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Growth variables assessment for young *Tectona grandis* Linn.f. plantation in Nnamdi Azikiwe University Awka, Southeastern Nigeria

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Abstract

Many tropical countries' afforestation programmes emphasized on plantation establishment, neglecting subsequent silvicultural management decisions. This study aimed at assessing growth characteristics of the five years old Tectona grandis plantation in Nnamdi Azikiwe University, Southeastern Nigeriato provide precise information and inventory data for managing the plantation. Complete enumeration of T. grandis stands in the plantation was carried out. Stem diameters at base (Db), breast height (DBH), middle, and top, crown diameter (CD), total and merchantable heights (TH and MH) and crown projection area (CPA) were measured. The variables were used to estimate basal area (BA), total and merchantable volumes (TV and MV), crown ratio (CR) and tree slenderness coefficient (TSC). The data was subjected to descriptive and bivariate correlation statistics. A total of 295 trees were enumerated with mean DBH, CD, TH, MH, CPA, TV, MV, BA, TSC and CR of 8.9cm, 2.9cm, 10.6m, 1.9m, 7.656m^2, 0.032m^3, 0.006m^3, 0.007m^2, 125 and 0.86, respectively. DBH significantly correlated with CD (0.56), TH (0.62), MH (0.49), CPA (0.53), TV (0.85), MV (0.75), BA (0.97) and CR (0.42). The study concluded that the size of the T. grand is stands were smaller than the typical harvestable size for timber. Hence, recommended restricted logging, whereas ensuring appropriate silvicultural practices in the plantation to avoid unnecessary competition for nutrient and sunlight.

Keywords: Biometrics, correlation, forest inventory, forest management, *Tectona grandis.*

Introduction

One of the challenges of forestry development in Nigeria is the dearth of periodic information on stand conditions of forest plantation species. Forest plantations play a vital role in limiting the depletion of natural forests and can serve basic needs such as firewood and timber. *Tectona grandis* is a popular hardwood timber species; well-known for its lightness, fine grain, strength, mellow colour, stability, durability and resistivity of termite infestation[1]. *Tectona grandis* strives well in plantations under good conditions. The yield of Teak plantations has been researched in several countries through sample plots. Model for predicting the productivity of *Tectona grand is* plantations using climatic factors both at local and global levels have been developed[2].

Most of the global *Tectona grandis* stands were established under Government's a forestation and reforestation programmes. Nevertheless, private sector in recent times has increased interest in plantation establishment, often supported by government and non-governmental organizations incentives[1]. Sustainable management of the Teak stands can only be ensured if up-to-date and reliable information on the growth condition of the stands are obtained; this information are usually assessed through forest inventory[3].

Inventory of the *Tectona grandis* (Teak) in the Nnamdi Azikiwe University, Awka Campus, Southeastern Nigeria has never been carried out and/or documented. Therefore, there is need to acquire periodic information on the Teak stands present in the plantation. This would be of great importance to forest managers and policy makers to provide timely and accurate information on the growing stock. The objective of this research was to provide relevant information on the growth variables of young *Tectona grandis* stands in Nnamdi Azikiwe University, southeastern Nigeria, for informed management decision.

Materials and methods

Study area: The field work was conducted in the five (5) years old Teak plantation located at the School of Postgraduate Studies (SPGS), Nnamdi Azikiwe University (NAU), Awka Campus. NAU is located in Awka metropolis of Anambra State, Southeastern Nigeria. The plantation lies between latitude 6.2465°N and 6.2471°N and longitudes 7.1162°E and 7.1171°E (Figure-1). NAU's climate is tropical type, with mean rainfall and temperature of 1828mm and 26.3°C, respectively and lies below 300m above sea level in a valley on the pains of the Mamu River[4].

Data Collection: Total enumeration (Figure-2) method was used for this study. Stem diameter at the top, breast height, mid-point, and top (cm), total and merchantable height (m), crown diameter (m), height to live crown base (m) of each of the trees in the plantation were measured. Coordinates and elevation (above sea level) of all the trees (Figure-2) were also collected using handheld geographic positioning system.

Data Computation and Analysis: The tree growth variable data obtained were processed and the following variables were derived for individual trees:

Volume: The total and merchantable volumes (TV and MV, respectively) of each tree were computed using the Newton's formula[5]:

$$V = \pi \frac{H}{24} \left(Db^2 + 4Dm^2 + Dt^2\right) \quad (1)$$

Where; H = total or merchantable height (m), V = total or merchantable volume (m^3), π = pi is constant (3.142) and D (b, m and t) = stem diameter at base, top and midpoint, respectively (m).

