., 2003; Battaglia *et al*., 2004), but there remains strong demand for forest growth forecasts in situations where efforts to calibrate and initialize models are hampered by a lack of data. Yield tables may be the oldest and most robust approach to yield prediction in forest plantations, but are severely constrained by the need to follow a standard management regime. In many situations where decision support is needed, plantation management regimes may not be standardized, and may be far from optimal. Furthermore, the demand for a growth model may be to explore harvesting and management options, not to lock in a prescribed production regime.

Teak (*Tectona grandis* Linn. F.) is considered the noblest among all woods not simply because of its golden hue and wonderful texture, but even more because of its durability, strength, attractiveness, workability, and superior seasoning capacity (Tewari, 1999). Teak is one of the most widely planted hardwood timber species in the world. In 2010, the global area of planted teak forests reported from 38 countries was estimated at 4.346 million ha, of which 83% grew in Asia, 11% in Africa, 6% in tropical America and less than 1% in Oceania. Countries of tropical Africa recorded about 470 000 ha of planted teak forests with Ghana having the largest area of approximately 214 000 ha (Kollert and Cherubini, 2012).

One of the major challenges of forestry development in Nigeria is the dearth of periodic information on stand conditions of forest plantation species. However, sustainable management of forest stands can only be ensured if current and reliable information on growth condition of the stand are available. This could be used by forest managers to provide accurate and timely information on the existing stock. Effective management of forest stock is paramount to forestry development all over the world. Hence, the aim of this study to provide relevant information on the growth variables of young *Tectona grandis* for sustainable management plans

Materials and Methods

Study Area

This study was carried out in fifteen years old *Tectona grandis* plantation (1.8 hectares) located in Moist Forest Research Station, Benin City, Edo State, Nigeria. It is located within latitude 6° 32′ 20.055″ N and 6° 32′ 20.0854″ N and longitude 5° 58′ 2.564″E and 5° 58′ 2.863″E at 99 m above sea level. It has a mean annual temperature range of 27°C and 32°C and the mean annual rainfall is 2078mm. It is situated on a total land area of 260 hectares with substations/forest research activities sections spread across the state. These include: Saponba Forest Reserve (1040ha), Agbede forest plantation (260ha), Okhuesan Forest Reserve (260ha), Uzairue Forest Reserve (260ha), Urhonigbe Forest Reserve (780ha), Okomu Forest Reserve (520ha), Iguobazua Forest Reserve (260ha), Ubiaja Forest Plantation (258ha) and Ohosun Forest Reserve (260ha).

Data Collection Methods

Total enumeration of the whole forest was carried out and the following variables were assessed: Stem height-St (m), diameter at breast height outer bark-dbh (cm) and diameters at the Base (Db), Middle (Dm) and Top (Dt).

Data Analysis

The data obtained were processed and the following variables were estimated accordingly:

Basal Area Estimation

The Basal Area (BA) of individual trees was estimated using the formula in equation 1 (Husch *et al*, 2003)

$$BA = \frac{\pi}{4} D^2 \quad \ldots\ldots 1$$

Where BA = Basal area (m^2), D = dbh (cm).

Volume Estimation

The volume of individual trees was estimated using Newton equation developed for stem volume estimation (Husch *et al*, 2003):

$$V = \pi H \left[\frac{Db^2 + 4Dm^2 + Dt^2}{24} \right] \quad \ldots\ldots 2$$

Where V = Stem volume (m^3), H = stem height (m), Db = Diameter at the base, Dm = Diameter at the middle, Dt = Diameter at the top and Π = 3.142 (constant)

Slenderness coefficient (TSC) Estimation

$$TSC = \frac{THt}{dbh} \quad \ldots\ldots 3$$

According to Navratil*et al*, (1996), slenderness coefficient values were classified into three categories.

TSC values > 99…………… High slenderness coefficient

70 < TSC values > 99………Moderate slenderness coefficient

TSC values < 70 …………….Low slenderness coefficient

Result and discussion

The summary of growth variables of the tree species assessed in this study are presented in Table 1. The dbh range revealed that the trees are still in fast/rapid growth stage because they are yet to attain minimum dbh class of 48 cm as prescribed by FORMECU (1999). Meanwhile, management objectives targeting at utilizing this for pole production can utilize this plantation at this stage. The maximum stem height attained shows that it is of tropical species (Husch *et al*, 2003). This is important information in convincing forest managers and investors in establishing this species as it can easily attain this height within fifteen years as against other tropical tree species such as *Milicia elcesa* that cannot be easily found in plantation state due to slow growth rate and more importantly insect and diseases infestation. Basal area is a function of dbh (Husch *et al*, 2003). Hence, the bigger the dbh the higher the basal area. The result obtained for this study shows that maximum of 0.17m^2/ha will be occupy by this species at fifteen years old per tree. This will also assist in land area management for the species thereby given foresight management plan that the land can be maximized sustainably by planting some annual crops to enhance food security. This shows that the species can be incorporated in agroforestry system as pointed out by Ige (2014). Maximum stem volume estimated in this study was 6.61m^3/ha. This shows that the species at this stage have the potentials of been used as timber species in few years time. This can successfully argument the incessant felling and use of our fragile tropical natural forest tree species that are far approaching extinction. The diameter size class distribution (Fig 1) reveals that the plantation is still emerging. The curve follows a normal distribution for tropical plantation tree species as pointed out by Husch *et al*, (2003). If proper management is gear towards the plantation, its growth and yield rate will be highly profitable in terms of merchantable logs and volume expected to be derivable from them.

