Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 8, Issue, 11, pp. 21459-21464, November, 2017

ISSN: 0976-3031

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Research Article

RADIAL PATTERNS OF WOOD DENSITY VARIATION IN *PINUS MERKUSII* JHUNGH & DE VRIESE

Lego K., Sharma M and Sharma C.L*

Wood Science and Forest Products Laboratory, Department of Forestry
NERIST, Nirjuli- 791109, Arunachal Pradesh, India

DOI: http://dx.doi.org/10.24327/ijrsr.2017.0811.1078

ARTICLE INFO

Article History:

Received 20th August, 2017
Received in revised form 29th September, 2017
Accepted 30th October, 2017
Published online 28th November, 2017

Key Words:

Breast-height, Juvenile wood, Mature wood, *Pinusmerkusii*, Radial variation, Wood density.

ABSTRACT

The present study was conducted in *Pinus merkusii* Jhungh & de Vriese to find out the patterns of wood density variation from pith to bark at breast-height and successive heights and to see the relationship between juvenile and mature wood. The study revealed gradual increase in wood density variation from pith to bark at all heights. The boundary was demarcated at 15th ring and a positive and significant relationship existed between juvenile and mature wood.

INTRODUCTION

Wood density is one of the important indicator of wood quality. It is one of the main functional characteristics of woody plant species. The woods with higher density are decay and drought resistant (Hietz *et al*.2013). It is related to above ground biomass and carbon stock estimation (Nogueira *et al*., 2008; Chave *et al*., 2009). It affects the shrinkage and swelling behaviour of wood. In addition, it is related to many physical properties like strength, stiffness, hardness ease of drying, machining (Jyske *et al*.2008), pulp yield and physical properties of fibrous products (Molteberg and Høibø, 2007), quality and quantity of wood products (Zobel and van Buitjtenen, 1989). Wood density also plays a major role for analysis of tree growth and prediction of future tree productivity due to climate change (Bouriaud *et al*. 2004).

A perusal of literature reveals that wood density is highly variable like other wood characteristics and varies within and among trees. It varies from pith to bark radially, from base to top axially, from one side of tree to other side around the circumference and even within an annual ring (Zobel and van Buijtenen, 1989). Wood density is under strong genetic control. Its variation provides an advantages for the development of better wood to the forester and also creates problems in developing efficient methods for utilization of wood for various products. The present investigation on radial patterns of wood density variations from pith to bark in *Pinus merkusii* Jhungh & de Vriese has been made with the objectives of (a) to determine the magnitude of wood density variations from pith to bark at breast-height and successive heights (b) to demarcate the boundary between juvenile wood and mature wood and (c) to see the relationship between juvenile wood and mature wood

MATERIAL AND METHODS

Six straight boled trees with uniform crown and no visible defects were selected from pure pine forest of Dong village under Walong administrative circle of Anjaw district, Arunachal Pradesh during the time of road construction by Border Road Organization (BRO) under Border Area Development Programme. The geographical coordinates of the selected sites taken with GPS were 28^{0}10'16.10"N latitude and 97^{0}02'32.88"E longitude. The cross-sectional discs of about 10 cm thickness were taken at breast height and at regular intervals of 3 meter above breast-height (Fig.1).The north direction was marked with a nail in each cross-sectional disc. A total of 42 cross-sectional discs were collected from six trees. The discs were packed in poly bags and brought to laboratory for further processing.

Corresponding author:* **Sharma C.L
Wood Science and Forest Products Laboratory, Department of Forestry NERIST, Nirjuli- 791109, Arunachal Pradesh, India

