Vessel morphology variation and ecoanatomical properties of anjily (*Artocarpus hirsutus* Lam.) wood grown in different agro-climatic zones of Thrissur, Kerala

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Abstract

Vessel morphological parameters viz., vessel frequency, vessel diameter, vessel area and vessel length of anjily wood collected from trees grown in three agro-climatic zones of Thrissur district, Kerala were studied. Three girth classes were selected from each zone. Three trees representing each girth class were then chosen for collection of wood samples. Significant variation was found only among agro-climatic zones for vessel length and not between girth classes within zones. Vessel area, vessel diameter and vessel frequency did not show any significant variation between three zones as well as between girth classes. Ecoanatomical properties like vulnerability and vessel mesomorphy were also calculated. Vulnerability showed significant difference between the three zones. Vessel mesomorphy values of anjily wood indicated that the species is mesic in nature.

Keywords: Agro-climatic zones, Mesomorphy,Vessel morphology, Vulnerability

Introduction

Western Ghats is endowed with a rich diversity of flora and fauna in its wet evergreen forests. These forests generally occur throughout the tropical parts of Southern India and Andamans. The vegetation consists of tree species like *Artocarpus hirsutus* Lam. commonly known as the wild jack tree (Khanna, 2009). The tree is one of the important endemic timbers of Southern Western Ghats and is also common along the Malabar Coast (Mathew et al., 2006). *Artocarpus hirsutus* forms one of the major woody components of homegardens in Southern India, especially in Kerala. The timber obtained from this species comes next to teak in economic value. The most common use is in furniture, house construction and boat making (Manilal, 2003). Wood obtained from the tree is having high calorific value and hence, it can be used for fuel wood purposes also (Gopikumar, 2009). However, no studies have been reported yet on anatomical properties of the wood of this important timber species, pertaining to homestead grown trees. Hence, in this paper we focused on some of the anatomical properties of the anjily wood collected from homesteads of Thrissur district, Kerala.

Materials and Methods

Wood samples were collected from three agro-climatic zones of Thrissur district namely coastal sandy, central mid land and Malayoram. Three girth classes were selected viz. 50-100 cm, 100-150 cm and > 150 cm. Wood samples were collected from three trees from each girth class by using a Haglöf Increment Borer. Wood sections were taken by using

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a Leica sliding wood microtome (Leica SM 2000R) for analyzing vessel frequency, vessel area and vessel diameter. Maceration was done for determining vessel length using Jeffery's solution. Permanent slides were prepared using DPX mountant. These slides were observed under an image analyzer (Labomed Digipro 2) for taking various anatomical measurements. Wood anatomical indices such as vulnerability (vessel member diameter divided by vessel frequency) and mesomorphy (vulnerability multiplied by mean vessel member length) were calculated from species means following the formulae provided by Carlquist (1977). Nested ANOVA and Tukey's test were performed for comparing different parameters between three zones as well as between girth classes within zones using a software MINITAB (Ver. 17).

Results and Discussion

Vessel morphology

Vessel frequency was found to vary from 2-3 no./mm^2 among the three agro-climatic zones and non-significant variation was found between the three agro-climatic zones as well as between the three girth classes. Most of the vessels were found to be solitary. This might be due to the higher frequency of vessels; smaller the diameter, greater the chance for grouping of vessels (Vijayan, 2017). Similar vessel frequency was also found in teak by Cardoso et al. (2015) from East Timor. Analysis revealed that no significant difference existed between zones or girth classes as all the three zones were experiencing more or less similar rainfall pattern and also since vessel frequency is mostly related to water conductivity. Vessel diameter also did not vary significantly between zones or girth classes. Vessel diameter ranged from 194.93 µm to 236.49 µm for coastal sandy, 245.47 µm to 291.52 µm for Central mid land and 222.85 µm to 261.22 µm for Malayoram. Vessel area ranged from 49432.03 µm^2 to 78869.70 µm^2 for coastal sandy, 70159.32 µm^2 to 93481.86 µm^2 for Central mid land and 69449.11µm^2 to 127585.48 µm^2 for Malayoram. There was no significant variation in vessel area between zones as well as between girth classes within zones. Vessel length ranged from 248.47 µm to 289.43 µm for coastal sandy, 126.86µm to 171.31 µm for Central mid land and 192.71 µm to 330.27 µm for Malayoram. There was significant difference in vessel length between zones. However, there was no significant difference in vessel length between girth classes within zones. Carlquist (2001) noted that along with moisture availability and freezing effect on xylem anatomy, geographical location of a wood sample also affects structure, or phenology, e.g., slope exposure, rainfall, deciduous nature of plant, leaf size, or seasonal stem dieback. Therefore, it can be inferred that the above difference can be attributed to slope and exposure as all the three zones have different topographical features. Singh et al. (2017) also found vessel length of 284.4 µm in

