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EVALUATION OF NATURAL DURABILITY OF THE WOOD OF *BORASSUS AETHIOPUM.* MART. AT DIFFERENT ECOLOGICAL ZONES AGAINST SUBTERRANEAN TERMITE (*MACROTERMES BELLICOSUS.* SMEATHMAN) IN NIGERIA

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Abstract

Natural durability of the wood of Borassus aethiopum was evaluated to assess its utilization potentials. Samples for the study were collected from natural forest locations in three ecological zones in Nigeria, namely: Derived savannah, Sudan savannah and Guinea savannah. Five trees were sampled at base (10 %), middle (50 %) and top (90 %) of the merchantable height and from bark to bark radially from each of the ecological zones. A split plot statistical method was used to test the significance of the variability in the percentage weight loss at 5% probability level. The percentage weight loss was 15.32 ± 0.05 % with mean value 10.37 ± 0.02 % at the base, 12.21 ± 0.21 % at the middle and 23.40 ± 0.11 % at the top. Across the bole, it ranges from 0% to 31.18±0.21% at the base, 0% to 34.57 ± 1.31 % at the middle and 0% to 61.16±0.78% at the top. However, among the ecological zones, highest weight loss was observed in Derived savannah followed by Guinea savannah and Sudan savannah with 15.98 ± 0.01 %, 15.26 ± 0.35 % and 14.75 ± 0.11 % respectively.

According to the rating, the outer wood, middle wood and inner wood are rated. We observed trace of termite attack: moderate termite attack and heavy termite attack respectively in accordance with ASTM D1758-74. We conclude that the outer wood of B. aethiopum can be used without preservation because termite was unable to destroy it but every other part (centre and inner wood) must be preserved to increase the service year.

Keywords: *B. aethiopum, M. bellicosus, durability, termite, and eco-zones*

1. Introduction

The importance of wood in the world economy cannot be over emphasized. Its excellent potential as a structural material can be jeopardized by the attack of bio-deteriorating agents such as fungi and insects. Ogunsanwo *et al.* (2002) noted that large quantities of timbers are destroyed annually by these agents. Wood is a biological material that can be viewed as a renewable source of energy which will continue to exist as long as the sun shines, and, when used properly, will not decay. But if exposed to favourable condition for bio-deteriorating agents when in use, lumber and other wood products succumb to the same biological processes that decompose dead trees in the forest. In the forest, decomposition of wood is nature's way of recycling, but to the homeowner or farmer, decayed wood products mean added repair or replacement costs (Reeb, 1997; Croan, 1997; Clausen, 2010). Wood is also liable to attack by agents of degradation especially in packaging, storage and service leading to deterioration. Wood destruction occurs when the cellulose cell walls are broken, and this result in loss of weights (80% of its dry weight) and value (Badejo, *et al.,* 2001). Wood structures are affected by fungi, insects and other micro-organisms which cause rot and decay, (Ogunsanwo *et al.,* 2002 and Akinyemi *et al.*, 2004) especially under a suitable humid climate or wherever wood comes in contact with ground or water (Ogunsanwo, *et al.*, 2002).

Termites cause the most serious damage of all wood-feeding insects especially in Nigeria. (Ojo, 2016). In addition to timber and wood products, they attack growing trees, leather, rubber, and wool as well as agricultural crops (Malaka, 1983). Significant damage is caused by termites to man-made fabrics, polythene, plastics, metal foils, books, furniture, wooden telephone poles, wooden railway sweepers, and insulators of electric cables (Malaka, 1996).

Therefore, if wood is to be effectively and maximally utilized for construction and engineering purposes, practices that will minimize the hazard of biodeterioration must be considered, and these include evaluation of its natural durability to establish if there will be need for preservation against termite.

