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ANATOMICAL PROPERTIES OF TWO THORNLESS BAMBOOS (*Bambusa balcooa and Bambusa vulgaris*)

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ABSTRACT
Studies were undertaken to elicit information on anatomical characters of *Bambusa balcooa* and *Bambusa vulgaris* across different age gradations. *Bambusa balcooa* and *Bambusa vulgaris* equally recorded its significant superiority. *Bambusa balcooa* recorded significantly higher values for fibre length, fibre diameter and fibre lumen width, whereas *Bambusa vulgaris* registered maximum significant values for fibre wall thickness, vessel length and vessel diameter. The performance of *Bambusa balcooa* and *Bambusa vulgaris* were found to be equal with respect to anatomical characters across different age gradation.

KEYWORDS: Bamboo, anatomy, fibre morphology, vessel morphology, *bambusa balcooa, Bambusa vulgaris.*

INTRODUCTION

The general consumption pattern of bamboo in India indicates that 8.4% of bamboo is being consumed by pulp and paper industries while, cottage, furniture and implements industries consume 65% bamboo (Tewari, 1996). In earlier days, more than 70% bamboo was used for paper and paperboard production. The indiscriminate exploitation of forest resources at global scale has considerably reduced the availability of the wood fibres for paper and pulp production. Consequently, the non-wood fibre resources are gaining increased attention to fulfil the ever-increasing gap between the demand and the supply in an environmentally sustainable manner. Bamboos constitute a major non-wood forest-fibre source for the paper and pulp production worldwide and a number of species have been identified as more useful. For instance, *Bambusa balcooa and Bambusa vulgaris* are the preferred species due to its mechanical strength, attributable to the high specific gravity and long fibres (Amita Pal *et al.,* 2010). In the case of *Bambusa balcooa and Bambusa vulgaris*, variations of anatomical characters at different age gradation over various agro climatic regions have to be studied to have wider knowledge of their effect on pulp quality. However such anatomical research are not carried out so far in these species and hence the current study is conceived.

MATERIALS & METHODS

The thorn less bamboos species *viz., Bambusa balcooa* and *Bambusa vulgaris* were chosen as the experimental material for the present study. One year, two year, three year, four year and five year old plantations of *Bambusa balcooa* and *Bambusa vulgaris* were selected. From each plantation, 25 clumps in three replications were selected and extracting a disk from the felled culms.

Maceration

Maceration of the culm samples was done using Jeffrey's method (Sass, 1971). For maceration, Jeffrey's solution was used and it is prepared by mixing equal volumes of 10% potassium dichromate and 10% nitric acid. Radial chips of culm shavings were taken from the $1cm^3$ culm blocks separately from the three radial positions *viz*., pith, middle and periphery. These chips were boiled in the maceration fluid for 15-20 minutes so that the individual fibres were separated. Then these test tubes were kept for 5-10 minutes so that the fibres settled at the bottom. The solution was discarded and the resultant material was thoroughly washed in distilled water until traces of acid were removed. The samples were stained using saffranin and mounted on temporary slides using glycerin as the mountant.

Fibre morphology

Fibre morphology (µm) was measured from macerated culm samples by measuring the fibre through Motic Image Analysis Software. Fibre morphology includes Fibre diameter, Fibre length, Fiber wall thickness and Fibre lumen width.

Vessel morphology

Vessel morphology (µm) was measured using the Motic Image Analysis software. Vessel morphology includes vessel length and vessel diameter.

TABLE 1. Fiber morphology of two thornless bamboo species (*Bambusa balcooa* and *Bambusa vulgaris*)

Fiber morphology	*Bambusa balcooa*					*Bambusa vulgaris*				
	1 Year	2 Year	3 Year	4 Year	5 Year	1 Year	2 Year	3 Year	4 Year	5 Year
Fiber Length	35.0148	36.9322	38.5815	39.6324	41.9032	31.6056	33.7639	35.9443	37.9733	39.1643
Fiber Diameter	18.1356	19.1049	20.5458	21.8949	22.7535	15.2654	16.7238	17.4438	18.5140	19.4448
Fibre Wall Thickness	6.4311	6.6368	6.8657	6.9135	7.0146	6.9340	7.0145	7.2242	7.3148	7.5145
Fibre Lumen Width	6.0138	5.9252	5.6656	5.0342	4.6963	2.6657	2.5466	2.4348	2.3153	2.2866

TABLE 2. Vessel morphology of two thornless bamboo species (*Bambusa balcooa* and *Bambusa vulgaris*)

