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DIMENSIONS OF VESSELS AND RAYS IN THE TRUNK OF *AFZELIA AFRICANA* SM. EX PERS

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ABSTRACT: *The dimensions of vessels and rays in the trunk of a fully grown tree of Afzelia africana were measured under the light microscope in order to obtain their actual lengths and widths in micrometer (µm). 50 measurements each of vessels and rays were carried out and their average means were determined using ANOVA and Duncan Multiple Range Test (D.M.R.T). The average length of vessels in the trunk were 0.37±0.20, 0.36±0.10 and 0.37±0.30 for the top, middle and basal portions while the average width were 191.92±0.30, 202.14±0.10 and 207.17±0.20 for the top , middle and basal portions of the trunk respectively. There were no significant differences (P≤0.05) in lengths of vessels from the base to the top of the trunk as well as from the core to the outer potion. Conversely, there were significant differences in the width of vessels from base to the top of the trunk as well as from the core to the outer portion. The ray cells, on the other hand, had 0.40±0.40, 0.38±0.30 and 0.37±0.20 as average mean lengths for the top, middle and basal portions of the trunk whereas, for these same portions the mean width of the ray cells were 49.41±0.20, 48.05±0.30 and 51.54±0.50 respectively. No significant difference was observed in the lengths of rays from the top to the base as well as from the core to the outer. Conversely, there were significant differences in the width of rays from base to middle but not from middle to top. In the same vein, there were significant differences in the width of rays from core to outer. Morphologically, the vessels were narrow, short, open-ended with simple perforation plates, and pits while the rays were multiseriate and heterogeneous. It was opined that the nature and dimensions of the vessels and the ray cells of this tree plant could be of physiological and pathological advantages to this taxon.*

KEYWORDS: Vessels, Rays, Trunk, Dimensions, Length, Width.

INTRODUCTION

Metcalfe and Chalk (1989) have clearly defined vessels and rays: a vessel consists a series of axially superimposed cells of which the intervening end walls have been perforated, thus providing a channel for water conduction unimpeded by any intervening membranes. Rays consist of sheets, ribbons, or panels of cells of variable height and width that lie radially in the secondary xylem and phloem. They function in the storage of food substances such as starch, fat (or fatty oils) and nitrogen compounds. They also aid in the conduction of water and food from phloem to the cambium and xylem parenchyma.

Afzelia africana Sm. ex pers is a tropical evergreen tree plant which belongs to the family, Fabaceae. It is an excellent wood for use in pleasure-crafts, especially for keels, stems and panels, for bridges, as well as interior fittings. The wood is also valued for journey and panelling, parquet floors, doors, frames, stairs, furniture and sporting goods. It has been used traditionally for building of canoes, mortars, masks, and drums. The wood is also used as

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firewood and for charcoal production (Chudnoff, 1980; ATIBT, 1986 and Gerard and Louppe, 2011)

According to Gill *et. al.* (1983), the need to thoroughly investigate the basic structure of plants from the tropics has been stressed by Metcalfe (1972). To the author's knowledge, this demand has not received the much expected attention. In the recent time, many researchers are primarily concerned with the phytochemical and medicinal values of tropical plants with little interest in the study of the structure of the cells and tissues that serve as the framework for the biochemical and medicinal properties of plants. However, in responds to the above demand the author and his collaborators have studied the tissues and cells in some tropical tree plant species as reported in Otoide *et. al.*,(2012), Otoide (2013), Otoide and Kayode (2013) and Otoide (2014).

This present study is another demonstration of the author's interest in examining the basic wood structure of tree plants in the tropics.

MATERIALS AND METHODS

Collection of Materials

A fully grown tree of *Afzelia africana* which could be of about 70 years old was felled at the diameter at chest height (1.3meters above ground level), from Igbo oluwa quarters in Iworoko village, Ekiti State, Nigeria. The log was thereafter taken to the Department of Wood Technology and Utilization (WT&U) of the Forest Research Institute of Nigeria (FRIN), Ibadan, Nigeria for identification and microscopic preparations for anatomical study.