Basal area (BA): BA was computed as:

$$BA = \frac{\pi (DBH)^2}{4} \quad (2)$$

Where; DBH =diameter at breast height (m), and π = pi (3.142).

Tree slenderness coefficient (TSC): TSC was computed as:

$$TSC = \frac{TH}{DBH} \quad (3)$$

Where; DBH = diameter at breast height (m) and TH = Tree total height (m)

Crown ratio (CR): CR was computed as:

$$CR = \frac{CL}{TH} \quad (4)$$

Where; CL = tree crown length and TH = total height.

Crown projection area (CPA): CPA (m^2) was computed as:

$$CPA = \frac{\pi \left(CD^2\right)}{4} \quad (5)$$

Where; CD = crown diameter (m) and π = pi is constant (3.142)

The tree growth variables were subjected to correlation analysis using Pearson's product-moment (square matrix) to establish the linear association between the variables. DBH was graphically plotted against other variables to display their relationship patterns.

The correlation coefficient was computed as:

$$r = \frac{\sum XY - \frac{(\sum X)(\sum Y)}{N}}{\sqrt{\left[\sum X^2 - \frac{(\sum X)^2}{N}\right]\left[\sum Y^2 - \frac{(\sum Y)^2}{N}\right]}} \quad (6)$$

Where, X = variable (1) to be compared, Y = variable (2) to be compared and N = total numbers of observations or trees measured.

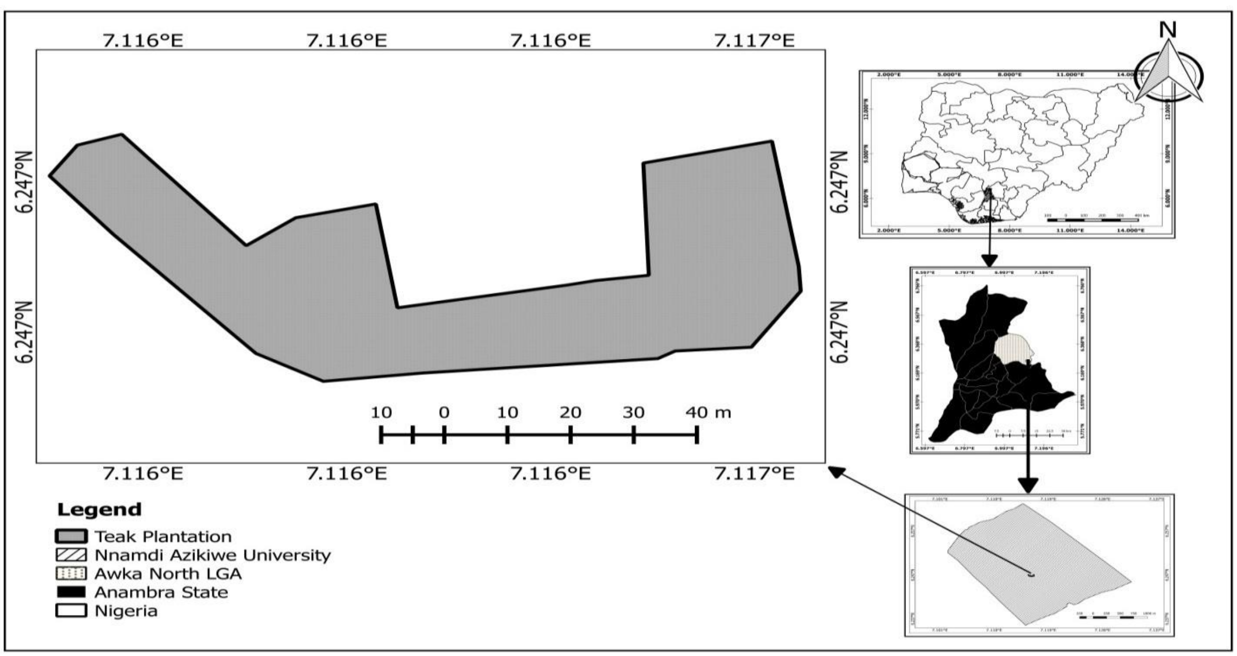

Figure-1: Map of NAU showing the study area.

