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INTRA–TREE VARIATIONS IN NATURAL DURABILITY OF *Borassus aethiopum* Mart. WOODS AGAINST TWO BASIDIOMYCETES (*Sclerotium rolfsii* and *Pleurotus florida*) IN SAVANNA ZONES OF NIGERIA

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Abstract

This study was conducted to evaluate variations in the natural durability of *B. aethiopum*. Five *B. aethiopum* trees each from Sudan, Guinea and Derived savanna zones in Nigeria were sampled at the base (10%), middle (50%) and top (90%) of the merchantable length. Weight loss experiment was used to assess natural durability by inoculating wood samples with *Sclerotium rolfsii* (Brown rot fungi) and *Pleurotus florida* (White rot fungi) for 24 weeks. Data were analysed using descriptive statistics and ANOVA. Brown rot fungi degraded *B. aethiopum* wood by 27.1±0.5%, 36.8±0.3% and 49.7±1.8% while, white rot reduced weight of samples by 24.8±0.5%, 33.3±0.7% and 42.1±0.6%, at the base, middle and top, respectively. Radially, Brown rot degraded wood by 5.0±0.07%, 26.6±1.2% and 81.9±2.8%, while white rot degraded it by 4.0±0.01%, 19.4±2.2% and 76.9±5.1% in the outer wood, centre wood and inner wood, respectively. Significant variation was not observed across the ecological zones, but there was significant difference radially and along the sampling height. It was observed that fungi naturally attack the wood of *B. aethiopum* especially when the condition is favourable, but the outer is resistant to fungi while other parts (centre and inner wood) are susceptible to fungi attack.

Keywords: Decay, fungi, bio-agent, Sudan, Derived, Guinea

Introduction

Decay-producing fungi may, under conditions that favour their growth, attack either heartwood or sapwood. The fungus in form of threadlike strands called hyphae, permeates the wood and uses parts of it as source of nutrient. Wood destroying fungi are an important ecological group in the ecosystem and are essentially connected to wood and decompose it by their activity. They cause great damages to living trees, processed wood and wood constructions. However from an economic point of view, it is possible to consider the activity of fungi as both beneficial and injurious. The injurious activities are moderated by defensive reactions on the part of the tree, products of its metabolism, antagonistic organisms and also unsuitable physical conditions in wood being attacked (Pavlik, 2005).

Wood decay basidiomycetes, often categorized as white rot or brown rot fungi with respect to their decay are common inhabitants of forest litter, where they play a key role in carbon cycling (Eriksson, *et. al.*, 1990). White rot fungi degrade all components of plant cell walls, including cellulose, hemicellulose, and lignin. Although unable to grow on lignin alone, these filamentous fungi have the unique ability to degrade a large proportion of lignin completely to CO_2 and H_2O. White rot fungi also employ an array of extracellular hydrolases that attack cellulose and hemicellulose while simultaneously depolymerizing the lignin by oxidative mechanisms (Kirk and Farrel, 1987).

Brown rot fungi on the other hand employ a different approach, early in the decay process, they rapidly depolymerize cellulose but without concomitant weight loss. As decay progresses, brown rot fungi modify lignin extensively, but the products remain *in situ* as a polymeric residue (Niemenmaa, *et al.*, 2007, Yelle, *et al.*, 2008, Wymelenberg, *et al.*, 2010). Brown rot fungi are of considerable economic importance as the principal agents causing the destructive decay of wooden structures. This general pattern of simplification is consistent with the view that brown rot fungi have acquired novel mechanisms for cellulose depolymerization and lost key components of the white rot lignocellulose-degrading system (Worrall, *et al.*, 1997).

Natural durability is the inherent resistance of a timber species to decay and insect attack. It is the ability of timber species to resist biological degradation and water permeability for a period of time and is known as 'natural durability' or 'natural resistance'. This refers to the heartwood of timber species except for those species with no differentiation between the heartwood and sapwood (Francis and Norton, 2006; Vittanen, *et al.*, 2006; Wong, *et al.*, 2005).

