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Growth Assessment and Slenderness Coefficient of *Gmelina arborea* Roxb. Plantation in Nazareth High School, Imeko-Afon, Ogun State

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ABSTRACT

Wind damage is a source of serious concern to forest manager. This study assessed the growth characteristics and slenderness coefficient of *Gmelina arborea* plantation in Nazareth High School, Imeko-Afon, Ogun state with the aim of ascertaining the stability of the tree stand against wind throw. Complete enumeration of the 184 trees was carried out. Tree height (TH) and diameter at breast height (DBH) were assessed while the basal area, volume and tree slenderness coefficient were estimated. DBH ranges from 20.0 cm to 80.70 cm with mean value of 36.33$\pm$0.88 cm while its height ranges from 3.80 m to 13.20 m with mean value 8.24$\pm$0.15m. Basal area and Volume ranges from 0.03m^2 to 5.37m^2 and 0.12m^3 to 5.37m^3 with mean value of 0.11$\pm$0.01 m^2 and 1.03$\pm$0.07 m^3 respectively. The result showed that t 137 of the 184 trees enumerated were in the height distribution class of 6-10cm while 126 are in the diameter class distribution of 20-39cm. All enumerated trees in the plantation had low TSC of >70 indicating a high stability and thus less susceptibility to wind throw. The study concludes that the plantation is less susceptible to damage as of the time of the study and recommends periodic assessment of the tree stability to avert environmental disaster and damage to students and teachers, buildings and properties.

Keywords: *Gmelina arborea*, Growth characteristics, Plantation forest, Slenderness coefficient,

Introduction

The forest, a renewable natural resource requires effective scientific management. The forest manager like any other resources manager requires reliable information of the current state of the standing timber on regular basis in terms of its yield, growth, quality, quantity, size and location of the forest resources available and how these resources are changing over time (Avery and Burkhart, 1994; Onilude and Adesoye, 2007). The information brings about knowledge on the growth and development of the forest stands which are considered very important in understanding the future behavior of the forest and also act as a guide to the forest manager in decision making on the forest.

Forests either natural or plantation plays a vital role in human life. They provides a wide range of resources, and ecosystem services such as carbon sink, produce oxygen vital for human existence on earth and also, help in regulation of hydrological cycle, purify water, provide wildlife habitat, help in reducing global warming, as well as absorbing toxic gases, contain pollution, conserve soil and above all connect human with nature (Owolabi, 2019). Despite the enormous benefits man obtained from the forests, man continuously making dangerous threats to the forest unbalancing the ecological system. These threats are commonly known as disturbances which can be natural or anthropogenic in nature, and can affect the composition and stability of forest stands.

Natural disturbances include wildfire, catastrophic wind events, drought, insect infestation, etc. while anthropogenic disturbances include pollution, forest fragmentation, and urbanization. The stability of a stand is mainly affected by both biological and physical factors (Nivert, 2001). The physical factors are related to the wind components, the topography and the site properties while the biological factors include the species characteristics. One of the measures that are being used to assess the stability of a tree stand is the slenderness coefficient.

The slenderness coefficient (SLC) of a tree is defined as the ratio of tree total height (TH) to diameter outside bark at 1.3m above the ground (DBH) when both variables are measure at the same units (Wang *et al*., 1998; Onilude and Adesoye, 2007; Oyebade *et al*., 2015). The SLC often serves as an index of tree stability or the resistance to wind throws (Navratil 1995; Onilude and Adesoye, 2007; Oyebade *et al*., 2015). The slenderness coefficient is important to the development and maintenance of crown size, leaf area (crown shyness) and the hydraulic supply of the leaf area (Onilude and Adesoye, 2007). The stability of a tree against wind throw may be influenced by several factors interacting together. These factors may include tree growth characteristics (for example, tree height, taper or form, the shape and size of crown, and the size and shape of the root system), site condition (for instance soil characteristics), and local wind characteristics (e.g. average wind speed, frequency of wind gusts).