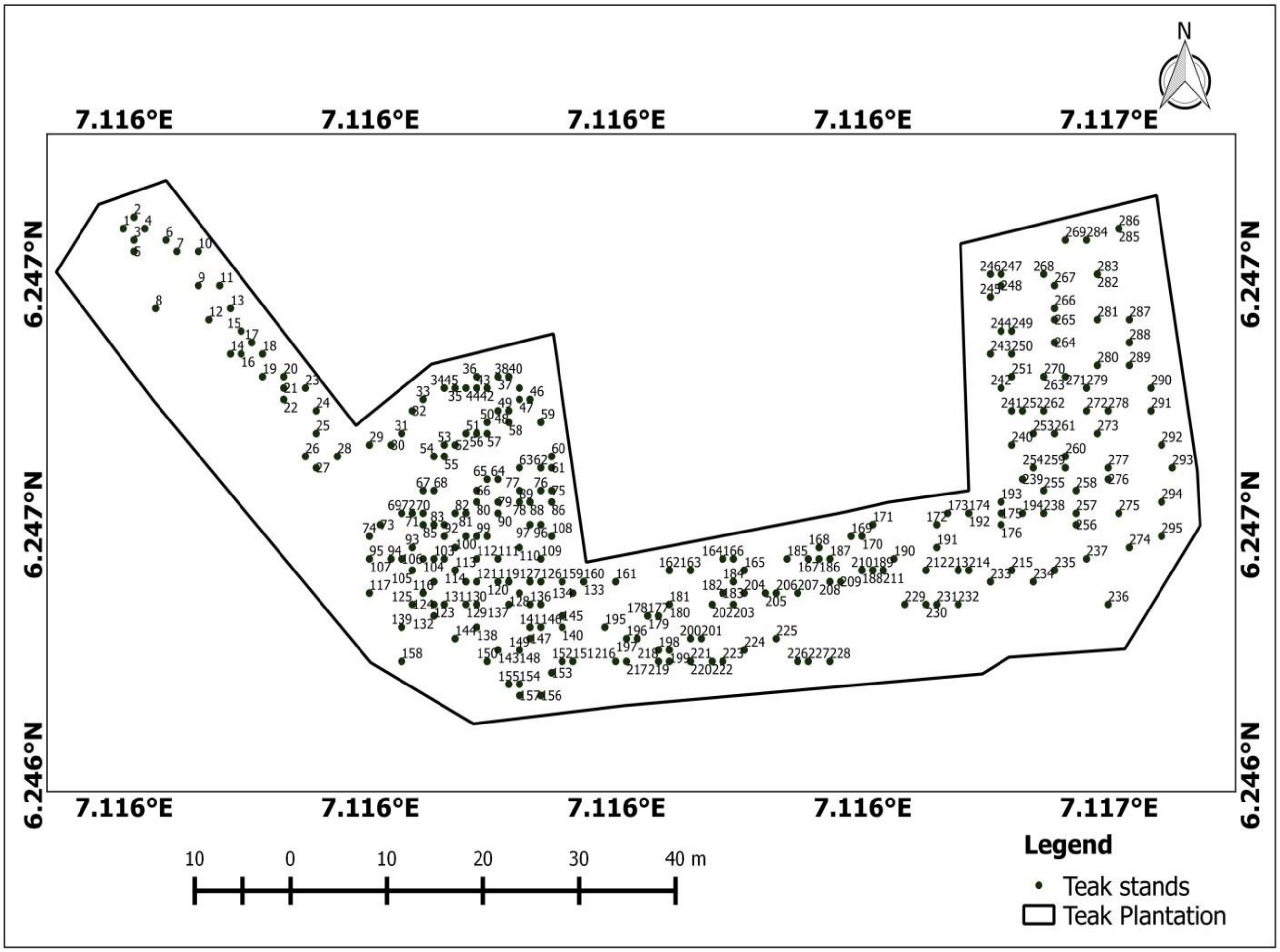

Figure-2: Map showing positions of trees enumerated in the study area.

Results and discussion

The summary of the growth variables for the Teak stands assessed in the plantation were presented in Table-1. DBH ranged from 3.0cm to 18.0cm, diameter at the base (Db) ranged from 4.1cm to 24.0cm, total height ranged from 1.8m to 17.3m, merchantable height ranged from 0.3m to 6.2m, total volume (TV) ranged from 0.002m^3 to 0.195m^3, merchantable volume (MV) ranged from 0.001m^3 to 0.054m^3, basal area (BA) ranged from 0.001m^2 to 0.027m^2, crown ratio (CR) ranged from 0.42 to 0.97, crown projection area ranged from 0.196m^2 to 23.7758m^2 and tree slenderness coefficient (TSC) ranged from 27 to 278. The mean distribution, standard error and standard deviation for the tree variables are presented in Table-1. The correlation result showed that DBH and Db had high, significant and positive correlation with correlation coefficient (r)= 0.96, DBH and BA (r= 0.97), DBH and TV (r= 0.85) (Table-2). Diameter at breast height had negative correlation with Tree slenderness coefficient (r= -0.03). Results of the graphical analysis showed that DBH displayed curvy-linear relationship with TV, MV, BA, CR and TSC and linear relationship with other tree growth variables (Figures-3a – 3m).

