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Wood Density Variation around the Circumference in Pinus Merkusii Jhungh & de Vriese

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***Abstract*— Wood density is one of the most important wood characteristics. It is an important indicator of wood quality and selection of wood for different end uses. The present study was carried out on cross- sectional discs of Pinus merkusii at breast-height collected from pine forest of Dong village, Anjaw district of Arunachal Pradesh. The main aim of the present study was to evolve an efficient sampling procedure for wood density comparison amongst trees. Analysis of variance carried out among eight cardinal directions revealed significant variation in wood density around the circumference. A non-significant variation was observed when wood density of two opposite directions was compared with mean of eight cardinal directions with multiple comparisons by using linear contrast. Hence, any two opposite directions can be suggested for comparison of wood density among Merkus Pine trees.**

***Keywords*: Breast-height, Cardinal directions, Pinus merkusii, Wood density.**

I. INTRODUCTION

Pinus merkusii is a fast growing species and is one of the few truly tropical pines in the world. It occurs naturally in South - East Asia in Burma, Thailand, Laos, Cambodia, Vietnam, Indonesia, Phillipines (Srivastava and Bahar, 2007} and introduced in countries like Sri Lanka, Papua, New Guinea, South Africa, Tasmania, Uganda and Zambia. In India, it occurs in huge tracks in Walong near Kibithoo in Anjaw district of Arunachal Pradesh neighbouring to China and Myanmar in Indo-Myanmar pine Forest Eco-region.It plays an important role in daily needs of the tribes of Anjaw district. It is known as ‘‘Rung sang and Rungpo aseng” by Miju Mishmi and Meyor tribes. The word ‘Rung’ and ‘Rungpo’ means resin and ‘sang’ or ‘aseng’ means tree in their local dialect. The young shoots of the tree are dried, ground and are used as a substitutes of green tea by the local tribe. The shoots and oleo-resin of the tree are also used for ritual purposes. The wood is light to moderately heavy, moderately hard, moderately refractory, straight grained with coarse texture. It is very easy to saw, work with tools and takes a good polish. Therefore, it is used for making furniture, poles, flooring, paneling and even for preparation of bunkers by Indian armed forces (Srivastava and Bahar, 2007). Due to over exploitation and unsustainable extraction for timber, degradation of habitat and frequent forest fire, its conservation status has been changed to vulnerable from rare (IUCN, 2011). Wood density is highly variable and variations are due to anatomical, physical and chemical characteristics which vary according to age, origin, spacing, growth rate, genus and species (Melo et al., 2013). Wood density is known to vary from tree to tree around the circumference, from pith to bark, from bottom to top of a tree and even within a small sampling unit like an annual ring (Koga and Zhang, 2004; Gűller et al. 2012). Since wood density is under strong genetic control, its variation provides an advantage for the development of better wood to the forester. On the other hand, it creates problems in developing efficient methods for utilization of wood for various products. The present study is an attempt to find out the minimum number of directions required to be sampled for comparison of wood density around the circumference.

II. MATERIAL AND METHODS

Sample collection

Six trees of Pinus merkusii with straight bole, uniform crown and with no visible defects were selected randomly from pure pine forest of Dong village under Walong administrative circle of Anjaw district of Arunachal Pradesh at the time of road construction by Border Road Organization (BRO) under border area development programme. The geographical coordinate of the selected sites taken with GPS were $28^0$10'16.10"N latitude and $97^0$02'32.88"E longitude. The age of the trees were 25-91 years with 17-37m in height and 1.25-2.80m in diameter. The north side of each tree was marked with nail. The cross-sectional discs of about 10 cm thickness were taken at breast height. (Fig.2) The discs were packed in plastic bags and brought to laboratory for further processing.

