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Variation in fibre dimensions of some angiosperm woods of South-East Rajasthan

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Abstract
In hardwood, the cells that make up the anatomical organization are the vessels, fibres, parenchymatous cells and wood rays. Fibers are the principal elements which are responsible for the strength of wood. The fibers are thick walled and narrow lumen cells which occupy major volume of wood and provide mechanical strength to wood. The fibre length can be controlled genetically and is not under influence of environmental fluctuations. Fiber morphology is an important indicator for wood end-use as it strongly affects on the general quality of most of the products produced from wood. Wood fiber differs in its characteristics from species to another. This variation need to be fully explored in order to suggest best uses for the species. The present study aimed to investigate the variation on wood fiber characteristics among some hardwood species growing in Jhalawar District of Rajasthan. The wood samples, were collected from three different sites *viz.* Jhalawar, Dag and Manoharthana site of Jhalawar District. Several fiber characteristics were investigated include fiber length and fiber diameter. The results showed significant variation among species in all the investigated fiber characteristics and no effect was seen in location due to locality factors. Thus; great variation is expected in their end uses.

Keywords: Hardwood species, fiber dimensions, Rajasthan

Introduction

A comprehensive knowledge of the characteristics of any material is essential for its best utilization. According to Hickey and King (2001) [7] wood is sometimes defined as the only secondary xylem in the stems of trees. Wood is a hard, fibrous tissue found in many trees. It has been used for hundreds of thousands of years for fire, fuel-wood, Paper and rayon, furniture, shelter, construction, industrial raw materials as well as structural and aesthetic materials in both residential and commercial buildings. Physical properties of wood denote inherent properties include mostly fiber dimension, which help in identifying the strength of wood species. Fibers are the principal elements which are responsible for the strength of wood (Panshin and Zeeuw, 1980, Desch and Dinwoodie, 1983) [14, 5]. They are shorter than softwood tracheids (0.2 to 1.2 mm), average about half the width of softwood tracheids, but are usually two to ten times longer than vessel elements. The thickness of the fiber cell wall is the major factor governing density and mechanical strength of hardwood timbers (Wiedenhoeft, 2010). Rasheed and Dasti (2003) [16] reported that the shape of fiber cell, its length and wall structure are important in the fiber industry. Fibre length is one of the quality parameters for timber, plywood, pulpwood and etc., (Jorge *et al.*, 2000) [9]. In papermaking, fibres are the cell elements that impart strength to the paper sheet (Riki *et al.*, 2019) [17]. The higher length of fibers is suitable for paper and furniture industries. The fiber length determines whether the quality of raw material is suitable for specific use in paper industry and also has its impact on paper characteristics such as strength, optical property and surface quality. (Kiaei *et al.*, 2014) [11]. Fibre diameters are determined by the dimensions of the cambial fusiform cells from which they are derived and by the process that occurs during cell differentiation (Izekor and Fuwape, 2011) [8]. Fibre diameter decreases in response to reduced water availability (David *et al.*, 2009) [4]. Rajasthan is endowed with a wide range of vegetation that can broadly be categorized into two distinct groups. One comprising the arid vegetation, falling into the western part of the state, while the other belongs to semi-arid to sub-humid category in the eastern and southern Rajasthan. As per the Champion & Seth Classification of Forest Types (1968) [2], the forests in Rajasthan belong to two Type groups i.e. Tropical Dry Deciduous and Tropical Thorn Forests which are further divided into 20 Forest Types. Southern and southeastern part of Rajasthan is mostly a plateau, commonly known as the Hadauti plateau. It has intrusions of black volcanic rocks into the Vindhyans and extends to a great part in Jhalawar, Baran and Kota districts.

