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Comparative Evaluation of Tree Slenderness Coefficients and Soil Properties of Two Teak Plantations in Ado-Ekiti, Nigeria

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Abstract: The susceptibility of a tree to windthrow is largely dependent on its tree slenderness coefficient (TSC). However, other factors such as soil properties may also be implicated. This study therefore evaluated TSC and soil properties of two teak plantations in Ekiti State University, Ado-Ekiti in order to deduce the reason for the susceptibility of one of them to windthrow. Plantation A has been highly susceptible to windthrow while Plantation B has not. Complete enumeration of all the trees in the two locations was done to obtain height and diameter at breast height data. Soil samples collected at depths 0-7, 7-15, 15-30, 30-60 and 60-80cm from the two plantations using soil auger and cores of known volumes were analyzed in the laboratory using standard methods. Furthermore, soil samples were analyzed for microbial biomass using standard methods. Results obtained showed that plantation A had 52 trees while plantation B had 143 trees with the two plantations having their highest number of trees in the diameter class 16-20cm followed by diameter class 21-25cm. The highest mean TSC value of 108.57 was found in plantation B in diameter class 10-15cm followed by 81.56 in plantation A still in diameter class 10-15cm while the least mean TSC value of 36.16 was obtained in plantation B under diameter class 36-40cm. Plantation B which has not been susceptible to windthrow had higher bacteria load than plantation A while reverse is the case in terms of fungi load. High soil bulk density (1.35 to 1.69 g/cm^3), high clay and silt content (30%) and high water table at 15 – 30cm depth plus high fungi activities under plantation A were factors implicated in the occurrence of windthrow. There was good relationship between TSC and some soil hydraulic properties. Therefore, sites that are prone to being waterlogged and with water table at shallow depth should be avoided for raising teak trees for these will make such trees susceptible to windthrow consequent upon shallow rooting depth and activities of fungi on the roots.

Key words: Tree Slenderness Coefficient · Soil Properties · Windthrow

INTRODUCTION

Tree Slenderness Coefficient (TSC) is the ratio of tree total height to diameter at breast height which is at 1.3m above ground level. It is important to evaluate TSC because of susceptibility of tree species to natural phenomena such as windthrow, breaking and total uprooting of trees as a result of heavy wind. According to Wang *et al*. [1], the effect of heavy wind on trees is seriously influenced by the TSC of such trees. Greater values of TSC usually above 100 indicate that the tree in question is tall, narrow and have greater risk of being windthrown while trees with lower TSC values of less than 80 are more stable. In other words, trees with TSC of between 80 and 100 could also be referred to as stable when all other environmental conditions are favourable but those below TSC of 80 are more stable and could withstand heavy wind. Tree with TSC of above 100 indicates that the tree is tall and unstable; that is such a tree is more susceptible to windthrow [2]. James [3] and Šebeň *et al*. [4] noted that slenderness coefficient of above 100 generally indicates low stability and the affected tree is likely to buckle under its own weight. However, that a tree is susceptible to windthrow may not

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be as a result of strong wind solely because other factors may be implicated especially that of soil. Stand conditions such as spacing, site soil and site quality such as soil fertility, presence of Nitrogen-fixing bacteria and other micro-organisms that are important for healthy growth of trees, topography (slope of the site) and wind patterns (direction of wind) are the significant factors that the TSC of trees largely depend [5]. Deep soils are better for tree growth than shallow soils because the former potentially have a greater store of nutrients and water holding capacity. Soil depth is one factor that may influence tree stability because planting deep-rooted species in a shallow soil may eventually impact on stability of such tree species. Rooting depth may be restricted by bedrock, coarse gravel, a hard pan layer or excess soil moisture thus making trees more susceptible to windthrow. Most tree species grow well when the soil remains moist most of the year, but only a few species tolerate very dry or very wet conditions [6]. Trees can be windthrown in strong winds especially when heavy rain has saturated soils reducing soil strength [7]. Soils may be too dry for good root growth where the soil is sandy, rocky or shallow, making trees in such plantations very susceptible to windthrow. Furthermore, soil meso-fauna and micro-fauna may also influence tree stability especially by causing rot and other diseases in such trees.

