Research Article

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Wood utilization prospects of Neolamarckia cadamba based on age and axial dependent fibre morphology

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ABSTRACT

The present study investigates the anatomical characteristics of Neolamarckia cadamba wood with emphasis on age-wise and axial variations in fibre morphology. Wood samples were collected from trees of five different ages (2, 4, 6, 8 and 10 years) and analyzed for fibre length, fibre diameter, lumen width and cell wall thickness using standard microscopic techniques. The results revealed significant variation in fibre morphology with age. Fibre length increased from 1509.00 µm at 2 years to 1854.16 µm at 10 years, indicating improved fibre development with maturity. Fibre diameter also showed a gradual increase, whereas lumen width increased up to 6 years and declined thereafter. In contrast, cell wall thickness increased substantially at older ages, suggesting enhanced fibre strength. Axial variation within the tree indicated that fibre length decreased significantly from base to top, while fibre diameter, lumen width and wall thickness showed non-significant variation along the stem. The findings highlight that age has a stronger influence than axial position on fibre characteristics. Neolamarckia cadamba exhibits favorable fibre properties, particularly at intermediate ages, making it a promising species for pulp, paper and other wood-based industries

INTRODUCTION

Neolamarckia cadamba (Roxb.) Bosser locally known as 'Kadamba', is a tropical tree species native to South Asia and Southeast Asia, including India. It is a large tropical tree with broad a crown and straight cylindrical bole having an average height of 15 meters with self- pruning ability. Under favorable climatic conditions, this tree attains a height of 20 m or more with a clean bole of about 9 m and a diameter of 40 to 60 cm. In Assam, the tree attains a height of 6.5 m and diameter of 12.7 cm at 4 years (Ghosh, 1977). The rate of growth is very fast in the earlier years, the height increment averages 3 m per annum for the first six or eight years after which the growth slow up to 20 years and thereafter becomes very slow. This species is increasingly important for wood- based industries. Wood of this species is suitable for multiple end uses, such as plywood, light construction materials, flooring, beams and rafters, boxes and crates, tea-chests, packing cases, shuttering, ceiling boards, toys, wooden shoes, bobbins, yokes, carvings, matches, chopsticks and pencils (Soerianegara and Lemmens, 1993). This species is expected to become highly important to meet the gap between demand and supply of raw materials for

pulpwood, matchwood, pencil and plywood wood-based industries. There is already a high demand for pencils, plywood and match splints in India. Although, the species is indigenous, fast growing with multiple uses, it has received little research attention and there is no tree improvement programme for this species. The objective of the study was to access the anatomical properties of *N. cadamba* wood at different ages.

MATERIALS AND METHODS

Species Name: *Neolamarckia cadamba* (Roxb.) Bosser

Sample collection

Age (years)	Diameter (cm)		
	Base	Middle	Top
2	11.60	10.70	10.15
4	12.25	11.20	10.40
6	14.35	12.15	11.45
8	20.20	19.90	18.30
10	25.55	24.20	23.40

Destructive sampling method was adopted to collect the wood samples across the different ages. Twelve trees per age was taken and averaged.

Estimation of anatomical properties

Three samples each of dimension 2 x 2 x 2 cm were sliced from the heartwood and sapwood regions of *Neolamarckia cadamba*. Thin microscopic sections(15 to 20 µm thick) were exampled using a *'Leica* SM 2000 R Microtome'. Measurement of various parameters was done using the Motic software.

Fibre length, Diameter, Cell wall thickness was measured from macerated wood samples by measuring both ends of the fibre using Motic Image Analysis Software.

RESULTS

Table 1: Fiber morphology of *Neolamarckia cadamba* at different ages

Age	Fibre Morphology			
	Fibre length (µm)	Fibre diameter (µm)	Fibre lumen width (µm)	Fibre wall thickness (µm)
2	1509.00	40.55	29.20	5.64
4	1463.25	41.43	29.15	6.13
6	1781.88	44.56	32.78	5.87
8	1758.43	41.69	30.10	5.82
10	1854.16	43.47	26.26	8.67
Mean	1673.34	42.34	29.49	6.42
SD	165.77	1.62	2.31	1.24
SEd	51.01	0.95	0.91	0.26
CD (p=0.05)	101.74	1.89	1.81	0.53

Table 2: Axial variation of fiber morphology of *Neolamarckia cadamba* wood at different ages (replicates of four)

Age	Axial position	Fibre Morphology			
		Fibre length (µm)	Fibre diameter (µm)	Fibre lumen width (µm)	Fibre wall thickness (µm)

2	Base	1647.50	41.97	30.25	5.90
	Middle	1555.75	41.06	29.47	5.86
	Top	1323.75	38.63	27.88	5.15
	Mean	1509.00	40.55	29.20	5.64
	SD	166.77	1.75	1.19	0.42
	SEd	61.67	2.17	1.51	0.64
	CD (p=0.05)	134.38	NS	NS	NS
4	Base	1573.85	42.63	30.49	6.00
	Middle	1446.25	41.08	29.20	5.92
	Top	1369.65	40.59	27.75	6.46
	Mean	1463.25	41.43	29.15	6.13
	SD	104.07	1.06	1.37	0.29
	SEd	40.11	1.72	1.68	0.32
	CD (p=0.05)	87.40	NS	NS	NS
6	Base	1909.55	45.58	33.50	6.09
	Middle	1808.50	44.42	32.99	5.65
	Top	1627.59	43.68	31.84	5.88
	Mean	1781.88	44.56	32.78	5.87
	SD	143.94	0.97	0.84	0.22
	SEd	72.03	1.53	1.65	0.48
	CD (p=0.05)	156.94	NS	NS	NS
8	Base	1867.14	42.54	31.94	5.92
	Middle	1780.54	42.18	29.91	5.78
	Top	1627.60	40.33	28.44	5.75
	Mean	1758.43	41.69	30.10	5.82
	SD	120.33	1.17	1.76	0.09
	SEd	3.46	1.05	1.36	0.47
	CD (p=0.05)	116.48	NS	NS	NS
10	Base	1963.29	44.60	26.93	9.03
	Middle	1886.25	43.48	26.01	8.63
	Top	1712.95	42.32	25.83	8.37
	Mean	1854.16	43.47	26.26	8.67
	SD	126.22	1.14	0.59	0.33
	SEd	45.43	1.43	1.50	0.39
	CD (p=0.05)	98.99	NS	NS	NS