Discussion: This study provided information on tree growth characteristics of *T. grand is* in Nnamdi Azikiwe University, Awka, Nigeria. The descriptive statistics result revealed that, the tree stem diameter tends to taper as the tree increases vertically (Db>Dbh>Dm>Dt). This was replica of ideal trees implied that the data is biologically realistic. This result is similar to the report that Teak stands in Omo Forest Reserve, Nigeria tapers with increase in height[6].

The study also provided information on the relationship among the tree growth characteristics of each stand of *T.grandis* using correlation analysis. The significant and positive correlation displayed between DBH and Db implied that as diameter at the base increases, DBH also increases; the result is comparable to the reports of Shamaki, S.B. and Akindele, S.O.[7] and Chukwu, O., Dau, J.H. and Ezenwenyi, J.U.[8]. Diameter at breast height showed significant and positive correlation with basal area, stem height, crown diameter, stem volume and crown projection area. Similar results were obtained for *Tectona grandis* in Omo Forest Reserve, Southwestern Nigeria[6,9,10]. This implied that as tree stem diameter increases, its basal area, stem height, crown diameter, stem volume and crown projection area also increase.

These further infer that trees with larger stem diameter have larger basal area, more volume and wider crown area cover. This trend agreed with the work of Burkhart, H.E., Avery, T.E. and Bullock, B.P.[11], that correlated growth variables that are peculiarly useful for forest management decision; they reported that tree stem volume and basal area increase with the increase in diameter at breast height.

However, a negative correlation relationship existed between DBH and tree slenderness coefficient. The negativity implied that as the individual stands of Teak trees in the plantation taper up (decrease), the DBH increases. This result is in agreement with the reports of several authors on the growth attributes and management scenarios for plantation species in Southwestern Nigeria[9,12]. The relationship between wind throw and slenderness coefficient is indirect and lower slenderness coefficient can be an indicator of larger crowns with lower center of gravity and a better developed root system[13]. Trees with higher TSC are more liable to wind throw than ones with lower TSC. This implies that most of the Teak stands in the study area are prone to wind throw. Crown ratio also correlated positively with DBH. This is in disagreement with report that correlated crown ratio with tree for Teak stands in Osho forest, Oyo State, Nigeria; that crown ratio decreased with increasing tree size[14]. This disagreement might be due to the young age of the plantation in the study area; hence, most of the tree size variables including the crown dimension are still in their development stage.

From the graphical analysis, linear and curvy-linear relationships exist between DBH and the tree size variables. The graphs were similar to that reported for *Tectona grandis* plantations in Nimbia, Osho and Omo ForestReserves, Nigeria[7,14,15]. This implies that the Teak Planation in Nnamdi Azikiwe University, Awka had similar growth trend with plantations in southern Nigeria.

Table-1: Summary statistics of tree characteristics.

Growth variables	Min.	Max.	Mean	Standard Error	Standard Dev.
Db (cm)	4.1	24	11.8	0.232	3.975
DBH (cm)	3.0	18	8.9	0.188	3.225
CD (m)	1.1	6	2.9	0.061	1.046
Dm (cm)	1.3	10	3.0	0.086	1.474
Dt (cm)	0.2	5	1.7	0.049	0.840
TH(m)	1.8	17.3	10.6	0.229	3.931
MH(m)	0.3	6.2	1.9	0.048	0.823
HCB (m)	0.4	2.7	1.3	0.020	0.341
CL (m)	1	16	9.3	0.224	3.845
TV (m^3)	0.002	0.195	0.032	0.002	0.031
MV (m^3)	0.001	0.054	0.006	0.001	0.007
BA (m^2)	0.001	0.027	0.007	0.001	0.005
TSC	27	278	125	2.494	42.833
CR	0.42	0.97	0.86	0.005	0.084
CPA (m^2)	0.196	23.758	7.656	0.282	4.840

Where: = Db, DBH, Dm and Dt = base, breast height, middle and top stem diameters; TH and MH = total and merchantable heights; TV and MV= total and merchantable volumes, respectively; BA=Basal area, TSC=tree slenderness coefficient, CR= crown ratio, CPA= crown projection area, CL= crown length, HCB= height to live crown diameter, crown base. Number of trees = 295.

Table-2: Correlation matrix between growth variables.

