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Physical and anatomical properties: the case of two progenies of *Melia dubia* Cav

Abstract

Two progenies of *Melia dubia* plantation of six year old were selected for studies on physical and anatomical properties of wood. Data for each selected trees progenies selected were recorded for height, clear bole length, diameter at breast height, initial moisture content, specific gravity and sapwood proportion. Macroscopic features were observed and recorded under 10 x lenses. Slides were prepared for microscopic views of the wood in three directions viz. pith, middle and periphery. Maceration was done as per Schultze's method to prepare slides for studies on fiber and vessel morphology of the wood samples. The analysis revealed that wood of *M. dubia* showed distinct growth rings, the sapwood was yellowish white in colour, the heartwood was yellowish brown in colour. The mean moisture content in the living trees was recorded to be 80.3%. The specific gravities of selected progenies were 0.43 and 0.35. The difference in specific gravities between the progenies was statistically significant. Mean sapwood % in both the progenies was 39.12 %. While the mean fiber length was 716.72µm, mean fiber wall thickness was 4.15µm. Mean vessel length of the progenies was 260.5 µm. Significant variability in physical and mechanical properties of wood, indicates a need of careful tree breeding programme for the species.

Keywords: density, Melia dubia, progeny, wood anatomy

Volume 2 Issue 6 - 2018

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Received: April 26, 2018 | **Published:** December 28, 2018

Introduction

Melia dubia Cav. is fast growing species with wide geographical distribution. It is found in India, Srilanka, Malyasia, China and Australia. It can attain average height of 9.2 m and diameter of 14.2 cm per year.[1] Due to its fast growth and better wood properties, it has attracted more attention. The wood is used for making packing cases, and plywood manufacturing etc. It has immense potential to become an important and alternative raw material for furniture industries. The species is suitable for intensive cultivation and management for short rotation round woods.

Wood quality improvement is recognized as integral part of tree breeding programmes as the wood volume growth and wood quality are not treated as independent traits.[2,3] Wood properties are greatly influenced by anatomical properties like cell size, proportion and arrangements.[4] The fiber length is an important parameter for quality paper production.[5] Specific gravity is considered to be a general indicator anatomy, strength, stiffness and drying, machining properties.[6]). Other wood properties like heartwood content, extractives etc are considered to be important for tree improvement programmes.[3] Huge variability in some physical properties of plantation grown *M. dubia* have been reported.[7] The anatomical features of the wood helps tree breeders in developing superior varieties suitable for various wood consuming industries.

However, extremely limited works have so far been carried out on the anatomical properties of *M. dubia*.[8–10] No work was found to be reported on variability in anatomical properties of the wood of *Melia dubia*. The present work focuses to determine some physical properties of two selected progenies of the age of six years, besides anatomical properties along variations in radial directions. The work is expected to give insight on variability in anatomical and physical properties to tree breeders working on the development of superior genotype of *M. dubia* plantation for quality timber production.

Materials and methods

Description of the plantation

The study site was located at Dehradun (N Latitude 29°58' to 31°02' 30" and E Longitude 77°34' 45" to 78°18' 30") on a plantation of *Melia dubia* to analyze a x E interaction. Elevation of the site is 410m. Summer average to temperature range is 16.7 to 36ºC, whereas, winter temperature ranges from 5.2 to 23.4ºC. Average annual rainfall of the place is 2073.3mm with bulk precipitation in the months of July- August. Soil of the site is silty loam to silty clay in texture and acidic to near neutral containing a high amount of organic carbon. The pure plantation spacing of 3 m x 3 m (1050 trees/ ha) and was maintained for proper expression of various progenies for growth, crown and other associated traits. Out of 1050 trees were screened and two progenies were selected for the study.

Selection and felling

Progenies 76(M76) and number 104(M104) were selected for the study, based on its performance in the previous studies.[7] East direction was marked on all four trees bases on 10 cm above the ground for felling. Before tree felling diameter at breast height (DBH) was recorded (1.37 m above ground) using diameter tape. Then trees were felled, stumps samples were collected for moisture content analysis and reconverted in size of 5×5×2.5cm^3 immediately and were placed and sealed in an airtight polythene bags. Following details of the trees were recorded after felling:

a. Full height of tree
b. Clear bole height i.e. height from which first branching started

Conversion

The trees were further cut into 1.5m log lengths for determination of heartwood and sapwood ratios. Thus, a total of 26 logs were

recovered from four trees of two progenies. The wood samples were converted as per the requirement of various tests as described in the following sections.