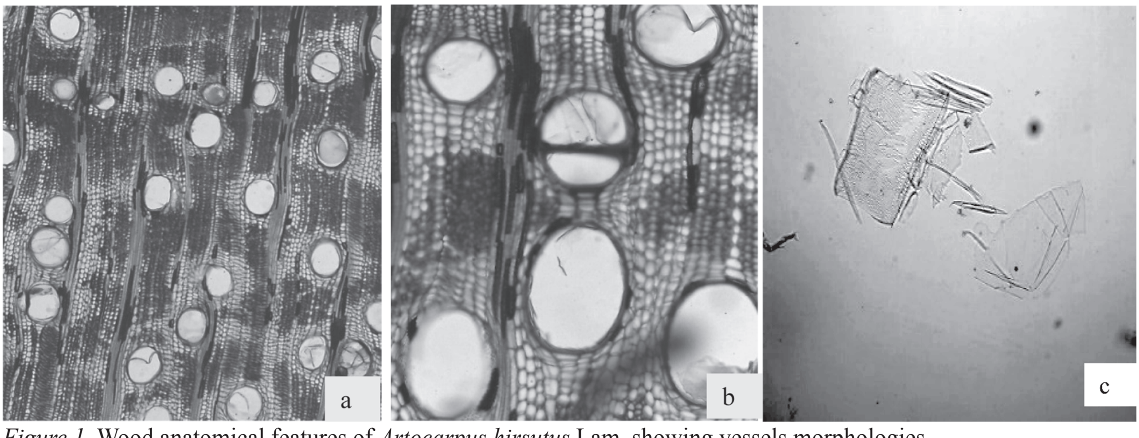

Figure 1. Wood anatomical features of *Artocarpus hirsutus* Lam. showing vessels morphologies
1a: vessels in TS (x4), 1b: tyloses in vessels (X10), 1c: vessel element (maceration X40)

Artocarpus nitidus collected from Assam and Mizoram. The vessel length of teak was also found to be 279 µm (Ahmed and Chun, 2011).

Ecoanatomical properties of anjily wood

Vulnerability and Mesomorphy are two indices determined by Carlquist (1977) for determining the role of ecological factors in variation in wood anatomy. The values of vulnerability and mesomorphy vary according to different climatic conditions. A low value for vulnerability (1.0) and mesomorphy (75) indicate adaptation to xeric condition i.e it can withstand the low water availability while high value of vulnerability and mesomorphy indicate the adaptation of species to mesic condition, according to Meena and Gupta (2014) who studied these parameters in *Albizia procera* which also possessed large vessels with low frequency. They also demonstrated that vulnerability of *A. procera* in tropical condition was 85.10 in Bangladesh and Mesomorphy in tropical area varied from 31999.10 to 10970. This finding is similar to our study in which we found that vulnerability ratio was highest in central mid-land zone of Thrissur i.e.136.82 and mesomorphy of three zones ranged from 21083.99 to 32955.65. *Artocarpus hirsutus* proved efficient enough in conductivity due to its large vessel area and few numbers. Nooshin (2012) who studied vulnerability and mesomorphy in *Haloxylon ammodendron* also found that it was

Table 1. Vessel frequency (no./mm^2) of *Artocarpus hirsutus* Lam. wood from different agro-climatic zones and girth classes

	Girth classes				
Agro-climatic zones	50-100 cm	100-150 cm	>150 cm	Zone Mean	F-value
Coastal sandy	2	3	2	2	1.75^{ns}
	(0.58)	(0.58)	(0.00)	(0.58)	(zones)
Central mid land	2	2	2	2	1.33 ^{ns}
	(0.00)	(0.00)	(0.00)	2(0.00)	(Girth classes
Malayoram	2	2	2	2	within zones)
	(0.58)	(0.00)	(0.00)	(0.00)	

Values within parentheses is standard deviation (SD); ns- non-significant at 0.05 level

Table 2. Vessel diameter (µm) of *Artocarpus hirsutus* Lam. wood from different agro-climatic zones and girth classes