	Db	Dbh	CD	Dm	Dt	TH	MH	HCB	CL	TV	MV	BA	TSC	CR	CPA
Db	1														
Dbh	0.96*	1													
CD	0.56*	0.56*	1												
Dm	0.78*	0.78*	0.55*	1											
Dt	0.83*	0.82*	0.62*	0.92*	1										
TH	0.57*	0.62*	0.41*	0.48*	0.57*	1									
MH	0.47*	0.49*	0.41*	0.47*	0.48*	0.71*	1								
HCB	0.27*	0.27*	0.26*	0.23*	0.28*	0.30*	0.47*	1							
CL	0.56*	0.61*	0.39*	0.47*	0.55*	0.97*	0.68*	0.21*	1						
TV	0.86*	0.85*	0.51*	0.89*	0.83*	0.67*	0.60*	0.25*	0.67*	1					
MV	0.77*	0.75*	0.49*	0.85*	0.77*	0.56*	0.73*	0.31*	0.54*	0.93*	1				
BA	0.94*	0.97*	0.52*	0.82*	0.81*	0.57*	0.48*	0.24*	0.56*	0.89*	0.81*	1			
TSC	-0.01*	-0.03*	0.01	-0.02*	-0.02*	0.02*	0.03*	0.04	0.02*	-0.01*	-0.02*	-0.01*	1		
CR	0.37*	0.42*	0.26*	0.28*	0.35*	0.78*	0.42*	-0.17	0.81*	0.42*	0.29*	0.36*	0.49*	1	
CPA	0.53*	0.53*	0.95*	0.53*	0.58*	0.37*	0.41*	0.25*	0.36*	0.50*	0.51*	0.50*	-0.15*	0.23*	1

Where: *= significant at 95% level (2-tailed), Db, DBH, Dm and Dt = base, breast height, middle and top stem diameters (cm); TH and MH = total and merchantable heights (m); TV and MV = total and merchantable volumes (m^3), respectively; BA=Basal area, TSC = Tree slenderness coefficient, CR= crown ratio, CPA = crown projection area, CL= crown length (m), HCB= height to live crown diameter (m)crown base (m). Number of trees = 295**.**

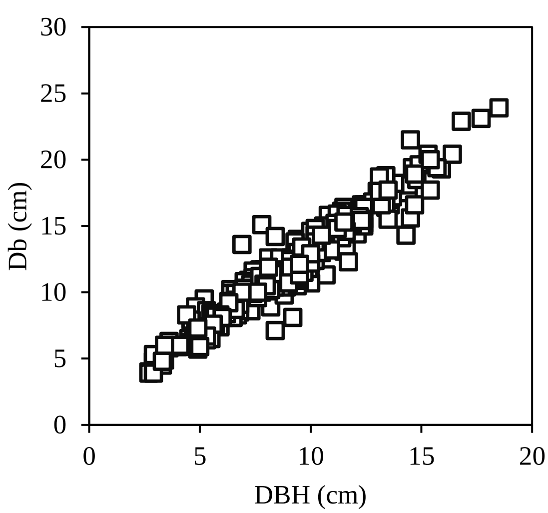

Figure-3a: Association of Db and DBH.

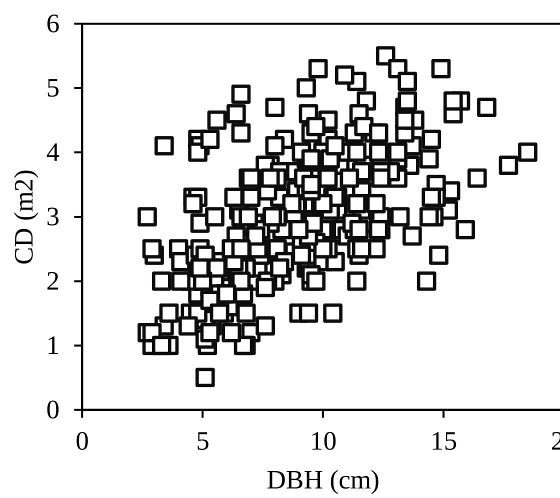

Figure-3b: Association ofCD and DBH.

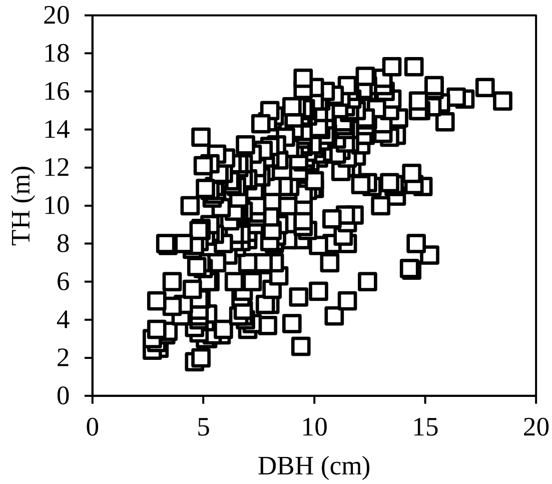

Figure-3c: Association of TH and DBH.