Determination of initial moisture content

Initial weights of the specimens in green condition were taken. The MC specimens were placed in an oven set at 103±2ºC for overnight. After 24 hours, these samples were taken out and allowed to cool and then weighed. This process was repeated until its weight became constant. Moisture content % was determined with following formula (ASTM, 2016):

$$\text{M.C\%} = \frac{(\text{Green weight} - \text{Oven dry weight})}{\text{Oven dry weight}} \times 100$$

Determination of specific gravity (SG)

2.5 cm thick discs were cut from the felled trees at DBH. A line from north to south direction was drawn on discs passing through centre as shown in Figure 1A. Then, two parallel lines at a distance of 2.5 cm from central line on both the sides of the lines were drawn. This 5cm wide strip was divided in three parts: near pith, near bark (periphery) and between pith and bark (middle). From each part, three strips were obtained so that each strip had at least 2 growth rings. These strips were put in water for three days to make them saturated with water. The green volume of samples was measured by water displacement after samples were fully soaked in water.[11] The specimens were placed in an oven for drying at 103±2ºC for 24hrs, and then samples weight was recorded, until constant weight was attained. SG of each sample was determined by gravimetric method using single pan balance in Figure 1B. SG was calculated with the help of following formula:

$$\text{Basic density} = \frac{\text{Oven dry wt.}}{\text{Volume of saturated wood sample}}$$

$$\text{S.G.} = \frac{\text{Basic Density of wood sample}}{\text{Density of water}}$$

Figure 1 (A) Tree discs of the two progenies. **(B)** Single pan balance for measuring green volume of sample.

Maximum moisture content (MMC)

Maximum moisture content (%) (MMC) specific gravity of the wood.[12] It is a state of moisture in wood when the cell walls are fully saturated and cell cavities are completely filled with water. It is a condition attained by wood in waterlogged condition. MMC was calculated by following equation:

$$\text{MMC}(\%) = \frac{1}{SG} - \frac{1}{1.46} x100$$

Where, SG is specific gravity of the wood and 1.46 is the specific gravity of oven dry wood substance determined by helium displacement.

Determination of sapwood (SW) percentage (%)

After converting the trees into logs of lengths of 1.5 m (including above clear boles), measurements were made on logs cross sections for: average sapwood width, average radius of log ends, and average radius of heartwood using measuring tape. The SW (%) was determined using following equation.[13]

$$SW(\%) = (R^2 - r^2) / R^2$$

Studies on anatomical features of the wood

Two discs of 2.5cm long were taken from the trees at stump height to determine specific gravity and anatomical studies (Figure 1).

Macroscopic features

After the tests on specific gravity were completed, the same specimens were used for recording macroscopic features of the wood. These blocks (core, middle and periphery) were observed under 10 x hand lens and different features were recorded.[14]

Microscopic features

Three fresh specimens from core, middle and periphery were obtained following the procedure as described for preparation of specific gravity specimens. The wood specimens were boiled and specimens were put in watch glasses (Figure 2) and washed properly with water, 30 % alcohol was added followed by staining with 2-3 drops of safranin dye for 30min using Schultze's method. The wood sections were put on slides (Figure 2) and trimmed. Some drops of glycerin were added and covered with cover slip without formation of bubble on the slide. Prepared slides were placed under microscope to get microscopic view of slides. Different microscopic features were recorded.

$$SW(\%) = (R^2 - r^2) / R^2$$

Fiber morphology

Small chips were taken from outer surfaces in radial direction. These chips were immersed in test tubes containing 50 % nitric acid and 50 % water solution and a pinch of potassium chloride (Figure 2). Then openings of test tubes were wrapped with aluminum foil and placed in sunlight until the color of solution converted into white. The samples were pressed gently and again placed in test tube, shaken vigorously till fibers got separated. Specimens were again placed on watch glasses and stained for 30 min. The stained and macerated

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wood specimens were placed on slides and fibers were separated with the help of brush before covering it with cover slip. The slides were observed under microscope. Lengths and diameters of the cells were measured under 10x and 40x lenses. 25 readings were taken for each of the dimensions.