Global studies on slenderness coefficient have shown that the slenderness coefficient is the principal factor affecting the susceptibility of a tree to wind or snow damage (Laiho, 1987; Lohmander and Helles, 1987; Rudnicki *et al*., 2004; Onilude and Adesoye, 2007; Oyebade *et al*., 2015). In general, a low slenderness coefficient value usually indicates a longer crown, lower center of gravity and a better developed root system (Onilude and Adesoye, 2007). Therefore, trees with higher slenderness coefficient values (i.e. slender trees) are much more susceptible to wind damage.

One major challenge of forestry development in Nigeria is the paucity of periodic information on stand growth. Sustainable management of forest stands can only be ensured if reliable and up to date information on growth condition is available. This information can assist the forest manager to have accurate and timely information on the current growing stock for better decision making. This study therefore aims to provide relevant information on the growth

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characteristics and stability status of the *Gmelina arborea* plantation in Nazareth High School, Imeko- Afon, Ogun State of Nigeria. This is done to avoid any possible injury to students and damages to the structure and buildings during heavy wind blow.

Material and Methods

Study Area

The study location was Nazareth High School, Imeko, Ogun state. The school is situated in the city of Imeko, Ogun state, Nigeria. It is located between latitudes of 7°24'N and 7°34'N. Longitudes of 2°45'E and 2°56'E. (Figure 1)

The study site is an area covering 0.154 hectare within Nazareth High school in Imeko-Afon. The plantation was seven years as of the time of the study. It was established in 1992 after *Gmelina arborea* Roxb, trees have been used for beautifying the school premises, so the remaining seeds were planted to occupy the open space and provide shade for students within the school compound.

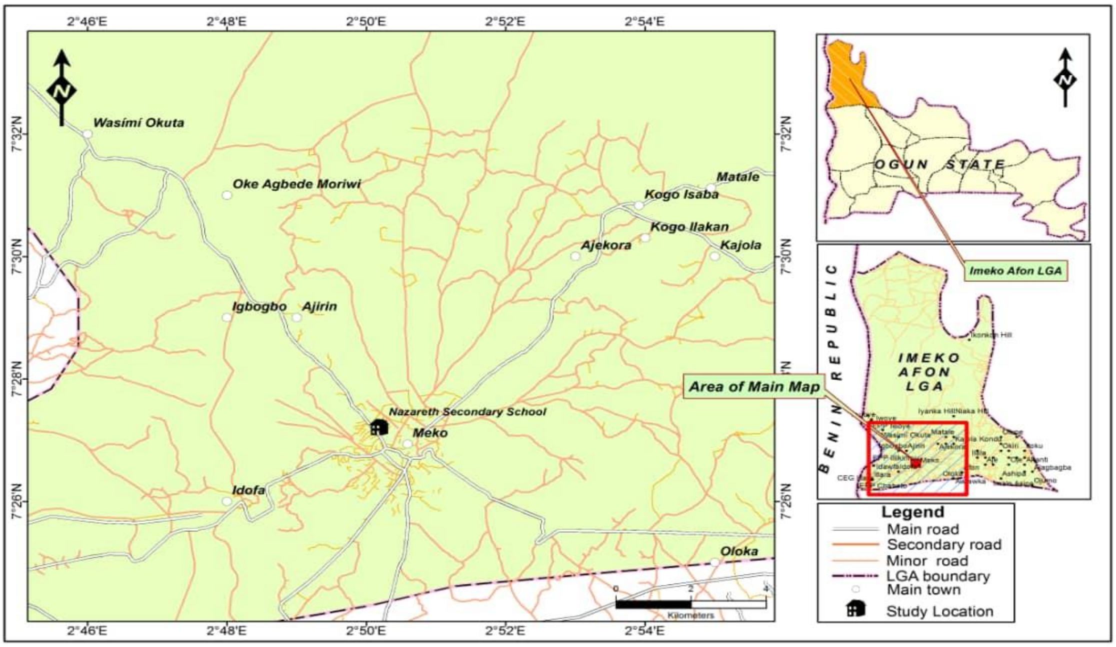

Figure 1: Map of study area

Sampling technique and data collection

Total enumeration of all the Gmelina stands was carried out using diameter tape and Haga altimeter. Data was collected on diameter at breast height (DBH) cm and Total height (m) of all the trees.