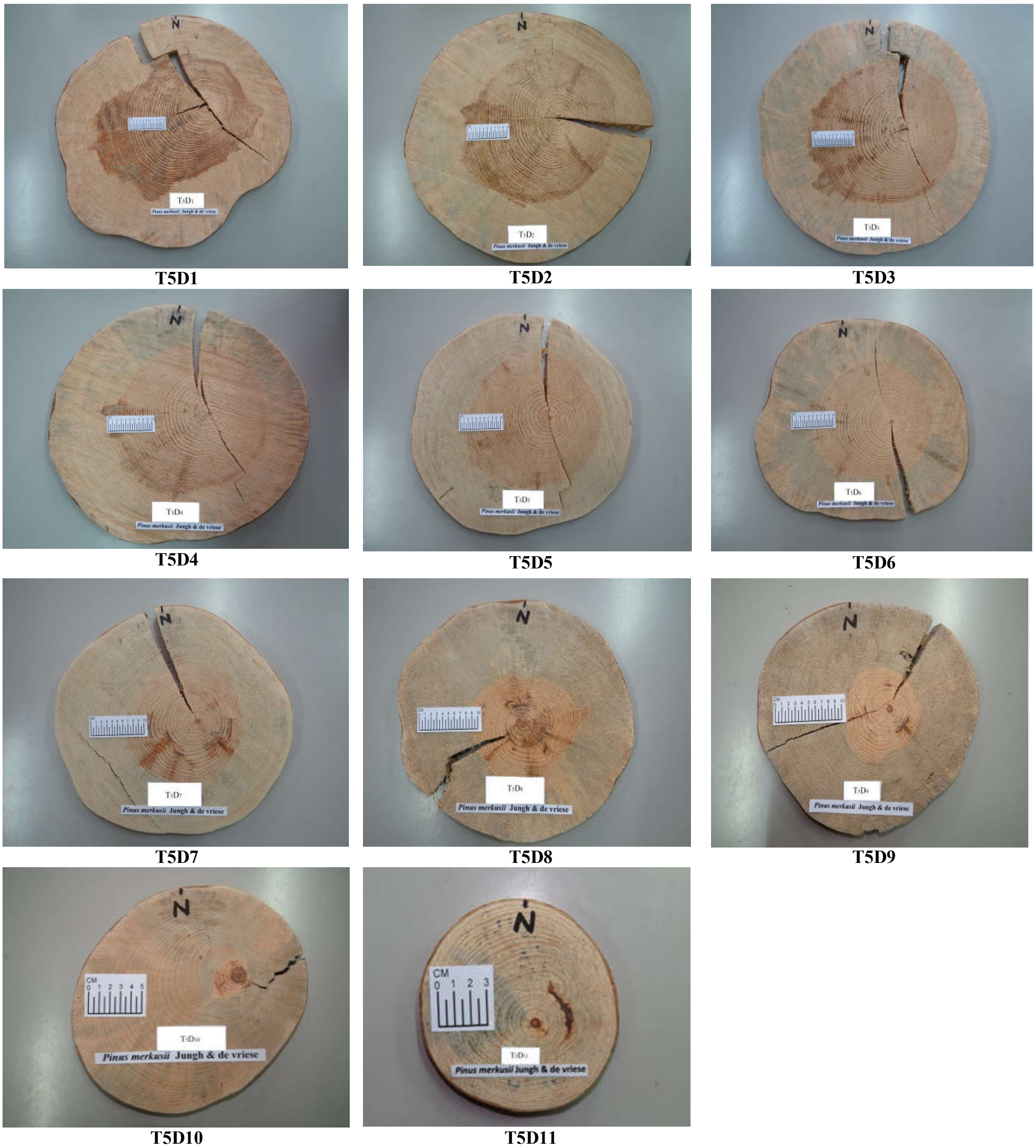

Fig 1 Cross-sectional discs *of Pinus merkusii* at breast height and successive heights of Tree 5

All cross- sectional discs were smoothened to end grain with the help of an electric planer and sand paper to obtain clear annual rings on the surface and were photographed. Radial wedges from two opposite directions namely North-South were sawn out from bark to pith in each disc (Lego *et al.*2017). The annual rings were separated out from the selected wedges and wood density of all annual rings was determined by water displacement method (Smith, 1955). SPSS software package was used for statistical analysis and graphs were plotted by Microsoft word.

There was gradual increase in wood density variation from pith to bark at breast-height and all successive heights (Figs.2-12) in both north and south directions of selected trees. The graphs of Tree 5 were presented here.