Soil is one of the most important reservoirs of biodiversity that reflects ecosystem metabolism as it is a medium for all the biological and geochemical processes that influence tree growth. Within the complex structure of soil, the biotic and abiotic components relate to control the degradation and decomposition of organic matter thus inducing nutrient recycling processes. In almost every ecosystem function, the importance and contributions of soil fauna and flora are enormous. Soil fauna is an agent of transformation for added and native organic matter. The activity of the microbial population is used to characterize the microbiological status of the soil [8]. The roles and functions of soil fauna were recognized in soil formation and leaf litter decomposition in the tropical forest region for mixed leaf litter [9]. The more common root diseases are caused by fungi, although root disease also can be associated with abiotic factors such as flooding and soil compaction. Root disease as a result of fungi attack can destroy the tree's root system, resulting in growth loss, decay, death, or windthrow of infected trees [10]. Soils are multi-component and multi-function systems which provide a series of ecosystem goods (biomass production to humans). It also provides many regulatory services such as the decomposition of soil organic matter, soil structure maintenance and nutrient cycling among others which ensure ecosystem sustainability. All these functions are output of biological processes provided by variety of organisms which live in the soil [11].

Importance of soil fauna in ecosystem cycling was disclosed in its potential as indicator of soil health [11]. They play a vital role in the functioning of soil with regards to the decomposition and mineralization process by creating new surface areas for microbial colonization. Nevertheless, soil fauna may cause diseases in trees such as root rot. Root rot is a disease that attacks the roots of trees growing in wet or damp soil. This decaying disease can cut short the life of any tree or plant and has symptoms similar to other diseases and pest problems, like poor growth, wilted leaves, early leaf drop, branch dieback and eventual death [12]. Heart rot is a fungal disease that causes decay at the center of trunks and branches thereby making such trees susceptible to windthrow. This study therefore investigates tree slenderness coefficient, soil properties and soil micro-fauna as they affect the susceptibility of *Tectona grandis* trees to windthrow.

MATERIALS AND METHODS

The study was conducted on the campus of Ekiti State University (EKSU), Ado-Ekiti, Southwestern Nigeria, which harbours two teak plantations used for this study. EKSU has humid tropical climate characterized by distinct dry and wet seasons. The choice of the two plantations is influenced by the fact that one of them has been highly susceptible to windthrow whereas the other is not. They will be referred to as Plantation A and Plantation B in this study with Plantation A being the one susceptible to windthrow while Plantation B is the one not susceptible to windthrow. Plantation A was established in 2007 while Plantation B was established in 2004.

Inventory Data, Collection of Soil Samples and Microbial Analysis: Total height and diameter at breast height (dbh) of all the trees in the two plantations were measured with the aid of Spiegel Relaskope and diameter tape respectively. Soil samples for microbial analysis were collected from the two sites into different polythene bags and covered with moistened sand. This was done to prevent the soil from drying out thereby affecting the microbial biomass negatively. The samples for evaluating the soil properties were collected at depths 0-7cm, 7-15cm, 15-30cm, 30-60cm and 60-80cm from the two plantations using cutlass, core and soil auger.