According to Zabel and Morell, (1992), the first principle of decay prevention is the use of naturally durable or preservative treated wood in those high hazardous – decay conditions in which wood cannot be kept dry by structural design or handling practices. The natural durability of heartwood in many wood species is mainly originated from the wood microstructure and chemical composition. The natural durability of wood species under terrestrial conditions is evaluated by a variety of standard and even non-standard methods of laboratory and field tests. These procedures rate timbers into durability classes. From field tests, the longevity and resilience of wooden stakes vary between temperate and tropical climates because of different rates of biodegradation between these two regions despite having the same durability classes (Francis and Norton, 2006). *Borassus aethiopum* (Mart) is a monocot of the family of Palmae. It is a diecious palm tree of African origin. (Keay, 1989). The English names are Ron Palm (Phillipe, 1999), Giant Africa Palmyra Palm, African fan palm (FAO, 2006) or Elephant palm (Sanon and Sacande, 2007). As at now in the savannah zones of Nigeria, *B. aethiopum* appears to be abundant, yet, it has remained unattended to in terms of properties durability evaluation. Therefore, the natural durability of *B. aethiopum* is being evaluated in order to classify it into durability classes hence promoting its acceptability in the world timber market

Outdoor utilisation of wood is limited due to its susceptibility to biodegradation (Ali, 2011). The inherent ability of wood species to resist biological deterioration is referred as *natural durability* or decay resistance (Eaton and Hale, 1993; Johnson, *et al*., 2006). The principal biological agents that degrade wood are bacteria, fungi, insects, e.g. termites and beetles, and marine borers (Tsunoda, 1990; Highley, 1999). Natural durability varies between wood species and is explained mainly by the composition and amount of wood extractives. Extractive deposits formed during the conversion of sapwood to heartwood often make the heartwood of some species more durable since generally higher heartwood extractive content impacts higher decay resistance of wood species (Onuorah, 2000; Pometti, *et al*., 2010). Knowledge about natural durability is obtained by field and laboratory tests as well as by practical experience of the end users (Willeitner and Peek, 1997; Gierlinger, *et al.,* 2003).

Moisture has great impact on wood durability and service life because it is a prerequisite of vital importance for the wood destroying organisms. Although studied intensively, no clear relationship between wood density and natural durability has been found (Boutelje and Nilsson, 1985). On the other hand, the most realistic description of microbiological deterioration is the monitoring of density changes by weight loss and decrease of some strength characteristics, for example, modulus of elasticity and compression strength

Materials and Method

Five (5) trees were felled at each of the sites (Derived savannah from South-western Nigeria, Guinea savannah and Sudan savannah) Plate 1, especially where they are numerous. In order to ensure minimal influence of age, lack of management and other variables, trees initiating swollen top with uniformly close diameter were chosen. Bolts of 50cm long were cut from each sample trees at the base (10 %), at the middle

(50 %) and at the top (90 %) of the merchantable length that is, below the swollen part resulting in fifteen (15) bolts in each of the ecological zone.

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 central planks were further sectioned into 6 (six) equal portions of about 3cm from bark to bark.

The accelerated biological test also known as fungi test was carried with the use of Brown Rot Fungi (*Sclerotium rolfsii*) and White Rot Fungi (*Pleurotus florida*) were used in the study being the most destructive of the available fungi and the procedure of the experimentation is given below:

Culture Medium

The inocula of *Sclerotium rolfsii* and *Pleurotus florida* were obtained from the pathology division of Forestry Research Institute of Nigeria, Ibadan. A nutrient medium of Potato Dextrose Agar (PDA) in distilled water were prepared. First the PDA (39g) was mixed with 1 litre of water in conical flask and then homogenized. After homogenizing, 40ml of PDA was poured into bottles and sterilized by autoclaving at 1.05kg/cm^2 for a period of 15 minutes. The PDA was incorporated with streptomycin to avoid bacteria contamination. After sterilization the flasks were laid sideways so that the medium is retained in the neck of the bottle. The medium were inoculated with the test fungi within 6 days after preparation of the bottles in accordance with (Arun, 2006; Sarker, *et al.*, 2006). The bottles were then incubated at room temperature (27 $\pm$ 2^{0}C) in the laboratory.

Infection of Test Blocks

The bottles containing the test blocks of 20 x 20 x20mm were incubated at 27 $\pm$ 2^{0}C for 24 weeks. At the end of the incubation period, the blocks were removed from the culture bottles, cleaned of the adhering mycelium, taking care not to remove the splinters of wood and weighed immediately to determine moisture absorbed. Then, weighed samples were oven-dried at 103^{0}C to constant dry wet in accordance with (Arora, 2006; Sarker, *et al.*, 2006). 270 test samples each were used for the test for brown and white rot fungi, 90 samples per each ecological zone making 270 samples altogether.