Maccrotermes bellicosus is an aggressive termite prevalent in tropical Africa causing high percentage of damage by termite in Nigeria. (Ojo, 2016), and *Borassus aethiopum* is a multipurpose palm, providing multifunctional uses in the areas of shelter, food supply, improvement of the economic status (income and employment) of the rural people and the protection of the environment from degradation and biodiversity depletion (Tee, *et al.*, 2006). Every part of the tree can serve any of the socio-cultural, economic and environmental needs of humanity. The wood has been excellently used in building construction and it is generally believed to be naturally durable (Ajaiyeoba and Nwaruh, 1983). The English names are Ron Palm (Phillipe, 1999), Giant Africa Palmyra Palm, African fan palm (FAO, 2006) or Elephant palm (Sanon and Sacande, 2007),

Apart from strength properties, resistance to decay and other wood deteriorating attacks is fundamental to wood utilization potentials. With the conditions in the tropics being extremely conducive for wood destroying agents, natural durability of wood and allied products is one of the most important factors affecting the use of timber. It is necessary therefore to investigate the natural durability of the species to bring out its full potentials for effective utilisation.

2. Materials and method

2.1.The study Area

The study area consists of three ecological zones in Nigeria, namely: a derived savannah from south west, Guinea savannah and Sudan savannah. The locations of collection were: Sudan savannah-Kano (Kano state), Guinea savannah-Okenne (Kogi state) and derived savannah-Ife-Odan (Osun state). Nigeria is located in the tropical zone (between latitude 10º 00'N and longitude 8º 00') with a vast area having savannah vegetation (Salako, 2003). This is a region that is itself diverse, necessitating a classification into derived savannah, southern Guinea savannah and northern Guinea savannah and Sudan savannah.

The states in the Sudan savannah ecological zone of Nigeria includes Sokoto, Bauchi, Kano, Kastina, Yobe, Zamfara, Jigawa, Kebbi, Taraba, Gombe, Borno and Adamawa state. The zone is characterized by tall grasses and Acacia trees with an annual rainfall of less than 1000mm and as low as 500mm in the upper region. The rainy season could be as short as 3 months, while the relative humidity is generally low (Adejumo and Raji, 2007).

Guinea savannah lies approximately between longitudes 3^0 and 14^0E and latitudes 7^0 and 10^0N. The climate of the area is characterized with relatively high temperatures throughout the year. The average annual maximum varies from 35ºC and 31ºC throughout the year while the average annual minimum is between 23ºC and 20ºC. The Guinea savannah area includes part of Adamawa and Taraba, Benue, Abuja, Kwara, Kogi and Niger, Enugu (Ayanlade and Odekunle, 2009).

While the derived savannah for this study is Iwo, in Osun sate, Osun state lies between latitudes 7^0 37'E and longitudes 4^0 10'N. It is located in the South Western part of Nigeria, bounded by Oyo in the West, Kwara in the North, Ekiti in the East and Ondo in the South. It has a total land area of 9,396km^2. It has the characteristic of West Africa Monsoonal climate with a markedly bimodal distribution of rain. The rainfall pattern ranges from 1,475mm per annum in the southern part to 1,125mm in the northern area. The maximum temperature is at 32.5^{0}C and relative humidity 79.90% (Nyenka, 2000).

2.2.Sample selection and Data collection

Five (5) trees were felled at each of the sites (Derived savannah, Guinea savannah and Sudan savannah) especially during the boom. To ensure minimal influence of age, lack of management and other variables, trees initiating swollen top with uniformly close diameter were chosen.

Bolts of 500mm long were cut from each sample tree at the base, middle and top of the merchantable height, resulting in fifteen (15) bolts in each of the ecological zone. The bolts were then taken to the Wood Workshop of Forest Products Development and Utilization Department, Forestry Research Institute of Nigeria, Ibadan for further conversion to test samples.

Selection of representative samples for test was carried out from the central planks obtained from all the bolts to give 45 planks from where test samples for all the experiment were obtained: 15 for each of the ecological zone. The radial position was divided into 6 compartment from bark to bark.