Vessel morphology	*Bambusa balcooa*					*Bambusa vulgaris*				
	1 Year	2 Year	3 Year	4 Year	5 Year	1 Year	2 Year	3 Year	4 Year	5 Year
Vessel Length	40.6863	43.3661	45.4144	47.3939	49.8152	122.1176	123.1357	124.2455	125.2654	126.8347
Vessel Diameter	125.5445	145.3770	163.7240	179.4648	198.1346	208.9342	223.4054	249.5036	267.4245	282.1956

RESELTS & DISSUSSION

Fibre Morphology

Fiber Length

The pulp and paper property are highly dependent on fibre morphology and sheet forming processes (Pavilainen, 1993; Seth *et al*., 1997). The maximum fibre length was observed in *Bambusa balcooa* (5^{th} year µm, 4^{th} year µm, 3^{th} year µm, 2^{th} year µm and 1^{th} year µm) compared to *Bambusa vulgaris* (5^{th} year µm, 4^{th} year µm, 3^{th} year µm, 2^{th} year µm and 1^{th} year µm). An increasing trend of fibre length was evidenced along with the age of the culm. This result establishes that wood fibre length increases with increase in age. The same line of findings had been reported by Jorge *et al.* (2000) who found that with increase in age there was an increase in fibre length from inner wood to outerwood.

Fiber Diameter

The same line of findings had been reported by Jorge *et al*. (2000) in *Eucalyptus globulus*. The current findings also in corroborate with the earlier findings of Saravanan (2012) in *Melia dubia* and Tavares *et al.* (2011) in *Acacia melanoxylon*. The observed increase in fibre diameter associated with the increasing age of the tree may be due to many molecular and physiological changes that occur in the vascular cambium as well as the increase in the wood cell wall thickness during the tree aging process (Plomion *et al*., 2001 and Roger *et al*., 2007).

Fibre Wall Thickness

Bambusa vulgaris exhibited its superiority over *Bambusa balcooa* by registering maximum fibre wall thickness in fifth year (7.5145 µm), fourth year (7.3148 µm), third year (7.2242 µm), second year (7.0145 µm) and first year (6.9340 µm). However, in all these age gradations, *Bambusa balcooa* registered only minimum fibre wall thickness in the order of 6.4311 µm, 6.6368 µm, 6.8657 µm, 6.9135 µm and 7.0146 µm in first year, second year, third