Determination of Weight Loss after Incubation

After the incubation period, the percentage moisture absorbed by the wood samples was determined. The wet weights of the blocks were calculated in order to evaluate the moisture content of the samples to show if the condition were favourable for fungi infestation after which they were oven-dried for 18hours at 103^{0}C. The test blocks were allowed to cool before final weighing. The percentage weight loss was determined as shown in the equation below and used for the analysis of the effect of the fungi on the wood samples accordance with ASTM D 2017-05.

$$W = \frac{W_1 - W_2}{W_1} X100$$

Where: W= Weight loss (%)

W_1=Initial weight before attack (g)

W_2=Final weight after attack (g)

Experimental Design

The experimental design adopted for the experiment was a 3 factor factorial experiment in a Completely Randomized Design 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.

Factor A= fungi

Factor B= Sampling Height

Factor C= Radial position

Result and Discussion

The result shows that average percentage weight loss for Brown rot and white rot fungi were 33.04 ± 17.21 % and 37.84 ± 8.72 % respectively (Table 1), With mean value 24.81 ± 0.46 % at the base, 33.33 ± 0.69 % at the middle and 42.08 ± 0.60 % at the top and With mean value 27.06 ± 0.53 % at the base, 36.76 ± 0.32 % at the middle and 49.70 ± 1.77 % at the top for brown rot and white rot fungi respectively (Table 1). Across the bole, it ranges from 0.70 ± 0.05 % to 71.00 ± 1.00 % at the base, 1.96 ± 0.89 % to 83.45 ± 2.05 % at the middle and 12.09 ± 1.62 % to 92.04 ± 0.58 % at the top for the brown rot fungi and 0.00 % to 66.46 ± 0.89 %, 0.12 ± 0.01 % and 11.84 ± 0.59 % to 86.02 ± 0.53 % for the base, middle and the top respectively for the white rot fungi. 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 sample from bark to bark across the bole. (Figure 1 and 2). However, the weight loss observed in derived and Guinea savannah were similar with slight difference for the brown rot fungi with mean value of 38.25 % and 38.24 % respectively and 37.03 % for Sudan savannah while highest weight loss was observed in Guinea savannah followed by Sudan savannah and derived savannah with mean value of 33.80 %, 33.64 % and 32.78 % respectively for the white rot fungi (Table 1)

The test fungi *(Sclerotium rolfsii* and *Pleurotus florida)* showed appreciable mycelia growth in the PDA, during the seven days of incubation, indicating the suitability of the medium for culturing the test fungi. There was enough sporulation of the test fungi (saprophytes)

Knowledge about the natural durability of wood species can provide useful information on their possible end-uses as well as important predictions on product service life (Gambetta, *et al.*, 2004)

Consequently, the value for durability test against fungi for the species recorded for the outer (peripheral), central and the innermost zones is a function of their hardness which apparently prevented or do not allow the hyphae of the fungi from easy penetration. Analysis of variance shows significant difference between and among all the factors considered and all possible interactions were also significant (Table 2).

Conclusion and Recommendation

Evidently from this research work, it was observed that fungi will naturally attack the wood of *B. aethiopum* especially when the condition is favourable, but the outer is resistant to fungi while other parts (centre and inner wood) are susceptible to fungi attack. This is in contradiction with the general belief that *B. aethiopum* wood is resistant to fungi attack. It is recommended that preservation of the wood of *B. aethiopum* must be embarked upon in order to increase its service life

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Table 1: % Weight Loss for Fungi for the Ecological Zones in Nigeria