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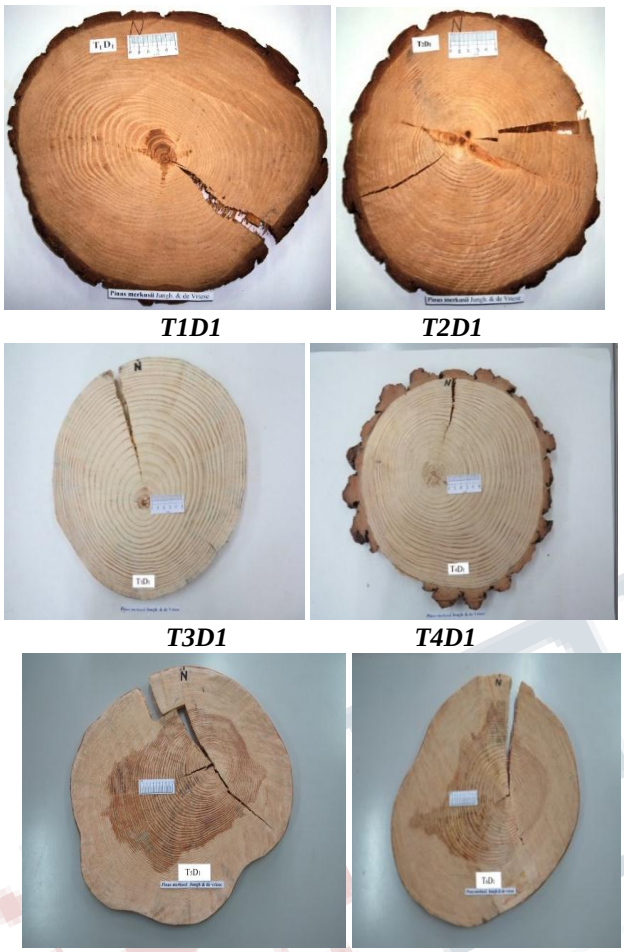

Fig.1. Cross-sectional discs of Pinus merkusii Jhungh & de Vriese trees at breast-height.

Processing of wood samples

All cross- sectional discs were smoothened to end grain with the help of an electric planner and sand paper to obtain clear annual rings on the surface and were photographed. The cross-sectional discs were marked into eight cardinal directions namely North, South, East, West, North West, North East, South West and South East. with a marker pen (Fig.1). Some of the rings which could be easily identified were marked in all directions around the circumference to facilitate the equal counting of rings. A few rings were selected randomly from each tree and thus, a total of 360 rings were selected randomly from 48 wedges sawn out from cross-sectional discs to study circumferential variation in ring width. Wood density of all selected annual rings was determined by water displacement method (Smith, 1955).

Analysis of variation was carried out to see the variation in wood density around the circumference. The result presented in Table.1 showed a non- statistically significant variation around the circumference except Trees 3, 4 and pooled data. Further analysis of variance was carried out with mean of wood density of two opposite directions and mean of wood density of eight cardinal directions with multiple comparison by using linear contrast (Freese, 1974) in Tree 3, 4 and pooled data. The results given in Table.2 showed non-significant difference in wood density between mean of two opposite directions versus eight cardinal directions around the circumference.

Table 1. Analysis of variance for wood density values at breast height in Pinus merkusii. amongst eight cardinal directions

Tree no.	Source of variation	Degree of freedom	Sum of square	Mean square	F-ratio
Tree 1	Directions	7	0.020	0.003	2.067^{ns}
	Rings	6	0.006	0.001	0.728^{ns}
	Error	42	0.059	0.001	
	Total	56	10.716		
Tree 2	Directions	7	0.008	0.001	1.786^{ns}
	Rings	6	0.112	0.019	29.455^{**}
	Error	42	0.027	0.001	
	Total	56	10.044		
Tree 3	Directions	7	0.017	0.002	3.086^{*}
	Rings	6	0.005	0.001	1.107^{ns}
	Error	42	0.032	0.001	
	Total	56	11.530		
Tree 4	Directions	7	0.017	0.002	2.615^{*}
	Rings	6	0.114	0.024	25.579^{**}
	Error	42	0.039	0.001	
	Total	56	9.614		
Tree 5	Directions	7	0.011	0.002	1.342^{ns}
	Rings	7	0.082	0.012	9.637^{**}
	Error	49	0.059	0.001	
	Total	64	14.735		
Tree 6	Directions	7	0.012	0.003	1.948^{ns}
	Rings	8	0.22	0.003	3.147^{**}
	Error	56	0.049	0.001	
	Total	72	18.547		
Pooled	Directions	7	0.040	0.006	5.71^{**}
	Rings	44	0.169	0.004	3.80^{*}
	Error	328	0.336	0.001	
	Total	380	61.903		