	Girth classes				
Agro-climatic zones	50-100 cm	100-150 cm	>150 cm	Zone Mean	F-value
Coastal sandy	236.49	223.08	194.93	218.26	4.65^{ns}
	(41.19)	(22.09)	(67.37)	(21.21)	(Zones)
Central mid land	245.47	283.18	291.52	273.39	1.63 ^{ns}
	(18.99)	(15.12)	(17.27)	(24.53)	(Girth classes
Malayoram	261.22	222.85	255.66	246.57	within zones)
	(4.33)	(23.25)	(9.02)	(20.73)	

Values within parentheses is standard deviation (SD); ns- non-significant at 0.05 level

Table 3. Vessel area (µm^2) of *Artocarpus hirsutus* Lam. wood from different agro-climatic zones and girth classes

	Girth classes				
Agro-climatic zones	50-100 cm	100-150 cm	>150 cm	Zone Mean	F-value
Coastal sandy	78869.7	61746.08	49432.03	63349.27	1.12^{ns}
	(55949.60)	(8289.14)	(25416.11)	(14784.17)	(zones)
Central mid land	70159.32	93481.86	72912.51	78851.23	1.11 ^{ns}
	(14588.22)	(16933.03)	(15952.51)	(12705.45)	(Girth classes
Malayoram	127585.48	69449.11	73216.46	90083.68	within zones)
	(83357.50)	(12551.09)	(5007.35)	(32532.08)	

Values within parentheses is standard deviation (SD); ns- non-significant at 0.05 level

Table 4. Vessel length of *Artocarpus hirsutus* Lam. wood from different agro-climatic zones and girth classes

	Girth classes				
Agro-climatic zones	50-100 cm	100-150 cm	>150 cm	Zone Mean	F-value
Coastal sandy	271.24	289.43	248.47	269.71^{B}	6.47*
	(46.64)	(74.70)	(35.22)	(20.522)	(zones)
Central mid land	126.86	160.35	171.31	152.84^{A}	1.11^{ns}
	(2.36)	(25.50)	(19.74)	(23.15)	(Girth classes
Malayoram	330.27	329.02	192.71	284^{B}	within zones)
	(86.65)	(62.84)	(58.14)	(79.06)	

Values within parentheses is standard deviation (SD); ns- non-significant at 0.05 level;*- significant at 0.05 level
Means with same letter as superscript indicates homogeneous groups

Table 5. Vulnerability index of *Artocarpus hirsutus* Lam wood from different agro- climatic zones and girth classes

	Girth classes				
Agro-climatic zones	50-100 cm	100-150 cm	>150 cm	Zone Mean	F-value
Coastal sandy	105.85	85.41	97.46	96.24^{A}	11.26*
	(33.69)	(12.45)	(33.68)	(10.27)	(zones)
Central mid land	122.73	141.99	145.76	136.82^{B}	0.88^{ns}
	(9.49)	(7.56)	(8.63)	(12.35)	(girth classes
Malayoram	97.46	145.76	127.83	118.39^{AB}	within zones)
	(33.68)	(8.63)	(4.51)	(8.47)	

Values within parentheses is standard deviation (SD);ns- non-significant at 0.05 level;*- significant at 0.05 level
Means with same letter as superscript indicates homogeneous group

Table 6. Vessel mesomorphy of *Artocarpus hirsutus* Lam.wood from different agro- climatic zones and girth classes

	Girth classes				
Agro-climatic zones	50-100 cm	100-150 cm	>150 cm	Zone Mean	F-value
Coastal sandy	29317.70	24226.26	24937.41	26160.45	3.76^{ns}
	(13557.07)	(3716.67)	(10903.85)	(2757.27)	(zones)
Central mid land	15556.60	22833.02	24862.36	21083.99	1.33^{ns}
	(912.06)	(4423.26)	(1427.36)	(4893.22)	(girth classes
Malayoram	37485.71	36844.75	24536.51	32955.65	within zones)
	(9669.53)	(9474.96)	(7088.06)	(7298.43)	

Values within parentheses is standard deviation (SD); ns- non-significant at 0.05 level

resistant to drought condition. Vessel diameter is inversely proportional to vessel density and is a good indicator of determination of vulnerability and mesomorphy (Carlquist, 1988).

The present study revealed that only vessel length showed significant difference between girth classes across three agro-climatic zones. Vessel frequency, vessel area and vessel diameter did not show significant difference across the three agro-climatic zones. Ecoanatomical characters like vulnerability index and vessel mesomorphy were also analysed and vulnerability index was found to be highest in central mid land. The results of the present study can be used as a baseline data for future tree improvement programme of this species for different end uses. As information on wood properties of *Artocarpus hirsutus* is very scarce, this study can provide important details regarding wood properties of this species.

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