The fibre morphology of *Neolamarckia cadamba* exhibited significant variation across different ages (2–10 years), particularly in fibre length, diameter, lumen width and wall thickness (Table 1). Fibre length ranged from 1463.25 µm at 4 years to 1854.16 µm at 10 years, showing an overall increasing trend with age despite minor fluctuations. The increase was more pronounced from 6 years onward, indicating enhanced fibre development during later growth stages. Fibre diameter also showed a gradual increase with age, reaching a maximum of 44.56 µm at 6 years before slightly declining at older ages. The statistical analysis (CD = 1.89) confirms significant differences among age classes

(Table 1).122ibre lumen width initially increased from 29.20 µm at 2 years to 32.78 µm at 6 years, followed by a decline to 26.26 µm at 10 years, suggesting increased secondary wall deposition in older wood. In contrast, fibre wall thickness showed a clear increasing trend, particularly at 10 years (8.67 µm), indicating strengthening of fibres with maturity. All these variations were statistically significant, highlighting the influence of age on fibre characteristics (Table 1).Axial variation within the tree revealed a consistent pattern across all ages (Table 2). Fibre length was highest at the base and lowest at the top, with significant differences observed along the stem. For instance, at 6 years, fibre length decreased from 1909.55 µm at the base to 1627.59 µm at the top, reflecting the maturity gradient along the stem. However, fibre diameter, lumen width and wall thickness did not show significant axial variation (NS), although numerically they tended to decrease from base to top (Figure 1).

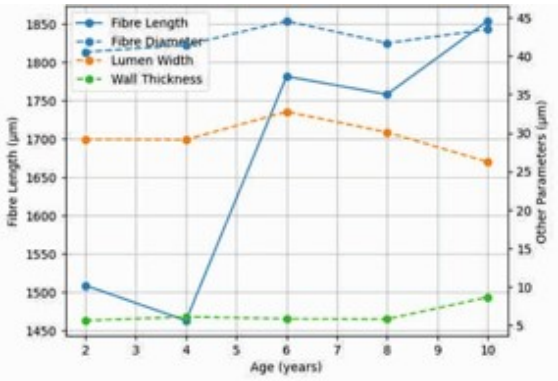

Figure 1. Figure 1: Fibre morphology vs Age (Dual axis graph)

DISCUSSIONS FIBRE LENGTH

Fibre length is a critical property influencing fibre bonding and strength, as longer fibres form stronger networks (Johansson, 2011). In the present study, fibre length ranged from 1463.25 µm to 1854.16 µm, with values at 6, 8 and 10 years not significantly different. Although no strict linear trend was observed, fibre length generally increased with age. The values recorded were higher than several species such as *Eucalyptus camaldulensis* (670 µm) and *Eucalyptus globulus* (716 µm) and *Melia dubia* (936.60 µm) (Saravanan et al., 2013), *Albizzia chinensis* (1147 µm) (Darmawan et al., 2013) and young teak wood (Wahyudi et al., 2014). Axially, fibre length varied significantly, decreasing from base to top, consistent with findings in *Ricinodendron heudelotii* (Ogunleye, 2017), *Moringa oleifera* (Ekhuemelo et al., 2016) and *Eucalyptus tereticornis* (Uniyal, 2012).

Fibre diameter

Fibre diameter increased gradually with age, indicating enhanced cell development in older wood. Similar trends were reported in *Afzelia africana* (Idu and Ijomah, 1996). However, axial variation was non- significant, though diameter decreased slightly from base to top. This may be attributed to reduced photosynthate availability at upper stem portions, affecting cell development (Ismail et al., 1995).

Fibre lumen width and wall thickness

Fibre lumen width (26.26–32.78 µm) and wall thickness (5.64–8.67 µm) varied significantly with age but without a clear trend. Increased wall thickness with age has been reported in *Eucalyptus* clones (Grzeskowiak *et al.*, 2000), while a strong relationship between fibre width and wall thickness was noted in *Quercus suber* (Leal *et al.*, 2006). Similar patterns were observed in *Ricinodendron heudelotii* (Ogunleye *et al.*, 2017) and *Azadirachta excelsa* (Nordahlia *et al.*, 2014). These variations may be linked to cambial age and physiological development (Moya Roque *et al.*, 2007).

CONCLUSION

The present study demonstrated that fibre morphology of *Neolamarckia cadamba* is significantly influenced by age, with comparatively lesser variation along the axial positions of the stem. Fibre length, diameter and wall thickness generally increased with age, indicating progressive maturation and improved mechanical strength of wood. In contrast, fibre lumen width showed variable trends, reflecting changes in cell development and wall deposition. Axial variation revealed that fibre length decreased from base to top, while other parameters remained statistically non- significant, suggesting relative uniformity within the stem. The results indicate that intermediate ages (6–8 years) provide a balance between fibre strength and desirable processing characteristics. *N. cadamba* exhibits favourable anatomical properties suitable for pulp, paper and other wood-based industries.

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