To evaluate durability of a timber, long term outdoor and ground contact testing, more commonly known as 'grave-yard' testing, has been adopted by many researchers, including Ling, *et al*., (2003)

Test specimen of 19x19x457mm in accordance with ASTM D 1758-74 was adopted as the testing protocol. The test samples were buried in a graveyard with evidence of infestation by termite, with spacing not less than 300mm between specimens and not less than 600mm between rows in accordance with ASTM D 1758-74 (Plate 1). The initial weight was first determined before taken to field. The experiment lasted for 12 months on the field (Timber graveyard) and the weight loss was determined by using the following formula in accordance with American standard for Testing Materials (ASTM D) 3345-08, 270 test samples were used for the test, 90 per each ecological zone

$$W = \frac{W_1 - W_2}{W_1} X100 \qquad \text{...1}$$

Where: W= Weight loss

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W_1=Initial weight

W_2=Final weight after attack

Apart from the weight loss, visual rating was also conducted base on ASTM D1758-74 visual biodegradation rating of field test specimen.

2.3.Experimental Design

The experimental design adopted was a two factor split plot with the main plot arrange in a Randomized Complete Block Design with five replications of the test sample for each of the ecological zones, and Analysis of Variance (ANOVA) was conducted to estimate the relative importance of various sources of variation. The main effects considered are differences among longitudinal direction (Base, Middle, and Top) and across the bole. Follow-up test was conducted with the use of Duncan Multiple Range Test. This was done to know the differences between two means, and also to choose the best treatment combination from the factors considered.

3. Result and Discussion

From table 2, the result shows that average percentage weight loss was 15.32 ± 0.05 %, with mean value 10.37 ± 0.02 % at the base, 12.21 ± 0.21 % at the middle and 23.40 ± 0.11 % at the top. Across the bole, it ranges from 0% to 31.18 ± 0.21 % at the base, 0 % to 34.57 ± 1.31 % at the middle and 0 % to 61.16 ± 0.78 % at the top (Table 2). This is in line with Wong, *et al.*, (2005) who affirmed that, natural durability of most tropical species varies from the pith to bark (radial variation).

The mean values for derived savannah were 11.15 ± 0.71 %, 12.46 ± 3.77 % and 24.33±3.77 for the base, middle and top respectively, while the values for Guinea savannah were 9.89 ± 0.36 %, 12.43 ± 1.21 % and 23.45 ± 2.38 % respectively. For the Sudan it was 10.08 ± 0.11 % at the base, 11.74 ± 0.53 % at the middle and 22.42 ± 0.11 % at the top, (Table 2). Radially, it ranged between 0 % and 31.11 ± 0.89 %, 0 % and 34.04 ± 0.57 %, 0 % and 29.09 ± 0.79 % at the base for derived, guinea and Sudan savannah, respectively. At the middle it ranged between 0% and 35.23 ± 2.11 %, 0 % and 36.37 ± 0.39 %, 0 % and 33.21 ± 0.56 % for derived, guinea and Sudan savannah respectively. At the top for derived, guinea and Sudan savannah respectively, the values ranged between 0 % and 65.37 ± 3.10 %, 0 % and 60.09 ± 2.36 %, 0 % and 58.02 ± 0.33 %.

Weight loss increases from base to the middle and further increased to the top along the axial axis while it increases from the outer (bark) to the inner part and further decreases to the bark since it was sampled from bark to bark across the bole (Figure 1). It was observed that termite visited virtually every part of the wood by creating tunnels on the test samples as shown in Plate 2, but could not devour the outer because of the hard pan layer of the species. Even in the forest, termites create tunnels on the body of the tree as observed below in plate 3. Termite could not cause any weight loss at the bark because of the hardness of the wood but caused weight loss at the inner part due to the nature of the inner part which is fluffy. This allows the termite to devour it massively. However, among the ecological zones, the highest weight loss was observed in derived savannah, followed by Guinea savannah and Sudan with 15.98 ± 0.01 %, 15.26 ± 0.35 % and 14.75 ± 0.11 % respectively (Table 2). Consequently, the value for durability test against termite for the species recorded for the outer (peripheral), central and the inner zones is a function of their hardness which apparently make the samples to be resistant or susceptible to termite attack. Though factors responsible for durability are numerous and diverse, some of them relating to conditions within the wood, others with circumstances attending to its use (FAO, 1986).