		Derived savannah		Guinea savannah		Sudan savannah		Pooled Mean	
Sampling height	Radial position	Brown Rot Fungi	White Rot Fungi	Brown Rot Fungi	White Rot Fungi	Brown Rot Fungi	White Rot Fungi	Brown Rot Fungi	White Rot Fungi
Base	1	0.70^a	0.008^x	0.68^a	0.00^x	0.81^a	0.00^x	0.73 ± 0.07^a	0.00 ± 0.00^x
	2	9.00^b	7.15^y	10.00^b	9.35^y	9.43^b	8.15^y	9.48 ± 0.50^b	8.22 ± 1.1^y
	3	70.00^c	65.64^z	71.00^c	66.34^z	72.00^c	67.41^z	71.00 ± 1.00^c	66.46 ± 0.89^z
	4	69.11^c	64.95^z	69.11^c	66.45^z	71.08^c	64.95^z	69.77 ± 1.13^c	65.45 ± 0.87^z
	5	10.10^b	8.11^y	10.19^b	9.11^y	11.80^b	8.90^y	10.70 ± 0.95^b	8.71 ± 0.53^y
	6	0.67^a	0.00^x	0.77^a	0.00^x	0.67^a	0.00^x	0.70 ± 0.05^a	0.00 ± 0.00^x
	Mean	**26.60**	**24.31**	**26.96**	**25.21**	**27.63**	**24.90**	**27.06±0.53**	**24.81±0.46**
Middle	1	1.18^a	0.00^x	1.78^a	0.25^x	2.92^a	0.10^x	1.96 ± 0.89^a	0.12 ± 0.01^x
	2	23.50^b	18.01^y	25.50^b	23.10^y	24.19^b	20.40^y	24.40 ± 1.02^b	20.50 ± 2.55^y
	3	85.21^c	78.37^z	80.21^c	78.97^z	83.11^c	79.27^z	82.84 ± 2.51^c	78.87 ± 0.46^z
	4	85.72^c	78.92^z	81.72^c	78.32^z	82.92^c	80.21^z	83.45 ± 2.05^c	79.15 ± 0.97^z
	5	24.87^b	20.31^y	26.87^b	22.94^y	24.87^b	20.31^y	25.54 ± 1.15^b	21.19 ± 1.52^y
	6	1.84^a	0.00^x	2.40^a	0.28^x	2.84^a	0.11^x	2.36 ± 0.50^a	0.13 ± 0.14^x
	Mean	**37.05**	**32.60**	**36.41**	**33.98**	**27.63**	**33.40**	**36.76±0.32**	**33.33±0.69**
Top	1	13.02^a	11.45^x	10.22^a	11.55^x	13.02^a	12.51^x	12.09 ± 1.62^a	11.84 ± 0.59^x
	2	47.36^b	27.51^y	41.36^b	29.73^y	45.36^b	29.10^y	44.69 ± 3.06^b	28.78 ± 1.14^y
	3	92.37^c	84.21^z	91.37^c	85.11^z	92.37^c	86.21^z	92.04 ± 0.58^c	85.18 ± 1.00^z
	4	93.01^c	86.33^z	90.01^c	85.41^z	93.01^c	86.31^z	92.01 ± 1.73^c	86.02 ± 0.53^z
	5	47.71^b	28.09^y	42.11^b	29.09^y	44.71^b	29.19^y	44.84 ± 2.80^b	28.79 ± 0.61^y
	6	13.19^a	10.93^x	11.20^a	12.31^x	13.19^a	12.33^x	12.53 ± 1.14^a	11.86 ± 0.80^x
	Mean	**51.11**	**41.42**	**47.71**	**42.20**	**50.28**	**42.61**	**49.70±1.77**	**42.08±0.60**
	Pooled mean	**38.25^a**	**32.78^b**	**37.03^a**	**33.80^b**	**38.24^a**	**33.64^b**	**33.04±17.21**	**37.84±8.72**

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

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Table 2: Analysis of Variance for % Weight Loss as a Result of Fungi Attack

Source of variation	Df	Sum of square	Mean of square	F-cal	P-value
Sampling Height (SH)	2	11857.26	5928.63	18526.97	0.000*
Radial Position (RP)	5	182283.84	36456.77	113927.41	0.000*
Fungi	1	878.03	878.03	2743.84	0.000*
SH x RP	10	1607.20	160.72	502.25	0.000*
SH x Fungi	2	221.38	110.69	345.91	0.000*
RP x Fungi	5	284.32	56.86	177.69	0.000*
SH x RP x Fungi	10	380.91	38.09	119.03	0.000*
Error	504	160.51	0.32		
Total	539	197673.46			