Microbial Analysis: Soil samples were taken from the two plantations at a depth of 0-15cm and 15-30cm from five different points in each plantation using soil auger. Samples of the same depth were bulked for each plantation to obtain two samples from each plantation. A portion of the sample (0.5g) was taken, saturated with distilled water and the resulting solutions subjected to serial dilution after shaking. For serial dilution, 40 small sterile test tubes were used to which 4.5ml of distilled water was added to each. The 40 test tubes were then divided into four groups of 10 test tubes. Each group was labelled according to the four samples. 0.5ml of each diluted sample was added to one test tube each from the four groups of test tubes according to the label. From the first group of test tubes, 0.5ml of the diluted micro-organism suspension from different groups was added to the second set of test tubes in the groups. The process continued in the same fashion to the tenth test tube in each group. Thus, in the first test tubes, the micro-organisms were diluted 10fold, a 1:10 dilution while in the second group of test tubes, micro-organisms were diluted 20fold, 1:20 up to the tenth tube where the suspension was diluted to 100fold 1:100 For the plating of cells, two agar were used. The Nutrient Agar (NA) was used for bacteria while Potato Dextrose Agar (PDA) was used for fungi. The culture was stored under appropriate conditions and after 36hrs, the number of colonies formed was counted from which the total bacteria and fungi were calculated using:

$$TBC/TFC = \frac{\text{Number of Colonies} \times \text{Volume of Inoculum}}{Dilution\ Factor}$$

where TBC is Total Bacteria Count and TFC is Total Fungi Count.

Soil Analysis: Particle size analysis of the soil samples was carried out using hydrometer method as proposed by Gee and Bauder [13].

Bulk density, estimated from undisturbed core samples that were oven-dried at 105°C for 48 hrs was determined according to the relations proposed by Blake and Hartge [14].

Soil moisture content was determined by weighing in situ, using sensitive weighing scale the soil samples collected on the field. Thereafter, the soil samples were taken to the laboratory and oven-dried at 105^0C for 48 hrs and the final weight was taken. Soil moisture was then calculated as follows:

$$GWC = M_w/M_{ds}$$

where GWC is the gravimetric water content gg^{-1}, M_w is the amount of water in the soil sample g, M_{ds} is the mass of oven-dried soil g.

Soil pH was determined in a 1:1 soil water suspension while readings were taken using Jenway pH meter by the glass electrode.

Organic matter (OM) was determined by Walkley-Black dichromate wet oxidation method as described by Nelson and Sommers [15].

Cation Exchange Capacity (CEC) was determined using the method described by Rhodes [16].

RESULTS

Tree Slenderness Coefficient (TSC) in the Two Plantations: The summary of inventory data and TSC in the two plantations is shown in Table (1). Plantation A had 52 trees while plantation B had 143 trees. The two plantations have their highest number of trees in the diameter class 16-20 cm followed by diameter class 21-25 cm. Plantation B has trees that have dbh of above 30 cm whereas only two trees in plantation A fell within diameter class 26-30 cm. The highest mean height was found in plantation A with a value of 13.5 m, followed by 13.29 m in plantation B while the least mean height value of 10.5 m was found in plantation A. The highest mean TSC value of 108.57 was found in plantation B in diameter class 10-15 cm followed by 81.56 in plantation A still in diameter class 10-15 cm while the least mean TSC value of 36.16 was obtained in plantation B under diameter class 36-40 cm (Table 1).

Population of Microorganisms in the Soil of the Two Plantations

Bacteria Population in the Soil of the Two Plantations: The total bacteria count (TBC) in the two plantations is shown in table (2). Plantation A with TBC value of 1.73×10^7 was higher than that of plantation B having a value of 8.6×10^6 at a depth of 0-15 cm with dilution factor of 10^{-5}. However, at the same depth with dilution factor of 10^{-6}, TBC in plantation A with a value of 1.3×10^7 was less than that of plantation B having a value of 1.7×10^7. Furthermore, TBC in plantation A with a value of 2.8×10^6 at a depth of 15-30 cm with dilution factor of 10^{-5} was less than that of plantation B having a value of 5.6×10^6. Similarly, at the same depth but with dilution factor of 10^{-6}, TBC in plantation A with a value of 2.1×10^7 was less than that of plantation B having a value of 3.3×10^7.