Statistically, result of changes in sampling heights revealed that both radial position and sampling heights are significantly different at 5% level of probability (Table 3). Effect of interaction between radial and sampling position was also significant at this level. The follow up test further revealed that sampling heights and radial positions were different from one another (Table 2).

4. Rating of the wood of *B. aethiopum*

Apart from the weight loss, visual rating was also conducted base on ASTM D 1758-74 visual biodegradation rating of field test specimens as given in table 4. The outerwood could be described as 9- Trace of termite, the centrewood as 7- Moderate termite attack and the innerwood as 4- Heavy termite attack

Durability of a wood product subjected to a decay hazard is determined by both the inherent decay resistance of the wood and the magnitude of the hazard. The risk of decay in wood products can vary widely with moisture availability, soil condition, and climate. Therefore, although the term "natural durability" is well understood, it may be applied differently for the same species in different locations. For example, a wood species that is durable in the northern United States may perform extremely poorly under tropical conditions (Scheffer and Morrell, 2005).

Density and other physical characteristics do not appreciably affect decay resistance. Superior decay resistance in many tropical hardwoods is associated with high extractive content—including decay inhibitors—rather than the density of the wood (Scheffer, 1973). A wood species might be resistant to one group of termites, but susceptible to others. Tewari, (1978) classified *Borassus flabellifer* palm to be highly perishable with the grade number 4.

5. Conclusion and Recommendation

We observed that termite will naturally visit the wood of *B. aethiopum*, but the outer part is resistant to termite while other parts (centre and inner wood) are susceptible to termite attack. This is in contradiction with the general belief that *B. aethiopum* wood is resistant to termite attack according to indigenous knowledge.

The results obtained from this study revealed that *Borassus aethiopum* has the potentials required by construction industries to substitute the primary timber species. It is recommended therefore that *B. aethiopum* Wood" from the outer zone and the "wood" from the butt before 65% of the merchantable height of the centre zone should be used without treatment (Preservation). This recommendation might provide a guideline for maximum utilization of the species and prompt research into other Tropical species believed to be naturally durable.

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References

Akinyemi, O., Adebayo, O.O., Alabi, O.O., Afuwape, M.A., Famuyide, O.O., Adejoba, O. R. and Ojo, M.O. (2004): Biodegradation responses of *Ceiba pentandra, Pterygota macrocarpa and Brachystegia eurycoma* wood samples treated with biopreservative and solignum. *Journal of Agricultural Technology.* Vol.12. pp.28-39.

Adejumo, B. A. and A. O Raji. (2007): "Technical Appraisal of Grain Storage Systems in the Nigerian Sudan Savannah". Agricultural Engineering International: the CIGR Ejournal. Invited Overview No. 11. Vol. IX. September, 2007. Pp 12.

Ajaiyeoba, D. B and Nwaruh, A. E. 1983: The place of the Fan Palm *(Borassus aethiopum)* in the Timber Industry: A case study of Benue State of Nigeria. Paper presented at the *19th Annual Conference of the Agricultural Society of Nigeria held in Ilorin, October 23-28, 1983.* Pp 1-10.

American Society for Testing and Materials ASTM, D 1758-74 (ASTM) (1974): Standard Methods of Evaluating Wood preservatives by field test with stake. ASTM International. Philadelphia pp 490-498.

American Society for Testing and Materials D 3345-08 (ASTM), (2008): Standard Test Method Laboratory Evaluation of wood and other Cellulosic Materials for resistance to termites. ASTM international, West Conshohocken, Pennsylvania.

Ayanlade, A. and Odekunle, O. T. (2009): GIS Approach in Assessing Seasonal Rainfall Variability in Guinea Savannah Part of Nigeria. *7th FIG Regional Conference Spatial Data Serving People: Land Governance and the Environment – Building the Capacity Hanoi, Vietnam, 19-22 October 2009.* pp 1-9.