Plate 1.Fibre morphology of *Bambusa balcooa*

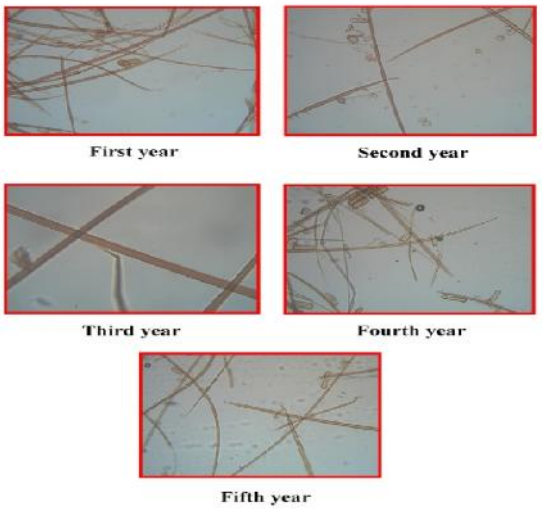


Plate 2.Fibre morphology of *Bambusa vulgaris*

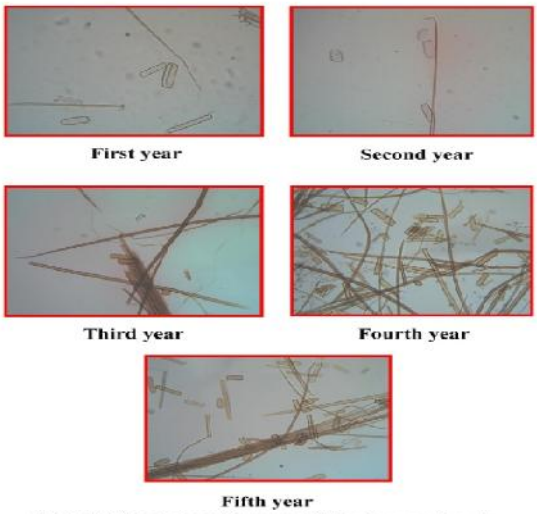


Plate 3. Vessel morphology of *Bambusa balcooa*

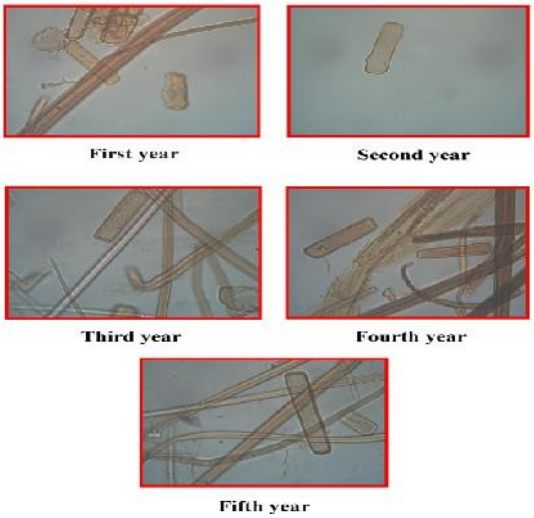
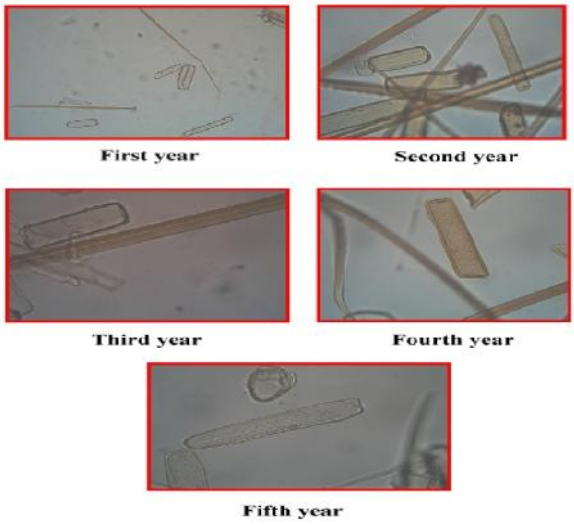


Plate 4. Vessel morphology of *Bambusa vulgaris*



year, fourth year and fifth year respectively. Current findings are in concurrence with studies on *Tectona grandis* by Izekor and Fuwape (2011) and *Melia dubia* by Saravanan (2012). Akachuku (1980) also attributed the increase in cell wall thickness if *Gmelina arborea* to changes in cell size that are associated with annual and periodical growth cycles and the increase in the age. Across the agro climatic regions also significant differences were recorded in *Bambusa vulgaris*.

Fibre Lumen Width

In the present study, the highest fibre lumen width was recorded by *Bambusa balcooa* and it ranged from (6.1576 µm to 4.7863 µm) across the age gradation. This showed that fibre lumen width decreases with age, which may be attributed due to the increase in the length of fibre initial association with increasing age of the cambium (Jorge *et al.*, 2000). The observed differences in lumen width with increasing age of the tree may also be due to increase in cell size and physiological development of the wood as the tree grows in girth (Jorge *et al.*, 2000). Roger *et al.* (2007) reported positive relationship between variations in lumen width and age of the cambium. A similar result was also evidenced in *Melia dubia* (Saravanan, 2012) which attests the findings of the current study.

Vessel morphology

Vessel length

The maximum vessel length was observed in *Bambusa balcooa* (5^{th} year µm, 4^{th} year µm, 3^{th} year µm, 2^{th} year µm and 1^{th} year µm) compared to *Bambusa vulgaris* (5^{th} year µm, 4^{th} year µm, 3^{th} year µm, 2^{th} year µm and 1^{th} year µm). This result establishes that wood vessel length increases with increase in age. This corroborates the earlier findings of Saravanan (2012) in *Melia dubia*, Rao *et al*. (2003) in *Tecomella undulata*, Anoop *et al.* (2005) in *Albizia odorantissima*, Vinay kumar Sahu, (2005) in *Samania saman* and Gimenez and Lopez (2000) in *Schinopsis quebrachocolorado*

Vessel diameter

Bambusa vulgaris exhibited its superiority over *Bambusa balcooa* by registering maximum fibre wall thickness in fifth year (282.1956 µm), fourth year (267.4245 µm), third year (249.5036 µm), second year (223.4054 µm) and first year (208.9342 µm). However, in all these age gradations, *Bambusa balcooa* registered only minimum fibre wall thickness in the order of 125.5445 µm, 145.3770 µm, 163.7240 µm, 179.4648 µm and 198.1346 µm in first year, second year, third year, fourth year and fifth year respectively. Similar results was also evidenced in Saravanan (2012) in *Melia dubia*, Rao *et al*. (2003) in *Tecomella undulata*, Anoop *et al.*, (2005) in *Albizia odorantissima*, and Vinay kumar Sahu, (2005) in *Samania saman*

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