Table 1: Summary of Inventory Data and TSC in the Two Plantations

	No. of Trees		MDbh (cm)		MTht (m)		MTSC	
Diameter Class (cm)	A	B	A	B	A	B	A	B
10-15	31	24	13.23	12.48	10.78	13.16	81.56	108.57
16-20	23	38	17.91	18.39	12.10	13.19	68.47	72.34
20-25	14	35	23.5	22.92	13.5	13.29	58.30	58.58
26-30	2	22	27.5	28.00	10.50	13.11	38.18	47.07
30-35	0	18	0	32.67	0	13.19	0	40.61
36-40	0	6	0	36.50	0	13.13	0	36.16
Total	52	143						

Where No. of Trees = Number of Trees, MDbh = Mean Diameter at Breast Height, MTht = Mean Total Height, MTSC = Mean Tree Slenderness Coefficient

Table 2: Bacteria Population in the Soil of the Two Plantations

Plantation	Depth (cm)	Inoculum (ml)	Dilution Factor	Agar	No. of Colonies	TBC
A	0-15	1	10^{-5}	N.A.	173	1.73×10^{7}
A	0-15	1	10^{-6}	N.A.	13	1.3×10^{7}
A	15-30	1	10^{-5}	N.A.	28	2.8×10^{6}
A	15-30	1	10^{-6}	N.A.	21	2.1×10^{7}
B	0-15	1	10^{-5}	N.A.	86	8.6×10^{6}
B	0-15	1	10^{-6}	N.A.	17	1.7×10^{7}
B	15-30	1	10^{-5}	N.A.	56	5.6×10^{6}
B	15-30	1	10^{-6}	N.A.	33	3.3×10^{7}

*N.A. = Nutrient Agar, TBC = Total Bacteria Count

Table 3: Fungi Population in the Soil of the Two Plantations

Plantation	Depth(cm)	Inoculum(ml)	Dilution Factor	Agar	No. of Colonies	TFC
A	0-15	1	10^{-3}	PDA	528	5.28×10^{5}
A	0-15	1	10^{-4}	PDA	152	1.52×10^{6}
A	15-30	1	10^{-3}	PDA	184	1.84×10^{5}
A	15-30	1	10^{-4}	PDA	161	1.61×10^{6}
B	0-15	1	10^{-3}	PDA	172	1.72×10^{5}
B	0-15	1	10^{-4}	PDA	89	8.9×10^{5}
B	15-30	1	10^{-3}	PDA	91	9.1×10^{5}
B	15-30	1	10^{-4}	PDA	47	4.7×10^{5}

*PDA = Potato Dextrose Agar, TFC = Total Fungi Count

Fungi Population in the Soil of the Two Plantations: The total fungi count (TFC) in the two plantations are shown in Table (3). Plantation A with TFC value of 5.28×10^{5} was higher than that of plantation B having a value of 1.72×10^{5} at a depth of 0-15 cm with dilution factor of 10^{-3}. Similarly, at the same depth with dilution factor of 10^{-4}, TFC in plantation A with a value of 1.52×10^{6} was still higher than that of plantation B having a value of 8.9×10^{5}. Furthermore, TFC in plantation A with a value of 1.84×10^{5} at a depth of 15-30 cm with dilution factor of 10^{-3} was higher than that of plantation B having a value of 9.1×10^{5}. Similarly, at the same depth but with dilution factor of 10^{-4}, TFC in plantation A with a value of 1.61×10^{6} was higher than that of plantation B having a value of 4.7×10^{5}. At all depths and dilution factors, TFC in plantation A was higher than that of plantation B.

Soil Physical Properties in the Two Plantations: The summary of the results obtained from the physical analysis of soil samples collected from the two plantations is presented in Table (4). Textural class of the soils under the two plantations varied from sandy loam to loamy sand from surface (0 - 7cm) to bottom (60 - 80cm) of the sampling pits. Sand content of the two soils was high and ranged between 69.7% at 60 – 80cm in plantation A to 85.3% at 0 – 7cm under plantation B with significant difference noted from top to bottom across the two plantations, even as the values decreased generally down the pit. Silt and clay contents however, showed a contrary pattern. For instance, under plantation A, total silt and clay contents increased from 17.5 at 0 – 7 cm to 30.3 at 60 – 80 cm depth.