Data processing and analysis

The data collected were processed into suitable form for statistical analysis. The data collected were analyzed using descriptive statistics. The results were presented using tables and figures.

i. **Basal Area:** The basal areas of the trees in the plantation were calculated using this formula.

$$BA = \frac{\pi D^2}{4} \text{.........} \quad (1)$$

Where, BA = Basal Area (m^2), D = Diameter at breast height (cm), $\pi = 3.142$

ii. **Tree Slenderness Estimation:** Tree slenderness was estimated for all trees using this formula. .

$$SLC = \frac{TH}{DBH} \quad \text{.........} \ (2)$$

Where SLC = Slenderness coefficient, TH =Tree height (m), DBH = Diameter at breast height (cm). According to Onilude and Adesoye (2007), the slenderness coefficient values obtained were classified into the following categories

SLC value > 99 ………..High slenderness coefficient

70 <SLC values > 99 … Moderate slenderness coefficient

SLC values < 70 ……… Low slenderness coefficient

Result and Discussion

A total of 184 trees of *Gmelina arborea* stands were encountered within the school. Summary of the descriptive statistics is presented in table 1.

Table 1: Descriptive statistics of the *Gmelina arborea* stands in the study area

Variables	Min	Max	Std.Dev
DBH (cm)	20.00	80.70	11.91
TH (m)	3.80	13.20	2.01
BA (m^2)	0.03	0.51	0.08
SLC	70	90	

Note: DBH= diameter at breast height; TH= Tree height, BA = Basal Area; Vol = Volume; SLC slenderness coefficient, Min and Max= Minimum and Maximum value,, Std.Dev = Standard Deviation

Table 1 showed that the diameter at breast height ranges from 20.0cm to 80.70cm with mean value of 36.33±0.88 cm while its height ranges from 3.80m to 13.20 m with mean value 8.24±0.15m. Basal area and Volume ranges from 0.03m^2 to 5.37$m^2$and 0.12m^3 to 5.37$m^3$with mean value of 0.11±0.01 m^2 and 1.03±0.07 m^3 respectively. The plantation showed potential for rapid growth when compared with the result of Addo danso *et al.*, (2011) who reported an average diameter at breast height (DBH) of 9.5cm in a 5 year old

Nauclea diderichii plantation. Figure 2 shows that majority of the tree stands were in the class distribution of 6 – 10cm with 137 tree stands in that category while the least tree stands was found in class greater than 10. Also, 26 tree stands were in the class category 1 – 5cm.

The generality of the trees in the plantation were in the dominant height class of 6 – 10cm. This indicates a high growth rate among trees within that class distribution. This study correlates with the report of Kilawe *et al.*, (2001) who stated that even-aged plantation especially, young forest display rapid growth in their study of above ground biomass and carbon sink in Tanzania.