Legend:
***=** significant at $P<0.05$

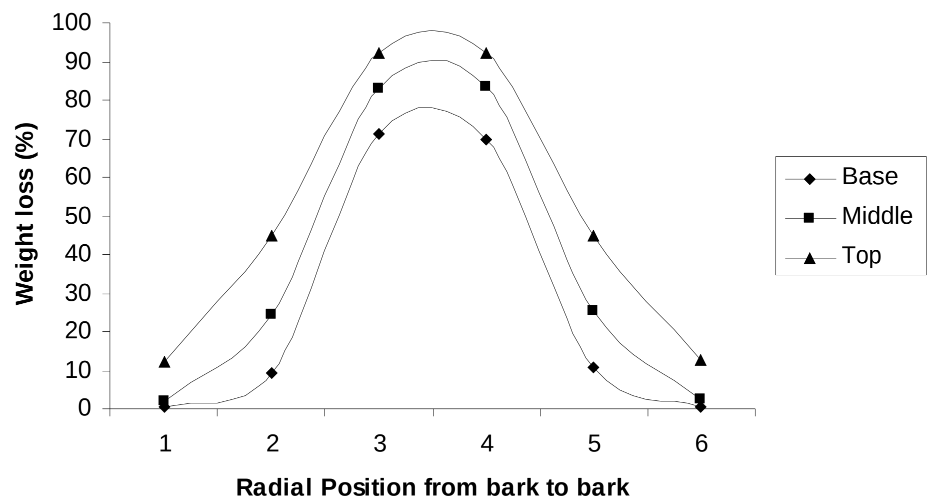

Figure 1: Weight loss for Brown rot fungi of the wood of *B aethiopum* with respect to wood samples across the bole

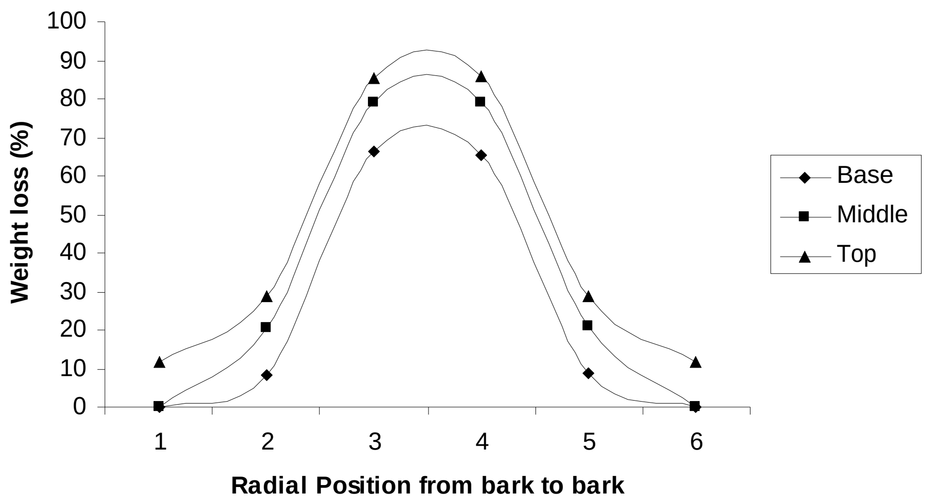

Figure 2: Weight loss for White rot fungi of the wood of *B aethiopum* with respect to wood samples across the bole

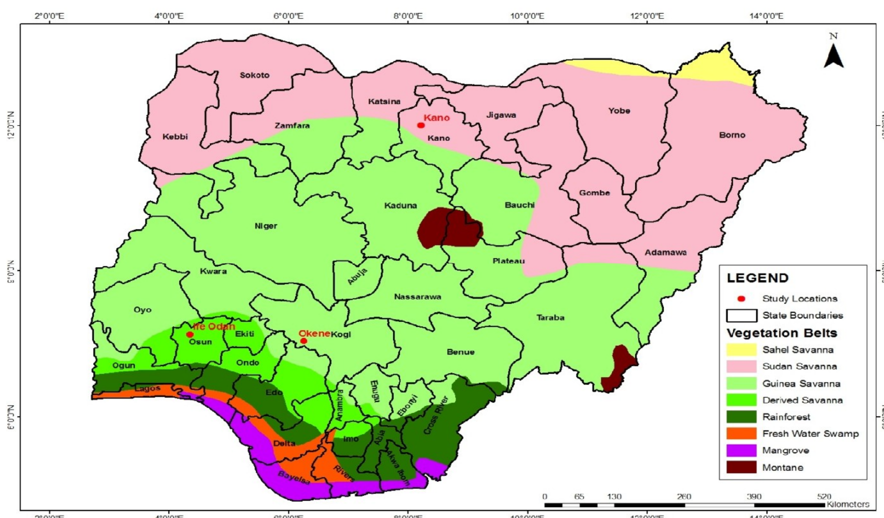

Plate 1: Map of Nigeria Showing Different Ecological Zones and Study Location

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