Table 4: Mean Values for Soil Physical Properties in the Two Plantations

Soil Depth (cm)	Sand (%) A	Sand (%) B	Clay (%) A	Clay (%) B	Silt (%) A	Silt (%) B	BD(g/cm3) % A	BD(g/cm3) % B	Moisture A	Moisture B	OM A	OM B
0-7	82.5	85.3	7.0	7.4	10.5	7.8	1.5	1.2	13.5	12.7	3.43	4.09
7-15	80.8	85.3	7.7	8.9	11.5	5.8	1.5	1.2	12.7	9.9	1.48	3.26
15-30	78.5	82.8	8.7	12.4	12.8	4.8	-	-	-	-	1.40	3.11
30-60	75.5	84.3	10.7	6.3	13.8	4.5	-	-	-	-	0.67	2.31
60-80	69.7	71.3	13.0	14.9	17.3	8.3	-	-	-	-	0.48	1.38

Where BD= Bulk density and OM= Organic Matter

Table 5: Students' t-test Result for Some Soil Properties of the Two Plantations

	CEC	Sand	Clay	Silt	OM	pH
Sig. (2-tailed)	0.00*	0.02*	0.70	0.00*	0.15	0.00*

*indicates significance at $p \leq 0.05$
Where OM= Organic Matter and CEC= Cation Exchange Capacity

Table 6: Mean Values for pH and CEC in the Two Plantations

Soil-Depth (cm)	Mean pH A	Mean pH B	Mean CEC ($cmol^{-1}$) A	Mean CEC ($cmol^{-1}$) B
0-7	6.35	6.71	9.18	10.85
7-15	6.47	6.22	5.03	8.73
15-30	6.01	6.42	5.03	8.88
30-60	6.09	6.31	4.10	6.25
60-80	5.61	6.47	3.33	6.25

CEC= Cation Exchange Capacity

The bulk density values were markedly different for the two plantations as shown in Table 4. Bulk density values of the surface soil for Plantation A ranged from 1.35 to 1.69g/cm^3 averaging 1.50g/cm^3. On the other hand, soil bulk density under plantation B averaged 1.2g/cm^3. Furthermore, when soil moisture content was considered, plantation A had the higher values of 13.5% and 12.7% for the two depths sampled than those of plantation B which were 12.7% and 9.9%.

Furthermore, organic matter content decreased as soil depth increased for the two plantations. Nevertheless, the highest value of 4.09 was obtained in plantation B followed by 3.43 in plantation A while the lowest value of 0.48 was obtained in plantation A (Table 4).

Students' t-test result for soil properties of the two plantations are shown in Table 5. There was significant difference in percentage sand and silt whereas there was no significant difference for percentage clay and organic matter content in the two plantations.

Soil Chemical Properties in the Two Plantations: The chemical properties of the soils under the two plantations are presented in Table 6. The pH values ranged from 5.61 at 60 – 80cm depth to 6.47 at 7 – 15cm depth. The average pH value of over 6 indicates a slightly acidic condition for the two soils. Furthermore, cation exchange capacity (CEC) decreased as soil depth increased in the two plantations. The highest mean CEC value of 10.85cmol^{-1} was obtained in Plantation B followed by 9.18cmol^{-1} in Plantation A while the lowest value of 3.33cmol^{-1} was obtained in Plantation A (Table 6). Students' t-test revealed significant difference for pH and CEC in the two plantations (Table 4).