EXPERIMENTAL PROCEDURES AND MACERATION OF WOOD SAMPLES

The procedures used in this assessment strictly followed Otoide *et. al.*, (2012) the bole length of the felled tree was measured with the aid of a measuring tape from the level of chest height, to the crown and the value was 1.10meters. Thereafter, transverse disc of 20cm thick axially was cut from the base, middle and the top of the log. A total of three transverse discs was cut out of the entire log. Each of the discs was divided longitudinally into two semi-circular hemispheres with the line of division passing through the pith. One of the two semi-circular hemispheres was tagged as the Northern hemisphere and the other one, the Southern hemisphere. Only the Northern semi-circular hemispheres were used for the whole of the experiments while the Southern semi-circular hemispheres were discarded. The base, middle and the top semi-circular hemispheres were further divided into three regions, with the lines of division parallel to the equator, which passes through the centre of the pith. These three regions were labelled as:

- CORE (C),
- MIDDLE (M) and
- OUTER (O).

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Five blocks of the dimension, 2cm x 2cm x 2cm and another five blocks of the dimension, 2cm x 2cm x 6cm cut out of the core, middle and outer blocks earlier extracted from the three semi-circular hemispheres, each of which was cut out from the base, middle and the top of the log. On the base disc, five replicate extracts, each from the core, middle and the outer regions of the semi-circular hemisphere were cut out, making a total of 15 blocks of the dimension, 2cm x 2cm x 2cm and also a total of 15 blocks of the dimension, 2cm x 2cm x 6cm. A total of 30 blocks were extracted separately from the Base, Middle and the Top of the log. Ground total of 90 blocks of wood pellets was extracted from the whole of the tree trunk/log. All the 90 blocks of wood pellets were used for the whole of the experiments involved in the study.

MACERATION OF WOOD SAMPLES

In order to determine the length and width of vessels and rays in the trunk of this species, the method outlined by Otoide *et.al.,*(2012) was followed.

Thin slivers of wood materials were removed from the whole of the 2cm x 2cm x 2cm blocks and placed in separate test tubes containing mixture of equal amount of hydrogen peroxide and acetic acid (i.e. in ratio 1:1) individually, such that no slivers of different blocks were placed together in a test tube. The test tubes were then placed inside an electric oven for 4 hours at 80^oC. The test tubes were then removed from the oven and shaken properly so as to defibrize the slivers. The test tube samples were then dropped on clean cover slides with the aid of a pipette and the slides were viewed under a calibrated microscope. Length and width measurements of vessel members and rays were averages of 50 measurements.

EXPERIMENTAL DESIGN

The Experimental Design adopted for this work is a two Factorial in a Complete Randomized Design (C.R.D) with different replications of the test Samples.

FACTOR A: The longitudinal direction (Base, Middle and Top) of the trunk.

FACTOR B: The radial directions, where the sample sticks were collected (The Core, Middle and Outer) region of the trunk.

STATISTICAL ANALYSIS

Analysis of Variance (ANOVA) was conducted to test the relative importance of various sources of variation on the length (µm) and width (µm) of the vessels and rays. The main effects considered were differences along the longitudinal (i.e. Axial) and Radial Positions. The Follow up test was conducted, using Duncan Multiple Range Test (D.M.R.T). This was done to know the significant difference between the two Means at $P \leq 0.05$.

The mathematical Model for the two Factors factorial experiment is given as:

$$Yij = u + Ai + Bj + (AB)ij + Eij$$

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Where:

μ = General mean of individual observation;
Ai = Effect of Factor A;
Bj = Effect of Factor B;
(AB)ij = Effect of interaction between Factor A and B;
Eij = Effect of interaction Error term.

RESULTS AND DISCUSSION

The means (μm) of the lengths and widths of the vessels and rays in the trunk of *Afzelia africana* have been summarised in tables 1-4 and further illustrated in Plate1.

From the axial direction, the dimensions of the vessels were 0.37±0.20μm and 191.92±0.30μm as mean length and mean width at the top of the trunk respectively. In the same vein, dimensions such as 0.36±0.10μm and 202.14±0.10μm were the mean length and mean width of the vessels at the median position of the trunk respectively. Down the base of the trunk, the dimensions of the vessels were 0.36±0.30μm and 207.17±0.20μm as means for the length and width of the vessels respectively.