The levels of significance used are:
* =5 percent at p<0.05 level i.e. significant.
** =1 percent at p<0.01 level i.e. highly significant

Table 2. Analysis of variance for wood density values at breast height in Pinus merkusii. between various directional combinations

Tree no.	Source of variation	Degree of freedom	Sum of square	Mean square	F-ratio
Tree 3	N+S vs $\bar{X}$	1	1.2E-4	1.2E-4	0.117^{ns}
	E + W vs $\bar{X}$	1	8.0E-5	8.0E-5	0.089^{ns}
	NE + SW vs $\bar{X}$	1	5.0E-7	5.0E-7	0.001^{ns}
	NW +SE vs $\bar{X}$	1	5.0E-7	5.0E-7	0.001^{ns}
Tree 4	N+S vs $\bar{X}$	1	7.0E-5	7.0E-5	0.075^{ns}
	E + W vs $\bar{X}$	1	2.0E-3	2.0E-3	0.002^{ns}
	NE + SW vs $\bar{X}$	1	8.0E-6	8.0E-6	0.008^{ns}
	NW +SE vs $\bar{X}$	1	1.0E-4	1.0E-4	0.13^{ns}
Pooled	N+S vs $\bar{X}$	1	1.0E-4	1.0E-4	0.085^{ns}
	E + W vs $\bar{X}$	1	1.0E-5	1.0E-5	0.007^{ns}
	NE + SW vs $\bar{X}$	1	2.0E-5	2.0E-5	0.009^{ns}
	NW +SE vs $\bar{X}$	1	1.0E-5	1.0E-5	0.007^{ns}

N, S, E, W, SE, NW, SW and NE - Eight cardinal directions viz, North, South, East, West, Southeast, Northwest, Southeast and Northeast.

$\bar{x}$=Mean of cardinal directions

vs =versus

ns=non-significant.

III. DISCUSSION

Circumferential variation in wood density is important to evolve sampling technique for its comparison among rings of same or different trees. It also helps to select minimum number of directions required for sampling to study further radial and axial variations. There is very limited and conflicting information available on these objectives in the literature. Andrew and Burley (1972) opted whole annual ring as sampling stratum whereas Seth et al.(1986) selected five sampling strata namely whole annual ring, whole-early wood, whole latewood, first formed early wood and last formed latewood to study wood density variation around the circumference. There are also different opinions for selection of number of directions for wood density sampling. Burley and Andrey (1970) suggested two radial random samples for P.kesiya. González (1989) and Seth et al. (1986) recommended to any two opposite directions for estimation of wood density in Pinus contorta and Cedrus deodara. On contrary to it, any single random radial direction was recommended by Seth and Agarwal, 1988; Andrew and Burley, 1972. The present investigation reveals that some of the annual rings were very narrow with less percentage of late wood around the circumference and was difficult to separate these in different sampling strata. Therefore, whole-annual ring sampling was adopted for the present study as it was easy to separate and identify around the circumference. The present findings showed that wood density varied significantly in Tree 3, Tree 4 and pooled data whereas non-significant variation existed in Tree1, Tree 2, Tree 5 and Tree 6, when the trees with significant variation were further subjected to analysis of variance between means of two opposite directions versus means of eight cardinal directions around the circumferences, a non-significant variation was observed. The significant difference in wood density around the circumference may be due to eccentric cross-sectional discs with presence of compression wood in some of the rings. The present study is in agreement with the findings of Seth et al. 1986 and Gonzalez, 1989. Hence, any two opposite directions may be selected for comparison of wood density among trees.

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