Relationship between Tree Slenderness Coefficient (TSC) and Soil Physico-Chemical Properties of the two Plantations: The relationship between TSC and some soil properties is shown in table (7). The result revealed positive relationship between TSC and pH; likewise between TSC and cation exchange capacity (CEC); TSC and organic matter; and TSC and Sand in the two plantations. The correlation coefficient values of 0.68 and 0.57 in plantations A and B respectively between TSC and pH are indications of strong positive relationship. It means that as pH increases, TSC will also increase. Also, correlation coefficient values of 0.84 and 0.94 for plantations A and B respectively between TSC and CEC revealed very strong positive relationship. It means that as CEC increases, TSC will likewise increase. The correlation coefficients values of 0.90 and 0.92 in plantations A and B respectively reveals a very strong direct relationship between TSC and organic matter. It means that as organic matter increases, TSC will also increase while the correlation coefficient values of 0.75 and 0.66 for plantations A and B respectively also revealed a strong positive relationship between TSC and Sand. It means that as sand content increases, TSC will also increase.

However, correlation coefficient values of -0.49 and -0.26 for plantations A and B respectively indicate an inverse relationship between TSC and Clay. It means that as clay increases, TSC will decrease. Correlation coefficient values of -0.26 and -0.27 for plantations A and B respectively are indications of very weak inverse relationship for TSC and Silt. This also means that as Silt content increases, TSC will decrease.

Table 7: Correlation of TSC and Some Soil Properties in the Two Plantations

	pH		CEC		OM		Sand		Clay		Silt	
	A	B	A	B	A	B	A	B	A	B	A	B
TSC	0.68	0.57	0.84	0.94	0.90	0.92	0.75	0.66	-0.58	-0.49	-0.26	-0.27

*CEC = Cation Exchange Capacity, OM = Organic Matter and TSC = Tree Slenderness Coefficient

DISCUSSION

The fact that no tree in plantation A had TSC value that is above 100 yet the trees there suffer windthrow requires investigation of other factors that influence windthrow. Contrariwise, the trees in plantation B which do not get affected by strong wind yet have higher TSC values than those in plantation A indicate that windthrow does not only occur when TSC values are higher than 100. James [3] and Šebeň *et al*. [4] noted that slenderness coefficient above 100 generally indicates low stability and the affected tree is likely to buckle under its own weight. However, this study revealed another factor that may influence the value of slenderness coefficient of a tree. It was discovered that trees in plantation B that have TSC of above 100 forked below breast height thereby making the forked trees to have smaller diameter values than other trees in the plantation yet such trees have not been susceptible to windthrow. Moreover, Stathers *et al.* [17] suggested other factors that affect windthrow to include individual tree characteristics, stand level characteristics, soil characteristics, topographic characteristics and meteorological conditions. The opinion of Ruel [5] that stand conditions such as spacing, site soil and site quality such as soil fertility, presence of Nitrogen-fixing bacteria and other micro-organisms that are important for healthy growth of trees, topography (slope of the site) and wind patterns (direction of wind) are the significant factors that the TSC of trees largely depend holds true for this study.

Plantation B which has not been susceptible to windthrow had higher bacteria load than plantation A whereas reverse is the case in terms of fungi load. This result indicates that bacteria activities in a site may not be lethal to growth of teak trees. Close observations of trees in plantation A that were totally uprooted due to strong wind revealed rotten roots which implicate fungi activities in this site. The values recorded for fungi load in plantation A were higher than most of the values recorded by Adeduntan [18] for fungi in Omo, Oluwa and Akure Forest Reserves which are strong indications of fungi activities affecting roots of teak trees in Plantation A thereby making the trees there susceptible to windthrow.