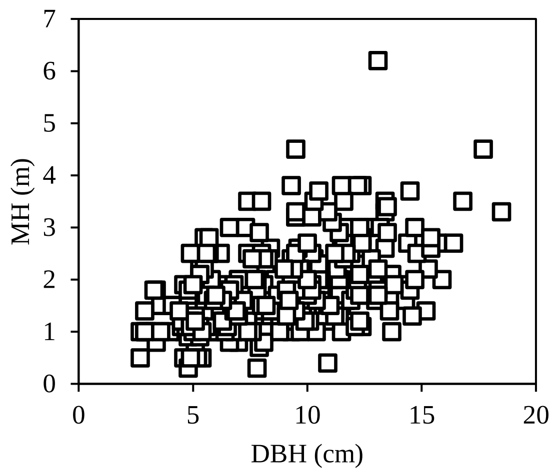

Figure-3d: Association of MH and DBH.

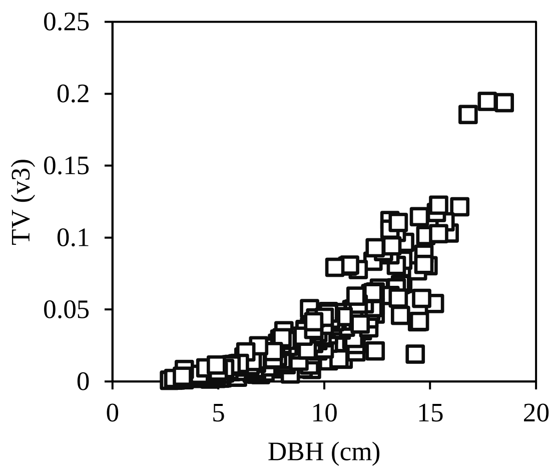

Figure-3e: Association ofTV and DBH.

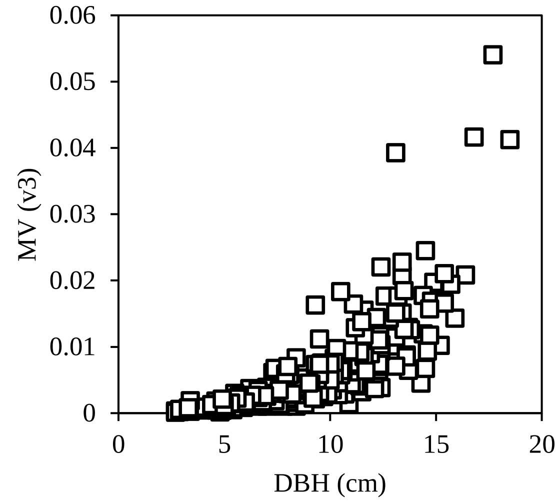

Figure-3f: Association ofMV and DBH.

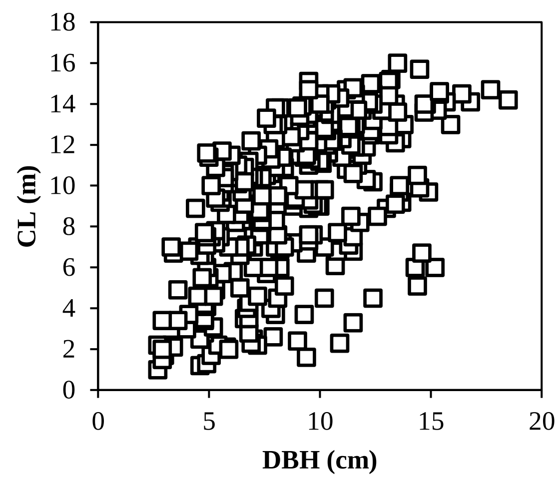

Figure 3g: Association ofCL and DBH.