Figure 2 A. Preparation of ections with help of sliding microtome. B. Cut sections in watch glasses. C. Prepared Slides of different sections. D. Macerated specimens

Results and discussion

Tree form: height, girth at DBH, canopy height

The height of four trees are presented in Figure 3. The mean height of the four trees was 16.6 m. However, the height of clear boles and canopies varied. The mean canopy height of M76 was higher than M104 while mean clear bole height in M104 was higher as compared to M76. Similar results also reported by Pande & Dhiman[15] on Poplar clones, stating DBH of the poplar progenies were significantly different due to genetic control.

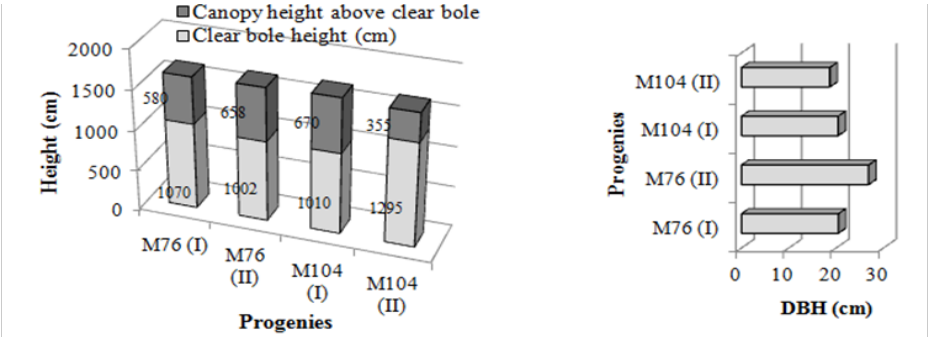

Figure 3 Height and DBH of 7 years old progenies of M. dubia investigated.

MC at the time of felling and specific gravity

Figure 4 illustrates extent of the moisture content and specific gravities in the two progenies.

Average moisture content was 80.3% and moisture content of both progenies was almost in line with teak and sissoo.[12] The maximum moisture content (MMC) of progenies was calculated to be 164.1% and 217% for M104 and M76 respectively. It may be seen that the MCs of the progenies at the time of felling was much lower than the MMC values. The information may be helpful in the trade of the wood logs of the species based on weight measurement. The Specific gravity of M104 was 0.43±0.05 where as that of M76 was 0.35±0.04. ANOVA for specific gravity revealed significant difference between mean specific gravities of progenies M104 (0.43±0.05) and M76 (0.35±0.04), F (1, 10) = 8.603, p=0.015. When the data was compared with that of a study done in last year[16] from same plantation and same group of progenies, a large difference in values of specific gravities was observed progenies. M104 (0.43±0.05) showed higher specific gravity for a different tree of the same progeny (0.39± 0.18) determined in the last study,[16] whereas, M76 (0.35±0.04) showed lower specific gravity than different trees of the same progeny (0.44±0.2). Thus, it is evident that the values of specific gravities obtained from these progenies in consecutive studies were not consistent i.e. variability within progeny. This fact indicates suitability of vegetative propagation methods for mass multiplication for a genetically superior progenies of the species.

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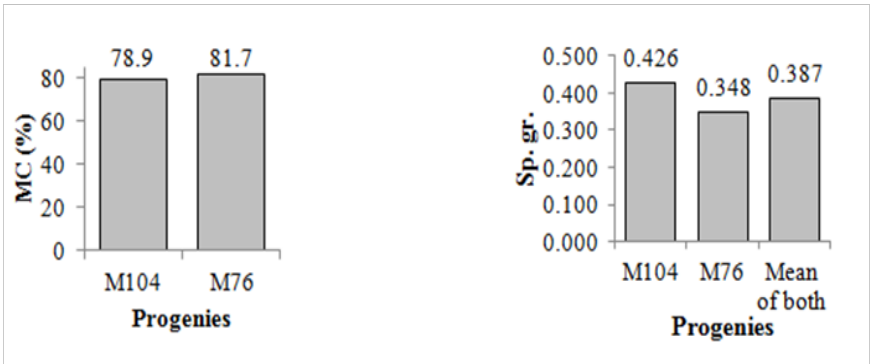

Figure 4 Moisture content and specific gravity of the two progenies.