Badejo, S.O.O., Adebayo. O. and Ogbogu. G.U. (2001): Studies on chemical preservation of Nigerian plantation grown *Gmelina arborea* for use as construction timber. *Bulletin of Science Association of Nigeria*. Vol.23:145-147.

Clausen, C. L. (2010): Biodeterioration of wood. Wood handbook—Wood as an engineering material. U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. General Technical Report FPL-GTR-190. Pp 508. (www.fpl.fs.fed.us).

Croan, S. (1997): Environmentally benign biological wood preservatives By *Streptomyces rimosus*, sc-36. The international research group on wood preservation working group 1 biology, prepared for the 28th annual whistler, Canada 25 - 30 May 1997. Pp 17.

Food and Agriculture Organization of the United Nations (FAO), (1986): Wood preservation manual. *FAO Forestry Paper 76; 152pp.*

Food and Agriculture Organization of the United Nations (FAO), (2006): Corporate document repository. African and the western Indian Ocean region. Available at *www.fao.org/docrep.*

Ling, W. C., Lai, J. K. and Sammy, J. (2003): Proposed revision of CCA penetration requirements for refractory timbers in Malaysian standard. Based on findings from graveyard test study conducted in Sibu, Sarawak. *Proceedings of TRRTC/STA Forest Products Seminar, 21-22 November 2003.* Kuching, Malaysia. pp149-161.

Malaka, S. L. O. (1983): Economic importance of Termites: six case studies in Nigeria and Ghana," *Nigerian Field*, vol. 47, no. 4, pp. 222–230.

Malaka, S. L. O. (1996): Termites in West Africa, University of Lagos Press, Lagos, Nigeria. Pp 165.

Nyenka, J. G. N. (2000): Prevalence, Utilization and Marketing of *Artocarpus altilis (Parkinson)* Fosberg in the rain forest Area of Osun State, Nigeria. Unpublished M.Sc Dissertation submitted to Department of Forest Resources Management. University of Ibadan. pp 137.

Ogunsanwo, O.Y., Adetogun, A.C and Mendie, M.I. (2002): Compressive Strenght of plantation grown obeche (Triplochiton scleroxylon K, Schum) treated with chromated copper Arsenate (CCA). *Nig. Jour. For*. 33(1) 40-44.

Ojo, A. R. (2016): Intra–Tree Variation in Physico-Mechanical Properties and Natural Durability of *Borassus aethiopum* Mart. Woods in Savanna Zones of Nigeria. A PhD Thesis submitted to the Department of Forest Resources Management. Faculty of Agric and Forestry, University of Ibadan. Pp 175.

Phillipe, F. (1999): Ron Palm. retrieved from *www.desert.com.*

Reeb, J. E. (1997): FOR-54 Wood-destroying organisms and wood preservation. Cooperative extension service, College of Agriculture, University of Kentucky retrieved from http://www.ca.uky.edu/forestryextension/Publications/FOR_FORFS/for54.pdf.

Salako, F. K. 2003: Soil Physical Conditions in Nigerian Savannahs and Biomass Production. Lecture given at the College on Soil Physics Trieste, Department of Soil Science and Agricultural Mechanization, University of Agriculture, Abeokuta, Nigeria. 3-21 March 2003. pp 365-377.

Sanon, M and Sacande, M. (2007): SEED LEAFLET. *Borassus aethiopum* Mart. No. 120 September 2007. Forestry and Land Scape. Millennium Seed Bank Project. retrieved from *www.kew.org/msbp.*

Scheffer, T.C. (1973): Microbiological degradation and the causal organisms, in *Wood Deterioration and its Prevention by Preservative Treatments*, Volume I, D.D. Nicholas, ed. Syracuse University Press, Syracuse NY. pp. 31–106.

Scheffer, T. C. and J. J. Morrell, (2005): Natural Durability of Wood: A Worldwide Checklist of Species. Forest Research Laboratory, Oregon State University. Research Contribution 22. pp 58.