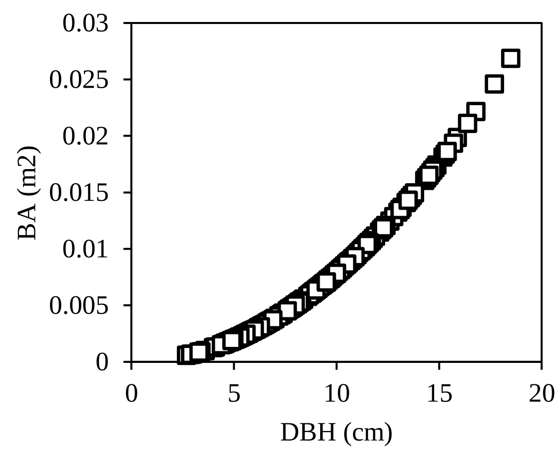

Figure-3h: Association of BA and DBH.

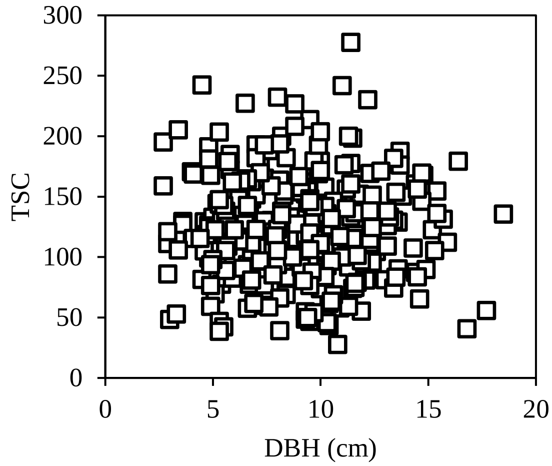

Figure-3i: Association of TSC and DBH.

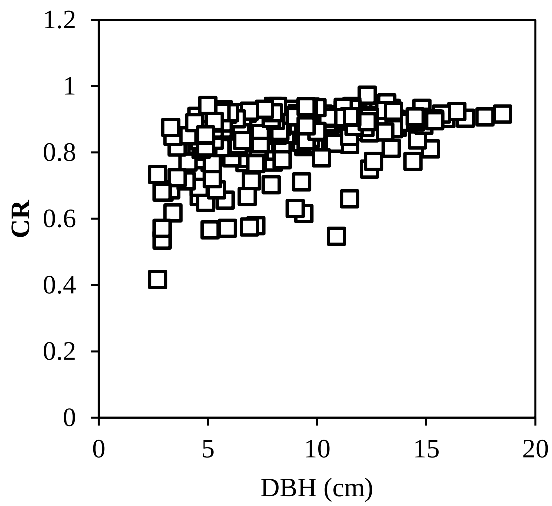

Figure-3j: Association ofCR and DBH.

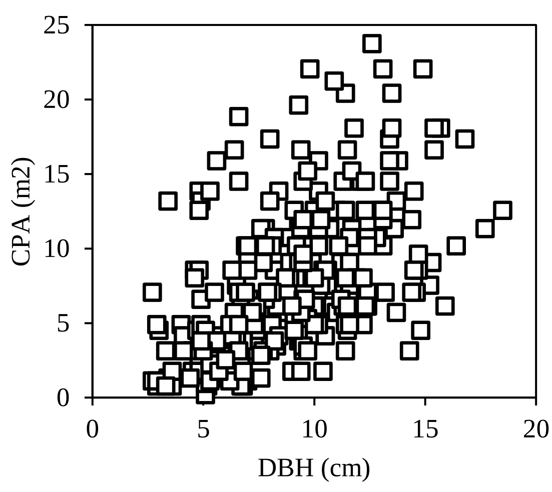

Figure-3l: Association ofCPA and DBH.

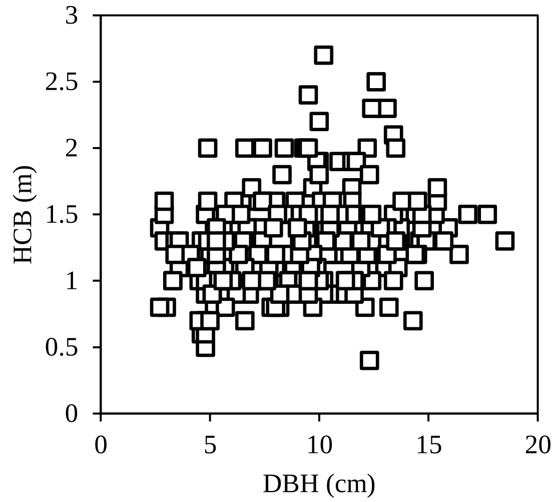

Figure-3m: Association of HCB and DBH.