SW%

The mean values of SW (%) for M104 were 39.12 %±6.81 whereas the SW% for M76 was 36.27 %±14.79. Thus, the HW was 60.88 % of the logs, which was better compared with to that of *T. grandis* at the age of 14 years 25–32 %.[17] The ANOVA of SW% revealed significant differences between SW% of both the progenies, F (1, 24) =0.398, p=0.534). The test of logs revealed the mean SW (%) for lower half was 37.49% (SD=13.69) where as for that of upper half, it was 37.94%±8.51. Independent samples t-test confirmed that the difference between SW% of both vertical halves was not significant, t (24) =-0.098, p=0.922.

Macroscopic features

Melia dubia wood is reddish brown in color and changes to light brown on sun light exposure. Wood is ring-porous having distinct growth rings and has straight grain pattern. Table 1 presents detailed macroscopic features of the species.

Table 1 Macroscopic features of *M. dubia*

Description of the wood	
Growth rings	Boundaries distinct or present
Porosity	Ring-porous
Vessel arrangement	Radial pattern
Vessel groupings	Radial multiples of 3 or more and also Solitary
Solitary vessel outline	Circular to oval
Size of vessels	Both small and large
Deposits	Present
Rays	Fine
Parenchyma	Scanty
Sapwood	
Color	Yellowish white
Distinct from heartwood	Yes
Width of sapwood	1-2.5cm
Heartwood	
Color	Reddish brown
Color on exposure	Light brown
Grain	Straight
Texture	Uneven
Luster	Lustrous
Odor	Present
No. of growth rings	6

Microscopic features

Table 2 presents the microscopic features of *M. dubia*. Microscopic view of the species in three directions is presented in Figure 5. Vessels were circular to oval and contain red gum deposits. Simple perforations plate and minute inter-vascular pits and alternately arranged, bordered pits were found. Scanty vasicentric parenchyma and homocellular rays are observed. The fibers were septet and thin to thick walled.

Table 2 Microscopic features of M. dubia

Description	
Growth rings	Boundaries distinct
Porosity	Ring-porous
Vessel arrangement	Radial pattern
Vessel groupings	Radial multiples of 3 or more and also Solitary
Solitary vessel outline	Circular to oval
Perforation plates	Simple
Inter-vessel pits: arrangement and size	Alternate, bordered, Minute–4 µm or less (1-1.5)
Helical thickenings in vessel elements	Throughout body of vessel element
Tangential diameter of vessel lumen	200µm or more
Deposits	Gum
Axial parenchyma	Scanty vasicentric
Vessel Ray pitting	Simple to minutely bordered pits
Rays	Fused
Ray width	Larger rays commonly 4- to 10-seriate
Rays: cellular composition	All ray cells procumbent
Rays per mm	12 or more /mm
Ground tissue fibers	Fibers with simple to minutely bordered pits
Fibers	Septet fibers present

Fiber morphology

Table 3 presents mean fiber lengths of the two progenies. The data includes fiber lengths included from all locations viz. near pith, middle and periphery.

The mean fiber length of *Melia dubia* was more than 700µm. However, in a similar study by Sarvanan[8] reported mean fiber length of 923µm. When compared with other species, fiber length of *M. dubia* was recorded to be lower than mango (770µm), poplar (1161±169.78µm) and teak wood (1215µm±72.72) species.[15,18,19]

Many studies have reported that the fiber length and growth rate are inversely proportional to each other (Figure 6).[20]

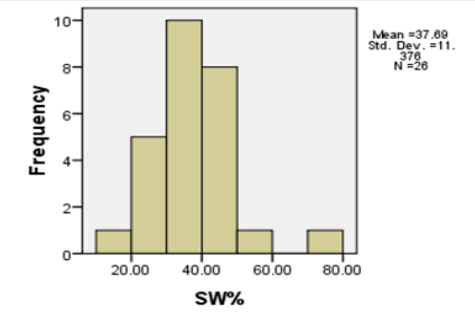

Figure 5 Sapwood proportion in *Melia dubia.*

The one-way ANOVA revealed that the difference between fiber length of M104 (mean= 703.86, SD=168.94) and M76 (mean=736.0, SD=246.9) was statically not significant, F (1, 248) =1.493, p=0.223, this implies the fiber lengths did not vary between the two progenies. Figure 7 illustrates the frequency histogram showing the distribution of fiber length of both the progenies combined.Q-Q plot (Figure 6) illustrates that the fiber length data is fulfilling the assumption of normality i.e. observed and expected values of fiber lengths are pretty close. Histogram shows the frequency distribution of the fiber lengths in µm. It can be concluded that the mean fiber length for the *Melia dubia* is 716.72±203.88µm**.** Moreover, one-way ANOVA among fiber length of different radial locations in wood log, inner (640.67 µm±160.42), middle (760.33µm ±194.05) and outer (740 µm±225.23) locations was statically significant, F (2, 247) =8.106, p=<0.001. Similar finding is also reported by other researchers.[21,22]