Smulski, S. (1996): *Wood-destroying Fungi in Residential construction*. Wood Specialists Incorporated. Shutesbury, Massachusetts.

Tee, N. T., Popoola, L, and Ancha, P. U. (2006): Investment potentials of *Borassus aethiopum* (Mart) in Northeastern Nigeria. *Obeche Journal. The Journal of the Tree club,* Department of Forest Resources Management. Univ. of Ibadan. Vol 25 (1) Pp 12-20.

Tewari, M.C. (1978): Data on Natural Durability of Timber Species (Installed in the Test Yard at New Forest, Dehra Dun) According to 1976 Inspection, Their Treatability and Seasoning Characteristics. IRG/WP/3127. International Research Group on Wood Preservation, Stockholm, Sweden.

Wong, A. H. H. (2004)**:** A Novel Malaysian biological hazard class selection guide. *Malaysian Wood Preserving Association, MWPA, Vol 4 (17)* December 2004. p p.708.

Wong, A. H. H., Kim, Y. S, Singh, A. P and Ling, W. C. (2005): Natural Durability of Tropical Species with Emphasis on Malaysian Hardwoods – Variations and Prospects. *The International Research Group on Wood Preservation. Doc No. IRG/WP/05-10568.* Paper Prepared for the 36th Annual Meeting Bangalore, India, 24-28 April 2005.

Appendix

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Table 1: ASTM D1758-74 visual biodegradation rating of field test specimens

Visual rating	Description
10	Sound timber, no decay / termite attack
9	Trace of termite attack
7	Moderate termite attack
4	Heavy termite attack
0	Failure due to termite attack

Table 2: Mean % Weight Loss for Termite for the Ecological Zones in Nigeria

		Derived savannah	Guinea savannah	Sudan savannah	Pooled Mean
Sampling height	Radial position				
Base	1	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	2	2.31 ± 0.001^{b}	1.82 ± 0.1^{b}	1.47 ± 0.05^{b}	1.86 ± 0.001^{b}
	3	30.42 ± 2.11^{c}	34.04 ± 0.57^{c}	29.09 ± 0.79^{c}	31.18 ± 0.21^{c}
	4	31.11 ± 0.89^{c}	21.13 ± 1.32^{c}	28.34 ± 0.99^{c}	26.86 ± 2.37^{c}
	5	3.05 ± 0.10^{b}	2.37 ± 0.12^{b}	1.55 ± 0.02^{b}	2.32 ± 0.11^{b}
	6	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	Mean	**11.15±0.71**	**9.89±0.36**	**10.08±0.11**	**10.37±0.02**
Middle	1	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	2	2.02 ± 0.001^{b}	1.21 ± 0.01^{b}	3.33 ± 0.04^{b}	2.18 ± 0.01^{b}
	3	35.23 ± 2.11^{c}	36.37 ± 0.39^{c}	32.11 ± 0.9^{c}	34.57 ± 1.31^{c}
	4	35.15 ± 0.54^{c}	34.45 ± 3.47^{c}	33.21 ± 0.56^{c}	34.27 ± 1.79^{c}
	5	2.33 ± 0.01^{b}	2.59 ± 0.07^{b}	1.79 ± 0.013^{b}	2.24 ± 0.025^{b}
	6	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	Mean	**12.46±3.77**	**12.43±1.21**	**11.74±0.53**	**12.21±0.21**
Top	1	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	2	10.41 ± 2.11^{b}	12.31 ± 0.01^{b}	9.13 ± 0.03^{b}	10.62 ± 0.59^{b}
	3	60.73 ± 0.12^{c}	57.11 ± 5.71^{c}	55.91 ± 2.48^{c}	57.92 ± 2.73^{c}
	4	65.37 ± 3.10^{c}	60.09 ± 2.36^{c}	58.02 ± 0.33^{c}	61.16 ± 0.78^{c}
	5	9.49 ± 0.21^{b}	11.21 ± 0.11^{b}	11.47 ± 2.10^{b}	10.72 ± 1.37^{b}
	6	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	Mean	**24.33±3.77**	**23.45±2.38**	**22.42±0.11**	**23.40±0.11**
	Pooled mean	**15.98 ± 0.01^{a}**	**15.26 ± 0.35^{a}**	**14.75 ± 0.11^{a}**	**15.32±0.05**