There was no significant difference between the length of vessels in the base, middle and top positions of the trunk at P≤0.05 level of significance (table 1) However, there was significant difference (table 2) between the width of vessels in the base and top positions of the trunk as against what operates between the vessels in the base and midian positions of the trunk.

TABLE 1: MEAN LENGTH OF THE VESSELS IN THE TRUNK OF AFZELIA AFRICANA

AXIAL POSITION AXIAL	RADIAL VESSEL POSITION	MEAN VESSEL LENGTH IN THE RADIAL AXES (μm)	MEAN LENGTH IN THE AXES (μm)
Base	Core	$0.39^{a}\pm 0.10$	$0.36^{a}\pm 0.30$
	Middle	$0.33^{a}\pm 0.20$	
	Outer	$0.37^{a}\pm 0.30$	
Middle	Core	$0.39^{a}\pm 0.10$	$0.36^{a}\pm 0.10$
	Middle	$0.34^{a}\pm 0.40$	
	Outer	$0.35^{a}\pm 0.20$	
Top	Core	$0.39^{a}\pm 0.10$	
	Middle	$0.34^{a}\pm 0.40$	$0.37^{a}\pm 0.20$
	Outer	$0.37^{a}\pm 0.20$	

Means with the same letter in each column are not significantly different at P≤ 0.05.

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TABLE 2: MEAN WIDTH OF VESSELS IN THE TRUNK OF AFZELIA AFRICANA.

AXIAL POSITION	RADIAL POSTION	MEAN VESSEL WIDTH IN THE RADIAL AXES (µm)	MEAN VESSEL WIDTH IN THE AXIAL AXES (µm)
Base	Core	$199.92^{b} \pm 0.50$	$207.17^{b} \pm 0.20$
	Middle	$229.84^{c} \pm 0.50$	
	Outer	$191.76^{a} \pm 0.40$	
Middle	Core	$236.64^{c} \pm 0.30$	
	Middle	$191.62^{b} \pm 0.30$	$202.14^{b} \pm 0.10$
	Outer	$178.16^{a} \pm 0.40$	
Top	Core	$199.92^{b} \pm 0.50$	$191.92^{a} \pm 0.30$
	Middle	$179.52^{a} \pm 0.20$	
	Outer	$220.32^{c} \pm 0.10$	

Means with same letter in each column are not significantly different at $P \leq 0.05$

TABLE 3: MEAN LENGTH OF RAYS IN THE TRUNK OF AFZELIA AFRICANA.

AXIAL POSITION	RADIAL POSTION	MEAN LENGTH OF RAYS IN THE RADIAL AXES (µm)	MEAN LENGTH OF RAYS IN THE AXIAL AXES (µm)
Base	Core	$0.39^{a} \pm 0.50$	$0.37^{a} \pm 0.20$
	Middle	$0.32^{b} \pm 0.20$	
	Outer	$0.39^{a} \pm 0.30$	
Middle	Core	$0.37^{a} \pm 0.50$	
	Middle	$0.36^{a} \pm 0.50$	$0.38^{a} \pm 0.30$
	Outer	$0.42^{a} \pm 0.20$	
Top	Core	$0.40^{a} \pm 0.30$	
	Middle	$0.36^{a} \pm 0.50$	$0.40^{a} \pm 0.40$
	Outer	$0.42^{a} \pm 0.20$	

Means with the same letter in each column are not significantly different at $P \leq 0.05$.