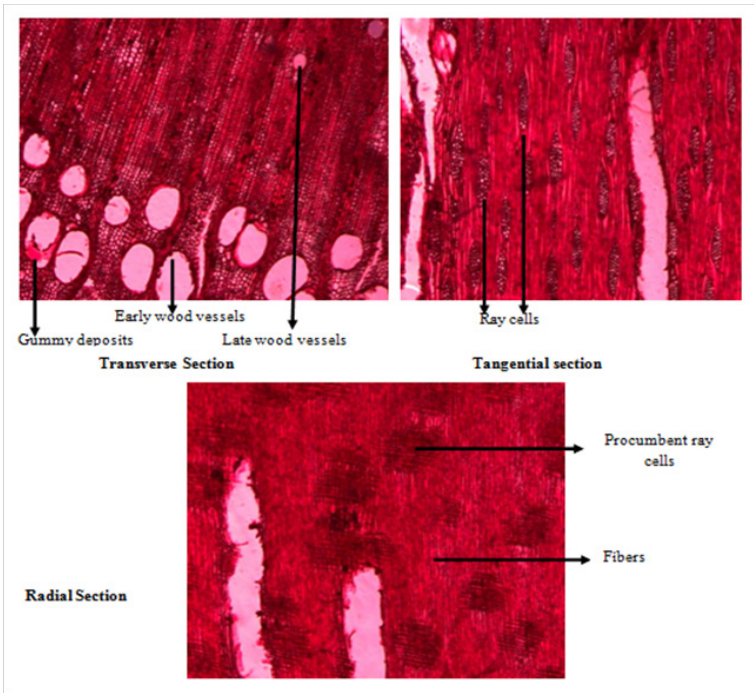

Figure 6 Cells morphology of *M. dubia*.

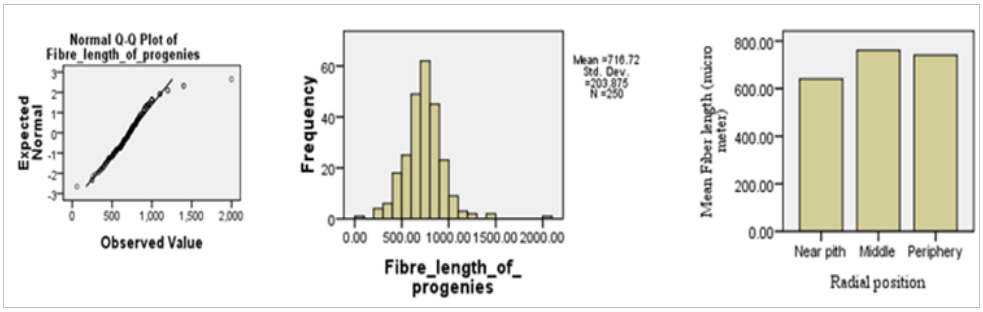

Figure 7 Q - Q plot, frequency histogram for fiber lengths and its radial variation.

Table 3 Descriptive statistics of fiber length of both progenies and different locations from pith to periphery

Progeny	Fiber length (µm)	Standard deviation	Minimum (µm)	Maximum (µm)
M104	703.86	168.94	250	1200
M76	736.00	246.90	60	2000

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Fiber wall thickness

Mean of the fiber wall thickness was 4.15µm±2.39µm for both the progenies (Figure 8). Fiber wall thickness of M104 was lower (3.52±1.67µm) than that of M76 (5.08±3.30µm). The one-way ANOVA confirmed that the difference between cell wall thickness of M76 was statically significant, F (1, 248) =27.909, p=<0.001). Thus, the cell wall thickness varied between the two progenies of *M. dubia*.