The textural composition of the soils under the two plantations exhibited a marked difference. For instance, sand content was significantly higher in plantation B than in A. Moreover, the clay plus silt content in the two plantations studied were also different from each other. However, bulk density was found to be significantly higher in Plantation A than Plantation B. Bulk density is an indication of soil compaction. It reflects the soil's ability to function for structural support, water and solute movement; and soil aeration [19]. Root growth and penetration is said to be supported at bulk density of $1.2g/^{cm3}$ and limited seriously when bulk densities exceed $1.6g/cm^3$[20]. Bulk density in Plantation A ranged from 1.3 to $1.69g/cm^3$ and had an average value of $1.5g/cm^3$ and thus could have seriously limited root growth of Teak trees in the plantation considering the fact that the value is closer to the peak value that does not favour root growth. Although, probably if lower depths were considered, the values for bulk density might have been higher still though collection of samples for bulk density at lower depths in Plantation A was hampered by the water table encountered at lower depths, especially from 15 – 30cm..

The soil moisture content in Plantation A was higher than that of Plantation B. As earlier pointed out, water table was discovered at about 15 - 30cm depth in Plantation A. Also, Plantation A is less than 20m distance from a perennial stream whereas Plantation B is about 1km away on the upland. Kadambi [21] reported that in waterlogged, alluvial and clayey soils, roots of *Tectona grandis* were stunted and the taproot very poorly developed. Similarly, Robertson [22] observed that waterlogged, shallow and compacted soils should be avoided for growing teak. The onset of water table at shallow depth could have also favoured activities of microorganisms especially fungi thereby having damaging effects on the roots of teak trees in Plantation A. Werner [7] reported that trees can be windthrown in strong winds especially when heavy rain has saturated soils reducing soil strength. This might have been another cause of susceptibility of trees in Plantation A to windthrow for the soil samples were taken during rainy season and this is usually the season when this windthrow usually occurs in the plantation.

The soil organic matter content of the soil in Plantation B was higher than in Plantation A across depths which is an indication of higher soil quality in the former than in the latter. Soil organic matter (SOM) is often used in assessing soil quality. SOM is the capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality and promote plant and animal health [23]. Many soil properties that have been suggested as measures of quality are directly or indirectly linked to SOM, such as total organic carbon (C)) and nitrogen (N), labile organic carbon, microbial biomass carbon and nitrogen, potentially mineralizable nitrogen, soil respiration and the ratio of microbial biomass carbon to total organic carbon [23,24].

CEC is a property of the soil that describes its capacity to supply nutrient cations to the soil solution for plant uptake [25]. Soils with a low CEC are more likely to develop deficiencies in potassium, magnesium and other cations while high CEC soils are less susceptible to leaching of these cations [26]. The lower the CEC of a soil, the faster the soil pH will decrease with time [27].

Soil pH in the two plantations showed slight acidicity with values averagely above 6 which is typical of soils in Southwestern Nigeria. Robertson [22] reported that teak thrives best in soils that are neutral, or slightly alkaline so the most favourable soils for growth and development usually have a pH of between 6.5 and 7.5. Extremes in soil pH (<4.5and>8.5) can make some nutrients toxic and others unavailable to plants [28].

CONCLUSION

This study examined the TSC, soil properties and microbial biomass of Two Teak Plantations in Ekiti State University, Ado-Ekiti, Nigeria. The TSC values in Plantation A did not indicate its susceptibility to windthrow for the values were below 100 for all trees. Even though Plantation B had some TSC values that were above 100, the trees there had not been susceptible to windthrow hitherto because soil conditions and microbial biomass were favourable. However, fungi population in Plantation A which was higher than that of Plantation B could have been responsible for root rot of teak trees in the former thereby making the trees susceptible to windthrow. In addition, high bulk density (1.69g/cm^3) and high clay plus silt content(30%) values coupled with the presence of moisture at shallow depth obtained in Plantation A could have caused limited root growth and penetration by reducing soil aeration at lower depth. This condition also could have made the trees in Plantation A susceptible to windthrow. Moreover, moisture availability at very shallow depth in Plantation A could have favoured fungi activities. Therefore, sites that are prone to being waterlogged and with water table at shallow depth should be avoided for raising teak trees for these will make such trees susceptible to windthrow consequent upon shallow rooting depth and activities of fungi on the roots.

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