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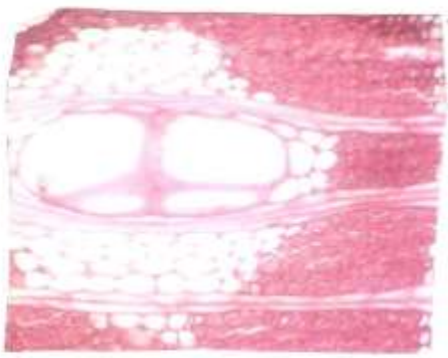
TABLE 4: MEAN WIDTH OF RAYS IN THE TRUNK OF AFZELIA AFRICANA

AXIAL POSITION	RADIAL POSTION	MEAN WIDTH OF RAYS IN THE RADIAL AXES (µm)	MEAN WIDTH OF RAYS IN THE AXIAL AXES (µm)
Base	Core	50.32^{a}± 0.40	
	Middle	53.99^{b}± 0.30	51.54^{b}± 0.50
	Outer	50.32^{a}± 0.20	
Middle	Core	44.88^{a}± 0.10	
	Middle	46.25^{b}± 0.20	48.05^{a}±0.30
	Outer	53.04^{c}± 0.10	
Top	Core	46.24^{a}± 0.50	
	Middle	47.60^{a}± 0.30	49.41^{a}± 0.20
	Outer	54.40^{b}± 0.20	

Means with the same letter in each column are not significantly different at P≤ 0.05

The mean lengths and widths of rays along the axial direction of the trunk were 0.40±0.40µm, 0.38±0.30µm and 0.37±0.20µm for the top, middle and basal positions respectively. There was no significant difference (P≤0.05) between the length of the rays in the top, middle and basal portions of the trunk (table 3). Conversely, the mean widths of rays from the axial direction were 49.41±0.20µm, 48.05±0.30µm and 51.54±0.50µm for the top, middle and basal portions of the trunk respectively. There was significant difference (P≤0.05) between the widths of the rays in the middle and basal portions of the trunk whereas, there was no significant difference between those in the top and middle portions of the trunk (table 4).



a.

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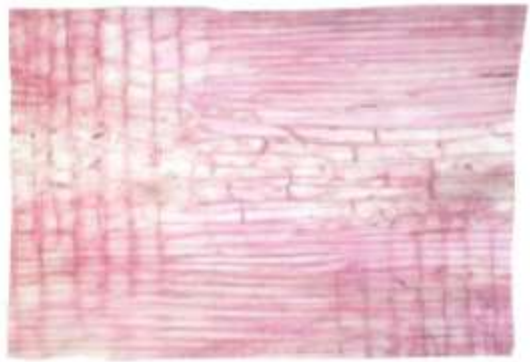

(b)

Plate 1: (a) Vessels in the trunk of *Afzelia Africana.* X400.
(b) Rays in the trunk of *Afzelia africana*. X400.

Results obtained in this study showed that the vessels in the trunk of this tree plant are short and narrow (< 350µm), open-ended and contained simple perforation plates. This could be of physiological advantage in enabling this species to resist negative pressure resulting from accumulation of air bubbles (embolisms). This view is not strange since Okoeguale and Gill (1995) aired same in their reports of narrow and short vessels on the woody stems of *Entandrophragma cylindricum*, *Guarea cedrata*, *Guarea thompsonii* and *Lovoa trichilioides* all of the Meliaceae family. Similarly, the open-ended nature of the vessels with their perforations are of pathological importance to this taxon as they serve as entry points for wood deteriorating agents as well as avenues for impregnation of wood with preservatives and fire retardants. In the same vein, the multiseriate and heterogeneous nature of the rays in the trunk of this species might also be advantageous in enhancing the food storage capacity of the trunk, thus enabling the plant to withstand long periods of food shortage. Conduction of water and food substances along the radial direction of the trunk is also enhanced by the nature of ray cells possessed by this specie.

The insignificant differences in the lengths of the vessels and rays from the axial and radial axes of the trunk (Tables 1 and 3) revealed that the growth and development in lengths of these two important and indispensible anatomical features were even and steady from the base, through the middle to the top of the trunk at the time of wood extraction for this research. However, this may not pose any physiological disadvantage on this sp. On the other hand, the significant differences in widths of vessels and rays from core , middle and top regions of the trunk (Tables 2 and 4) revealed that the growth and development in width of these features in this plant were not even and steady in both radial and axial axes of the trunk. This scenario is not unexpected and might be due to the force and other activities of vascular cambium within the plant enhancing increase in girth of the trunk.

Studies on the physical properties of the trunk of this tree plant is on-going so as to provide information on the moisture and density.

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