The one-way ANOVA confirmed that the difference between cell wall thickness of locations of inner (mean= 3.72µm, SD=1.89), middle (mean=4.16µm, SD=2.11) and outer (mean=4.56µm, SD=2.85) was not statically significant, F (2, 247) =2.07, p=0.128). On contrary of it, other studies show that the cell wall thickness increased from pith towards the bark in *Alnus glutinosa*.[23]

Vessel morphology

Table 4 presents vessel morphology of the two progenies of *M. dubia* viz. vessel length (VL) and vessel diameter (VD). Table 4 illustrates the fact that mean vessel length of M104 and M76 is 260.5µm. The mean vessel diameter of the species was 197.9µm.[24–27]

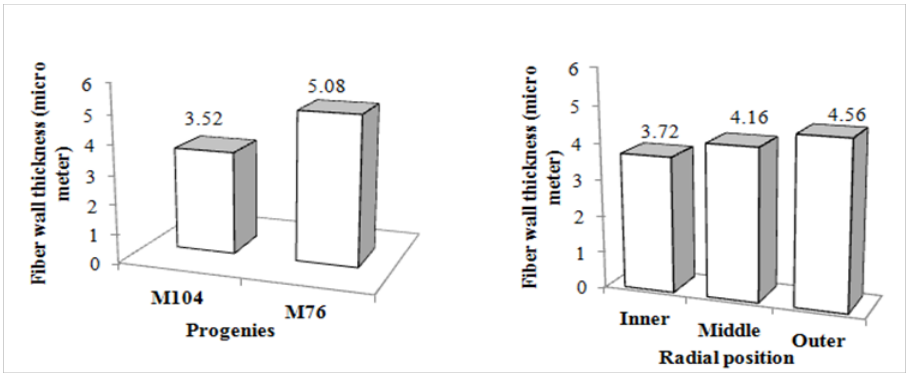

Figure 8 Fiber wall thicknesses of the two progenies and its radial variation.

Table 4 Vessel lengths of the two progenies of *M. dubia*

	M76		M104	
	VL	VD	VL	VD
Average	261.02	202.76	260.13	193.07
Max	520.00	400.00	410.00	350.00
Min	120.00	60.00	120.00	70.00
St Dev	69.08	70.50	62.09	57.13

Conclusion

Melia dubia is a ring-porous wood with distinct growth rings. The sapwood is found to be yellowish white, while the heartwood was found to be yellowish brown in colour. A six years old plantation of *Melia dubia* attained 16.6 m height. The mean moisture content in the living trees was, 80.3 %.Specific gravities of two progenies investigated were 0.43 and 0.35, moreover the difference in specific gravity was statistically significant. The mean heartwood for progenies was 60.88 %. The mean fiber length of *Melia dubia* was 716.72 µm. The fiber length of periphery was higher than that of near pith. Mean fiber wall thickness was 4.15 µm for both progenies. Cell wall thickness varied significantly between the progenies, Mean vessel length and diameter of the species were 260.5 µm and 197.9 µm respectively. The exploratory study indicates that being a very fast growing species, *Melia dubia* needs a careful tree breeding programme as the wood shows huge variability in its physical and anatomical properties amongst its progenies.

Acknowledgments

None.

Conflicts of interest

The author declares there are no conflicts of interest.

References

1. Chaturvedi OP, Sikka AK, Handa AK, et al. Agroforestry Technologies for Different Agro-climatic Zones of the Country. AICRPA, Central Agroforestry Research Institute, Jhansi, India. 2016.
2. Zobel B, The changing quality of the world wood supply. *Wood Science and Technology*. 1984;18(1):1–17.
3. Zhang SY, Chui YH. Selecting dry fiber weight for higher and better quality jack pine fiber production. *Wood and Fiber Science*. 1996;28(2):146–152.
4. Burley J, Palmer RR. Pulp and wood densitometric properties of *Pinus caribaea* from Fiji. C.F.I. Occasional Paper No. 1979. 66 p.
5. Jorge F, Quilho T, Pereira H. Variability of fibre length in wood and bark in Eucalyptus globules. *IAWA J*. 2000;21(1):41–48.
6. Panshin AJ, deZeeuw CE. Textbook of wood Technology. McGrawhill, NewYork; 1980. 643 p.
7. Kumar S, Kelkar BU, Mishra AK, et al. Variability in physical properties of plantation - grown progenies of Melia composita and determination of a kiln-drying schedule. *Journal of Forestry Research*. 2018;29:1435–1442.
8. Sarvanan V, Parthiban KT, Sekar I, et al. Radial variations in anatomical properties of *Melia dubia* cav. at five different ages. *Scientific Research and Essays*. 2013;8(45):2208–2217.
9. Swaminathan C, Vijendra Rao R, Shashikala S. Preliminary Evaluation of Variations in Anatomical Properties of *Melia dubia* Cav. *Wood International Research Journal of Biological Sciences*. 2012;1(4):1–6.
10. Narasimhamurthy, Upadhyay VK, Kushwaha PK, et al. Study on anatomical and mechanical properties of plantation grown *Melia dubia* & *Populus deltoids* andits suitability for plywood manufacturing. *International Journal of Engineering and Technical Research*. 2017;7(5):211–214.
11. Diana MS. Maximum moisture content method for determining specific gravity of small wood samples. United States Department of Agriculture,