Conclusion

The assessment of tree growth attributes is the fundamental and most important aspect of estimating and managing trees. This study has shown that the five (5) years old Teak plantation is still in a rapid growth stage. This study revealed a positive relationship between DBH and tree growth characteristics except tree slenderness coefficient (TSC) for Teak Stands in Nnamdi Azikiwe University, Awka. This study has projected the plantation to be susceptible to wind throw. This study recommended that regular inventory of the Teak plantation, in order to provide up-to-date information on the plantation to ensure sustainable management of the Teak stand.

However, the mean diameters at breast heights recorded in the study area were below the suggested harvestable size for timber. Therefore, restricted logging and appropriate silvi cultural practices were recommended in the plantation to avoid unnecessary competition for nutrient and sunlight.

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References

1. Pandey, D., & Brown, C. (2000). Teak: a global overview. UNASYLVA-FAO-, 3-13.

2. Pandey, D. (1996). Estimating Productivity of Tropical Forest Plantations by Climatic Factors. Report No. 7. Swedish University of Agricultural Sciences, Department of Forest Resource Management and Geomatics, Umeå, Sweden.

3. Ajewole O.I., Popoola, I and Aiyeola, A.A. (2005). Forest potential in actualizing natural economic empowerment development strategy. *In: Popoola L., Mfon, P., Oni P.I*, Sustainable forest Management in Nigeria: Lessons and Prospects. Proceedings of the 30th Annual conference of the Forestry Association of Nigeria held in Kaduna, Kaduna state, Nigeria. 07-11 Nov. 2005. pp 588 – 597

4. Chukwu, O., Ezenwenyi, J.U. and Kenechukwu, T.V. (2020). Checklist and Abundance of Open Grown Medico-Ethnoforest Tree Species in Nnamdi Azikiwe University, Awka, Nigeria. *Asian Journal of Biological Sciences*, 13(1), 105-112. https://doi.org/10.3923/ajbs.2020. 105.112

5. Husch, B., Beers, T.W. and Kershaw Jr., J.A. (2002). Forest Mensuration. 4th ed. John Wiley and Sons, Inc., New Jersey, USA, pp.1-456. ISBN-13: 978-0471018506.

6. Adesoye, P.O. and Ezenwenyi, J.U. (2014). Crown Diameter Prediction Models for *Tectona grandis* Linn. F. in Omo Forest Reserve, Nigeria. *Journal of Forestry Research and Management*, 11, 72-87.

7. Shamaki, S.B. and Akindele, S.O. (2013). Volume Estimation Models from Stump Diameter for Teak (*Tectona grandis* Linn f.) Plantation in Nimbia Forest Reserve, Nigeria. *Journal of Environmental Science and Water Resources*, 2(3), 89-94.

8. Chukwu, O., Dau, J.H. and Ezenwenyi, J.U. (2017). Crown-Stump Diameter Model for *Parkiabiglobosa* Benth.Species in Makurdi, Benue State, Nigeria. *Journal of Tropical Forestry and Environment*, 7(1), 43-53.

9. Chukwu, O. and Osho, J.S.A. (2017). Nonlinear Height-Stump Diameter Models for *Tectona grandis* Linn. f. Stands in Omo Forest Reserve, Nigeria. *Journal of Tropical Forestry and Environment*, 7(2), 45-54.

10. Chukwu, O. and Osho, J.S.A. (2018). Basal Area-Stump Diameter Models for *Tectona grandis* Linn. f. Stands in Omo Forest Reserve, Nigeria. *Journal of Forest and Environmental Science*, 34(2), 119-125 https://doi.org/10.7 747/JFES.2018.34.2.119

11. Burkhart, H.E., Avery, T.E. and Bullock, B.P. (2002). Forest Measurements. Sixth Edition. Waveland Press Inc, Illinois, USA. Pp 1-434. ISBN 13: 9781478636182.

12. Adeyemi, A.A and Adesoye, P.O. (2016). Tree Slenderness Coefficient and Percent Canopy Cover in Oban Group Forest. *Nigeria Journal of Natural Sciences Research*, 6(4), 31-42.

13. Faber, P.J. (2008). Stability of Stands to Wind: A Theoretical Approach. *Nederlands Bosbouwtijdschr*, 47, 320-325.

14. Popoola, F.S. and Adesoye, P.O. (2012). Crown Ratio Models for *Tectona grandis* (Linn. f.) Stands in Osho Forest Reserve, Oyo State, Nigeria. *Journal of Forest Science*, 28(2), 63-67.

15. Ezenwenyi, J.U., and Chukwu, O. (2017). Effects of Slenderness Coefficient in Crown Area Prediction for *Tectona grandis* Linn. f. in Omo Forest Reserve, Nigeria. @ *Current Life Science*, 3(4), 65-71. http://doi.org/10.5281 /zenodo.996326