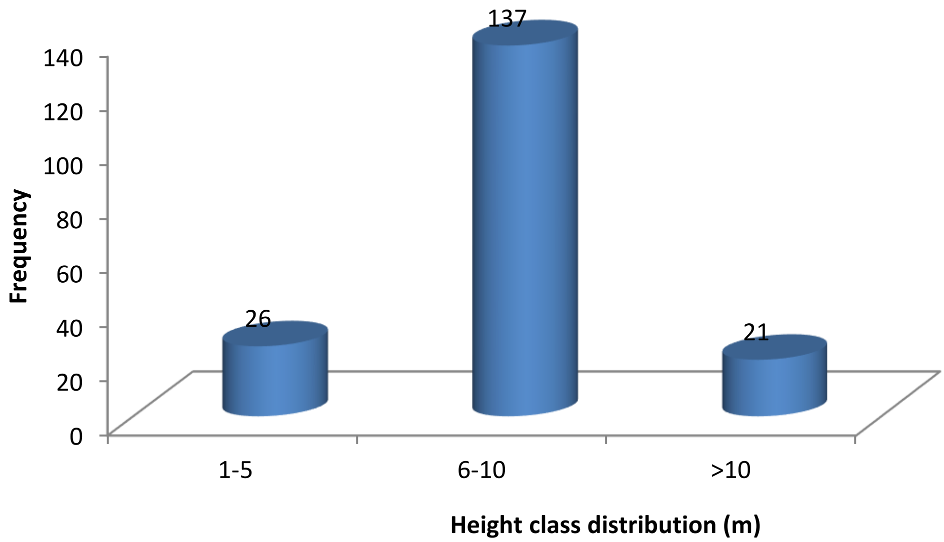

Figure 2: Height class distribution for *Gmelina arborea* tree stand

Figure 3 shows the diameter class distribution for the *Gmelina arborea* tree stands in the study site. 67 tree stands were in the Diameter class distribution of 20 – 29cm; this is closely followed by diameter class distribution 30-39cm with a total of 59 tree stands. The diameter class of 50-59cm had the least number of tree stands.

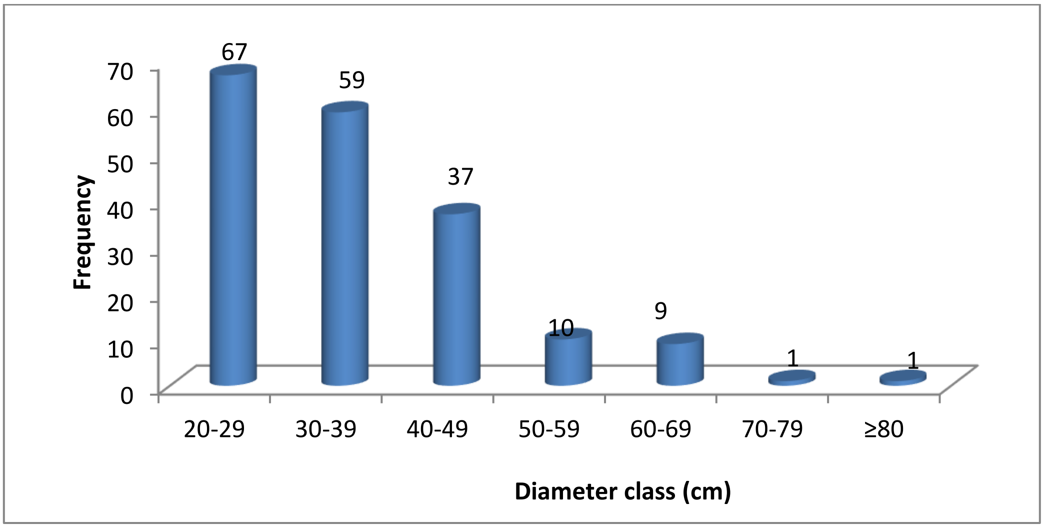

Figure 3: Diameter Class Distribution for *Gmelina arborea* tree stands

Figure 4 shows that all the trees within the premises of the Nazareth high school, Imeko-Afon are within the low slenderness coefficient category. This is an indication of good tree stability. When tree slenderness coefficient becomes very high, there is high possibility of such trees being susceptible to bending stress, leading to reaction wood, which may affect wood properties as well as the ultimate usage to which the wood can be put. This also implies that the likelihood of wind throw damage to trees leading to environmental hazard is low. This study corroborates the results of Onilude and Adesoye (2007); Ige and Akinyemi (2016) and Agbo-Adediran *et al*., (2018) who all reported that majority of the tree species in their studies were in the low slenderness coefficient category.