Legend: Mean with the same alphabets in the column are not significantly different from one another for each of the Base, Middle and top at 0.05 level of probability

Mean with the same alphabet in the row are not significantly different form one another for the ecological zones at 0.05 level of probability

Table 3: Analysis of Variance for % Weight Loss for Termite

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Source of variation	df	Sum of squrae	Mean of square	F-cal	P-value
Trees (Block)	14	25.19	1.79	1.62ns	0.999^{ns}
Sampling Height (SH)	2	3117.26	1558.63	1404.17	0.000*
Major plot Error	28	49.42	1.77		
Radial Position (RP)	5	31009.48	6201.90	5587.30	0.000*
Interaction (SH, RP)	10	3135.95	313.60	282.52	0.000*
Sub-Plot Error	210	232.28	1.11		
Total	269	37569.58			

Legend:
***=** significant at P<0.05
ns= not significant at P>0.05

Table 4: Visual rating of the wood of *B. aethiopum* (ASTM D1758-74)

Wood of *B. athiopum* across the bole	Description
1 (Outer)	9 Trace of termite visit (Plate. 4)
2 (centre)	7 Moderate termite attack (Plate. 5)
3 (innermost)	4 Heavy termite attack (Plate. 6)

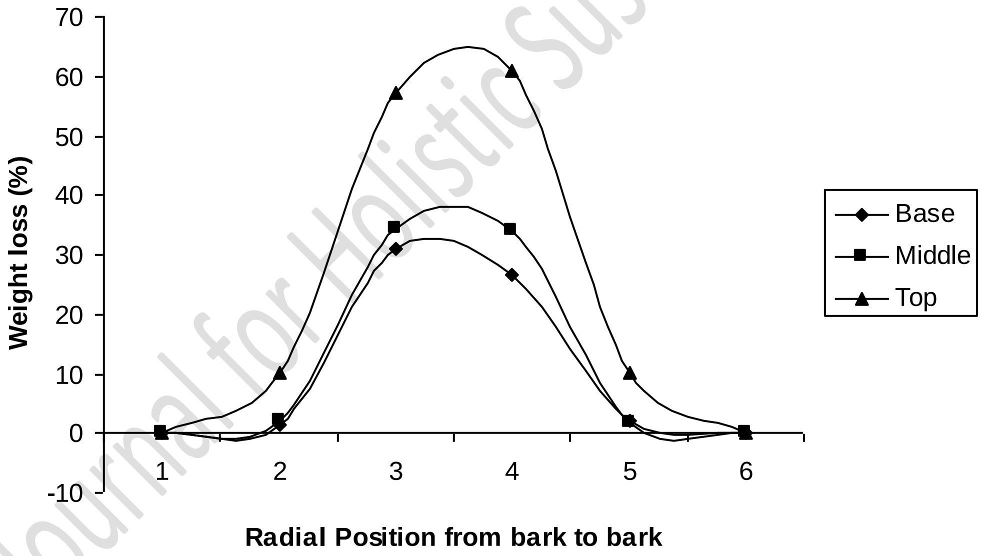

Figure 1: Showing %Weight loss for termite of the wood of *B. aethiopum* with respect to wood samples across the bole

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Plate 1: Graveyard Experiment with Evidence of Termite Infestation

2 3

Plate 2 and 3: showing termite attack on the field and in the forest creating tunnels on wood sample


Plate 4: Sound wood of outer part of *Borassus aethiopum* with traces of termite visitation

Figure 5: Moderately attacked of *Borassus aethiopum*


Figure 6: Heavily attacked of *Borassus aethiopum*