Dominant vegetation type is 'Ronj' (*Acacia leucophloea*) scattered across a flat landscape. The soil depth of this flat land is quite less resulting in sparse scrubby vegetation. Other vegetation types are *Anogeissus pendula*, *Butea monosperma*, *Diospyros melanoxylon*, *Zizyphus sp.*, *Prosopis juliflora* and *Madhuca indica.* There are small patches of moderately dense dry deciduous forest in the undulating parts of the area dominated by *Butea monosperma* and *Anogeissus pendula*.

Materials and Methods

Experimental sites - The present investigation was carried out during July 2019 to February 2020 at the laboratory of the department of Forest Products and Utilization, College of Horticulture and Forestry, Jhalawar, Agriculture University Kota (Rajasthan). The samples of six hardwood species *viz. Acacia nilotica*, *Dalbergia sissoo*, *Mangifera indica*, *Ailanthus excelsa*, *Acacia leucophloea* and, *Tectona grandis* (control) were collected from three different sites *viz.* Jhalawar (R_1), Manoharthana (R_2) and Dag (R_3). The recorded data was subjected to anova for statistical analysis.

Samples prepare for measurement of fiber dimensions

Fiber length was determined by macerating the wood shavings in Jeffery's solution, *i.e.* 10 per cent chromic acid and 10 per cent nitric acid, for 48 hours (Pandey *et al.*, 1968) [13]. Thereafter, the shavings were thoroughly washed, stained with safranine, and teased with the help of needle in 10 per cent glycerine prior to mounting on slides. Straight and complete fiber were selected and measured under a stereo microscope equipped with a 10X eyepiece. 4-5 measurements of fiber were made in each slide using an Ocular Micrometer fitted to the eyepiece of a microscope at 10 X magnification and standardized with the help of Stage Micrometer.

a. **Fiber length (mm):** The length (mm) of the fiber was observed from the macerated wood samples by using ocular and stage micrometer.
b. **Fiber diameter (µm):** Average diameter (µm) of the fiber was measured from macerated wood samples by measuring mid diameter of fiber with the help of ocular and stage micrometer.

Result and Discussion

Fiber length (mm)

The statistically analysed data related to fiber length (Plate-1) in wood for all the species and site locations are presented in Table 1. The examination of data depicted significant difference in fiber length in wood among different species at 5 per cent level of significance. The maximum fibre length was found in T_1 (*Acacia nilotica*) which value of 1.508 mm whereas lowest was found in T_3 (*Mangifera indica*) with value of 0.034 mm. Among the location, the result found to be non significant and ranged from 0.983 mm to 0.987 mm. The interactions between species and locations were also found to be non significant and ranged from 0.031 mm to 1.517 mm. In this present study the variation in fibre length and fiber diameter may be due to genetically (fiber length, chemical composition, Age, height, positions of trees etc.) and environmental (soil composition, mean annual precipitation, seasonality and temperature) factors. These similar results are in conformity with the findings of Krisdianto and Damayanti (2007) [12] and Saravanan *et. al.*, (2014) [18] has also noticed differences in the fibre length of *Acacia nilotica* samples collected from Jhadhmajri. According to Sykes *et al.* (2006) [19] fibre length is genetically controlled and is not under influence of environmental fluctuation. Similar findings have also been reported by Heena (2018) [6] in Ban oak, Chauhan *et al.*, (2017) [3] while studying fusiform rays of coniferous species, Bhat (2015) [1] in Sal, Patiyal, (2015) [15] in *Pinus roxburghii* and Thakur (2017) [20] in *Acacia nilotica*.

Table 1: Variation in fibre length (mm) of hardwood from different site locations.