Table 1. Summary of growth variables

Growth variables	Min	Max	Mean±S.E
DBH (cm)	7.96	46.15	22.57±1.35
St (m)	8.00	20.00	14.04±0.42
BA (m^2/ha)	0.01	0.17	0.05±0.01
VOL (m^3/ha)	0.32	6.61	1.64±0.12
TSC	34.62	116.12	69.04±3.16

Table 2 Correlation matrix between TSC and growth variables

	TSC	DBH	St	BA	Vol
TSC	1				
DBH	-0.8025	1			

St	0.0712	0.4555	1		
BA	-0.7667	0.9829	0.3978	1	
Vol	-0.6111	0.9501	0.6707	0.9409	1

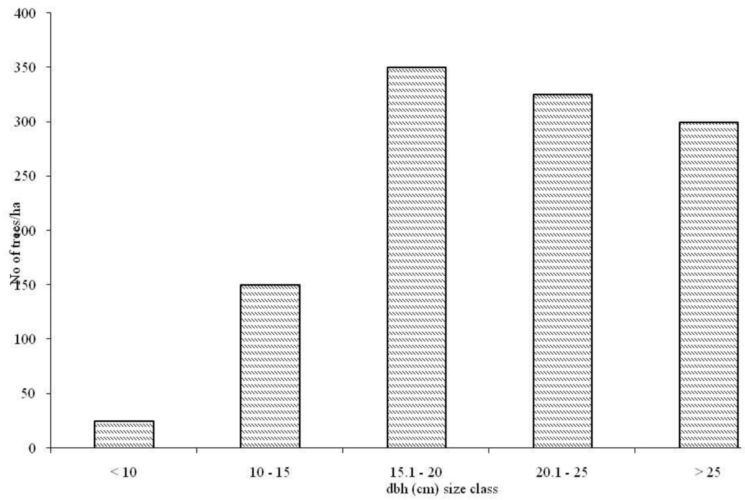

Fig 1: Diameter size class distribution

The result of correlation matrix (Table 2) reveals that all the growth variables assessed follows the same strength of relationship. DBH was highly positively correlated with BA and Volume. This might be as a result of the fact that dbh is good predictor of important growth variables in tropical forest (Ige and Akinyemi, 2016). The tree slenderness coefficient was negatively correlated with dbh. This is an indication that the bigger the dbh of a tree, the more stable it is to withstand wind throw. This result also agrees with Ige and Akinyemi (2016) study on *Triplochiton scleroxylon* plantation in Gambari forest reserve. Hence, proper management on increasing the growth of tree dbh will enhance stable and healthy tree in a forest ecosystem.

Table 3: Tree slenderness coefficient classification

TSC Range	Value (%/ha)	Implication
> 99	6.53	Prone to wind throw
70 – 99	41.30	Moderate
< 70	52.17	Withstand wind throw

Assuming that a slenderness coefficient value over 99 is considered to be at the high risk of wind throw as suggested by Navratil (1996), the result of this study indicated that 6.53% of Teak in the sampled stands in Benin City belongs to the high risk category of wind throw. The relationship of wind throw and slenderness coefficient is indirect. Lower slenderness coefficient can be an indicator of larger crowns, lower centre of gravity and a better developed root system. The desirable height/dbh ratios for adequate wind resistance vary according to species and country. In general, trees with a higher slenderness coefficient (low taper) are much more susceptible to damage than trees with low slenderness coefficient (high taper). Since smaller slenderness coefficient is usually indicating a higher resistance to wind throw, the relationships confirmed suggest that silvicultural treatments, such as producing long-crowned trees, and maintaining appropriate stand density through spacing, thinning, or gradually harvesting overstory trees, can be helpful in reducing the risk of wind throw (Wang *et al*., 1998; Eguakun and Oyebade, 2015).

Conclusion

It is evidence from this study that fifteen years old *Tectona grandis* are still in fast/rapid growth stage. The indices of stand vigouristy and health (slenderness coefficient) assessed in this study revealed that the stands have ability to withstand wind throw at this present age. Since smaller slenderness coefficient is usually indicating a higher resistance to wind throw, the relationships suggest that silvicultural treatments, such as producing long-crowned trees, and maintaining appropriate stand density through spacing, thinning, or gradually harvesting overstory trees, can be helpful in reducing the risk of wind throw. Therefore, long time sustainable management plan of the stand should be put in place to ensuring optimum growth and yield and continue goods and services provision in the study area and Nigeria at large.

Acknowledgement

I wish to appreciate Mr. Isebemhe E., Mr. Egberuare G. E and Mr. Osaro J. for technical assistance provided during collection of data for this study.

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