According to Adeyemi and Ugo-Mbonu (2017) high population of trees in the low slenderness coefficient category may be a result of adequate silvicultural treatments such as thinning at the early stage of stand development put in place. Jullien *et al*., (2013) observed that high slenderness coefficient is the best accurate indicator of tree growth stress as this was supported by the report of Peltola (2006) and Teste and Lieffers (2011).

However, with regards to the suggestion of Navratil (1995) that tree slenderness coefficient of > 99 be considered as having a high risk of wind throw, the plantation of *Gmelina arborea* in Nazareth High School, Imeko-Afon can be said to have high resistance to wind throw. Thus, indicating less damage to properties and injury to students.

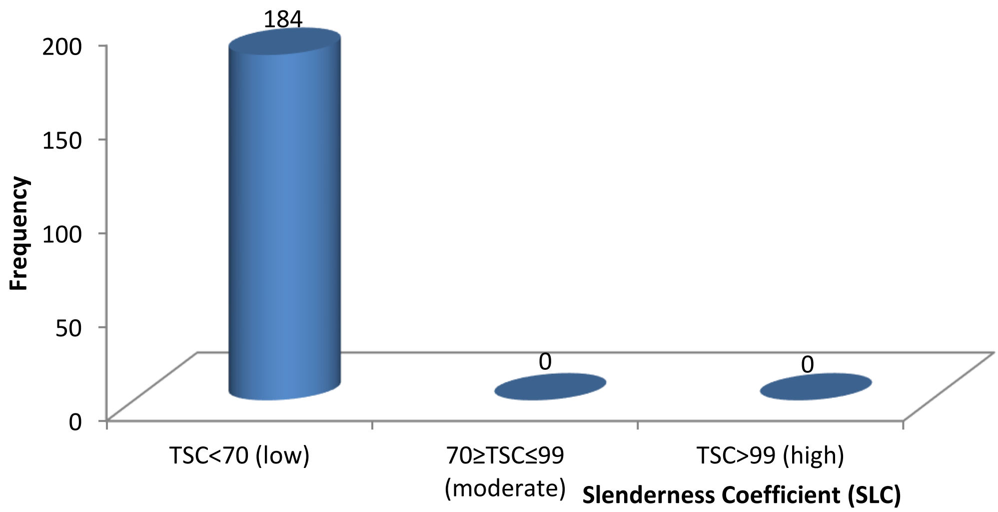

Figure 4: Tree slenderness coefficient

Figure 5 shows the relationship between diameter and the slenderness coefficient for the *Gmelina arborea* tree stands in the study area. The scatter plot revealed that diameter is inversely related with the slenderness coefficient. This implies that; as the diameter is increasing; the slenderness coefficient is decreasing, indicating that the trees are more stable as the diameter increases. This is in conformity with the result of Onilude and Adesoye (2007) and Ige and Akinyemi (2016).