Species (S)	Locations (L)			Mean
	(R_1) Jhalawar	(R_2) Manoharthana	(R_3) Dag	
T_0 (*Tectona grandis*)	1.152	1.152	1.152	1.152
T_1 (*Acacia nilotica*)	1.499	1.509	1.517	1.508
T_2 (*Dalbergia sissoo*)	1.005	1.007	0.972	0.995
T_3 (*Mangifera indica*)	0.033	0.039	0.031	0.034
T_4 (*Ailanthus excelsa*)	1.115	1.126	1.127	1.123
T_5 (*Acacia leucophloea*)	1.093	1.089	1.098	1.094
Mean	0.983	0.987	0.983	
CD $_{0.05}$				
Species	0.017			
Site	NS			
Species*Site	NS			

Fiber diameter (µm)

The statistically analysed data related to fiber diameter (Plate-1) in wood for all the species and site locations are presented in Table 2. The examination of data depicted significant difference in fiber diameter in wood among different species at 5 per cent level of significance. The maximum value of 36.92 µm was recorded in T_1 (*Acacia nilotica*) and minimum of 21.22 µm was found in T_2 (*Dalbergia sissoo*) which was statistically at par with 21.53 µm in T_3 (*Mangifera indica*). The results were found to be significant for all site locations. The highest value of 27.50 µm was found in R_3 (Dag) which was statistically at par with 27.17 µm in R_1 (Jhalawar) and lowest in R_2 (Manoharthana) with the value of 26.83 µm. The interactions between species and locations were found to be non significant and ranged from 20.67 µm to 37.10 µm. These similar results are in conformity with the findings Sheng-Wani and Khan (2010) [21] and Karimanisha *et al.*, (2020) [10] have shown significant variation in the wood fibre diameter from different positions of trees of *Populus nigra* and *Dalbergia sissoo* respectively. Saravanan *et al.*, (2013) [18] have been reported the mean diameter values 24.00, 24.90, 26.01, 26.75 and 27.52 µm for one, two, three, four and five year's old *Melia dubia* wood, respectively and significant increment in fibre width with increase in age and also from pith to periphery.

Table 2: Variation in fibre diameter (µm) of hardwood from different market locations.

Species (S)	Locations (L)			Mean
	Jhalawar (R_1)	Manoharthana (R_2)	Dag (R_3)	
T_1 (*Acacia nilotica*)	36.77	37.10	36.90	36.92
T_2 (*Dalbergia sissoo*)	20.67	21.33	21.67	21.22
T_3 (*Mangifera indica*)	20.95	21.67	21.99	21.53
T_4 (*Ailanthus excelsa*)	28.77	28.45	28.52	28.58
T_5 (*Acacia leucophloea*)	27.77	24.45	27.99	26.74
T_0 (*Tectona grandis*)	28.09	27.99	27.96	28.01
Mean	27.17	26.83	27.50	
CD $_{0.05}$				
Species	0.96			
Site	0.68			
Species*Site	NS			

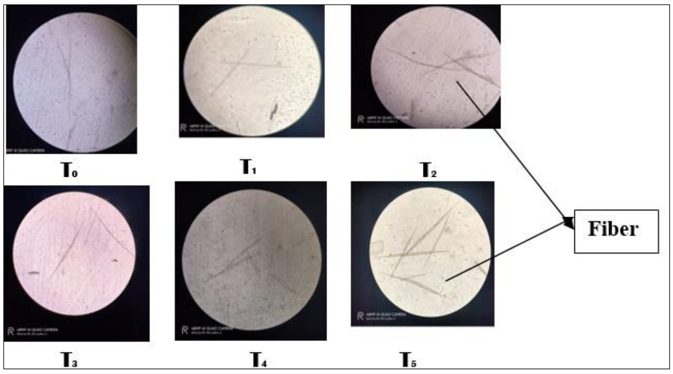

Fig 1: Fiber dimension view under microscope.

Conclusion

This study was chiefly embattled on utilization of diverse type of wood for their usage in different application. Further, the studies have shown that *Acacia nilotica* was found to be most suitable to be used in furniture industry, and further on the basis of studied properties, the woods can be suggested for different wood based industries and help to choosing good quality timber in wood based industrial sectors. Wood samples from different ecological zones should be looked into in order to assess the variations in the properties of the species from various regions. The detailed analysis should be conducted on *Acacia nilotica*, which will enhance its suitability as a potential source of fibre wood pulp.

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