Forest service, Forest Products Laboratory Madison, Wisconsin; 1954.

12. Pandey CN, Jain VK. 1992. Wood Seasoning Technology. Indian Council of Forestry Research and Education. 1992. 144 p.
13. Tan YE, Lim NPT, Gan KS, et al. Testing Methods for plantation grown tropical timbers. Report of ITTO project on improving utilizatio and value adding of plantation timbers from sustainable sources in Malaysiano. PD 306/ 04 (1), Forest research institute, Malaysia; 2010.
14. IAWA Committee. IAWA list of microscopic features for hardwood identification. In: Wheeler EA, Baas P, Gasson P, editors. *IAWA Bull*. 1989;10(3):219–332.
15. Pande PK, Dhiman RC. Performance and variability patterns in wood properties and growth traits in the parents, F1 and F2 generation hybrid clones of *Populus deltoides*. *Journal of Forestry Research*. 2011;22(3):379–385.
16. Kelkar UB. Determination of physical and drying properties of 31 progenies of *Melia composita*. MSc. thesis, Forest Research Institute (deemed) University, Dehradun; 2016. 48 p.
17. Zahabu E, Raphael T, Omari SA, et al. Effect of Spacing Regimes on Growth, Yield, and Wood Properties of *Tectona grandis* at Longuza Forest Plantation, Tanzania. *International Journal of Forestry Research*. 2015. p.
18. Subrahmanyam SV, Godiyal R, Janbade V, Preparation of monograph of different fibrous raw materials used by Indian paper industry. Cess project, Central Pulp and Paper research Institute, Saharanpur UP, India; 2004.
19. Lu S, Chun SK. Wood Anatomy of *Tectona grandis* Department of Wood Science and Engineering, College of Forest Scienc, Kangwon, National University Chunchon: 2006. p. 70–200.
20. Zobel BJ, Van Buijtenen JP. Wood variation: its causes and control. Berlin, Spirnger- Verlag. 1989. 418 p.
21. Chauhan L, Gupta S, Madhwal RC, et al. Interclonal, intraclonal and within tree variation in wood parameters of different clones of Populus deltoides. *Indian Forester.* 2001;127(7):777–784.
22. Ishiguri F, Eizawa J, Saito Y, et al. Variation in the wood properties of Paraserianthesis falcataria planted in Indonesia. *IAWA Journal*. 2007;28(3):339–348.
23. Kiaei M, Naji HR, Abdul-Hamid H, et al. Radial variation of fiber dimensions, annual ring width, and wood density from natural and plantation trees of alder (*Alnus glutinosa*) wood. *Wood Research*. 2016;61(1):55–64.
24. ASTM. Direct moisture content measurement of wood and wood-based materials. ASTM D4442–92. West Conshohocken, PA: American Society for Testing and Materials. 2016.
25. Honjo K, Fujitha M, Sahri MH. Radial variation in the morphology of axial elements in *Acacia mangium*. *IAWA Journal*. 2002;23(4):459–485.
26. Kumar A, Parveen Dobhal S, Sharma S. et al. Genetic screening and improvement of Melia composita willd. *Annals of Forestry*. 2013;21(2):189–196.
27. Lim SC, Gan KS. Some physical and anatomical features of fourteen year old *Acacia mangium. Journal of Tropical Forest Products*. 2000;6(2):206–213.

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