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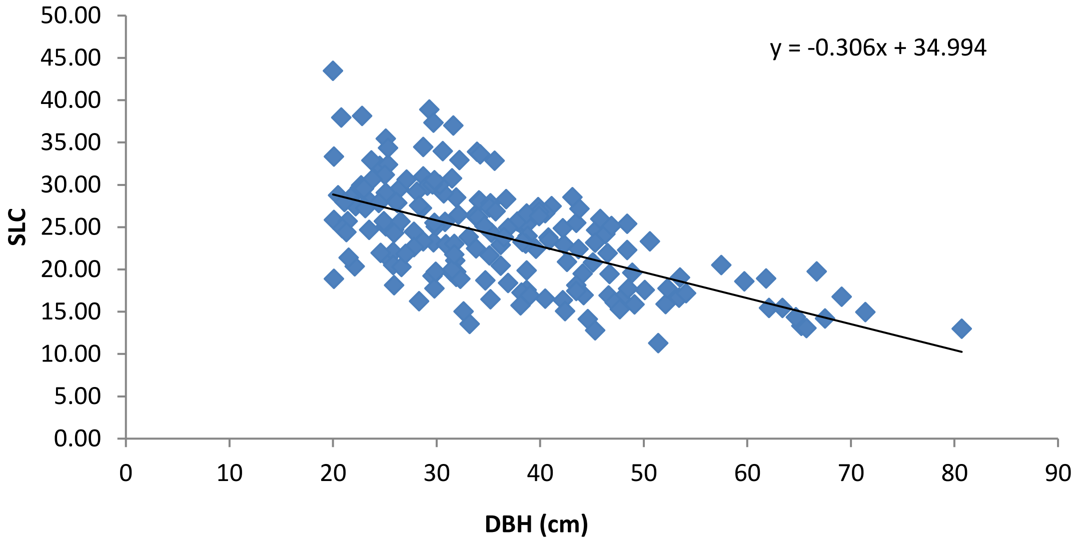

Figure 5: Scatter plot showing the relationship between diameter and tree slenderness coefficient

Figure 6 shows the relationship between tree height and the slenderness coefficient for the *Gmelina arborea* tree stands. The plot showed that with increase in height, there was a corresponding increase in the slenderness coefficient. This implies a higher susceptibility to wind throw as the trees grow taller. That is; increase in height is directly proportional to tree stability. This result agreed with the findings of Agbo-Adediran *et al.*, (2018) which reported that increase in height is directly proportional to stability (i.e. high SLC) in tree stands while increase in DBH is inversely proportion.

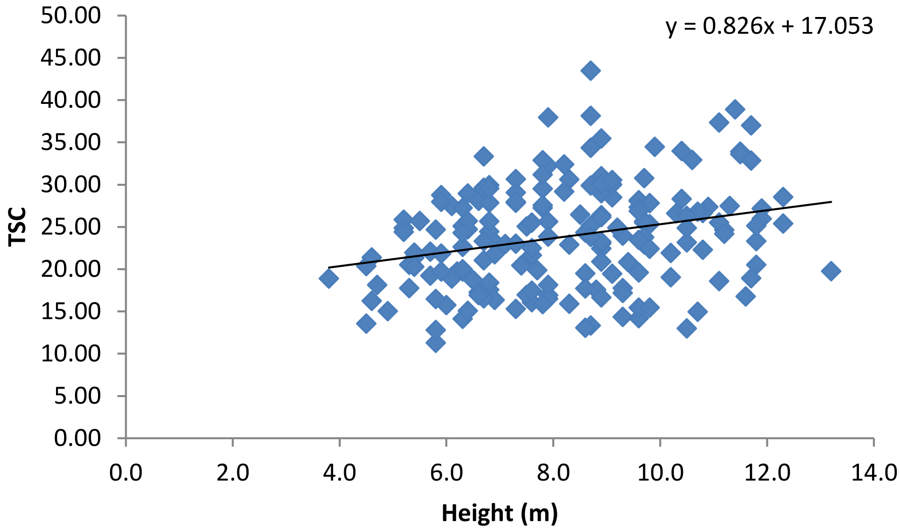

Figure 6: Scatter plot showing the relationship between tree height and tree slenderness coefficient

Conclusion and Recommendation

The study has projected the low possibility of occurrence of wind throw among the *Gmelina arborea* Roxb, trees in the plantation within the Nazareth High School, Imeko-Afon, Ogun state. The entire trees enumerated had low slenderness coefficient, indicating that the plantation is stable and less susceptibility to wind-induced damage.

The study therefore advances the need for periodic assessment of tree and or stand stability among other plantation to reduce susceptibility to wind throw so as to avert environmental disaster within forest plantations in Nigeria.

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