The scattered diagram plotted by logarithmic regression analysis (Fig.13) showed a steep increase in wood density up to 15 years and afterwards it remained constant.

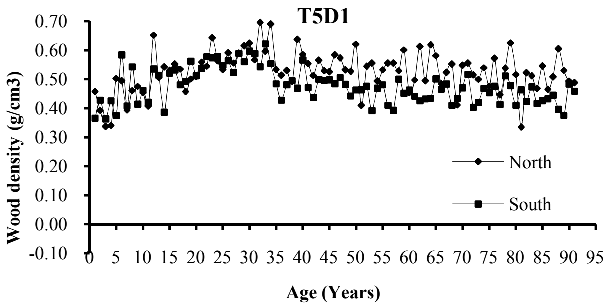

Fig 2

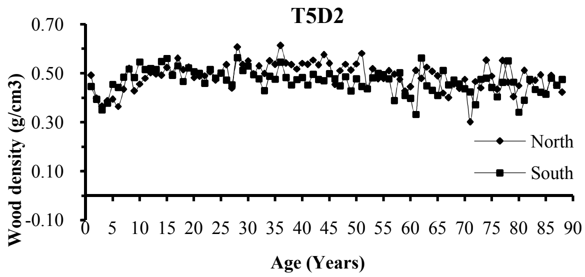

Fig 3

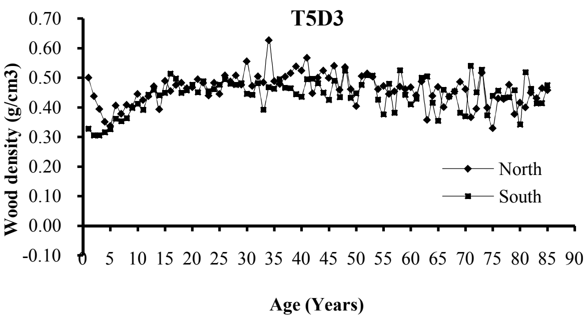

Fig 4

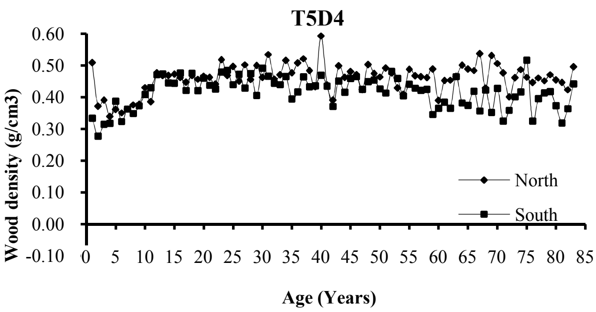

Fig 5

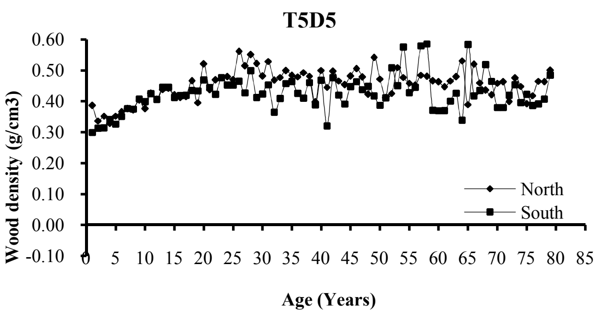

Fig 6

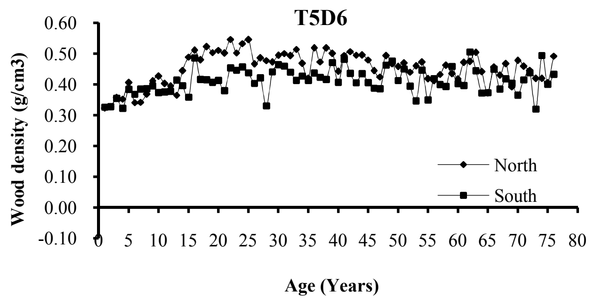

Fig 7

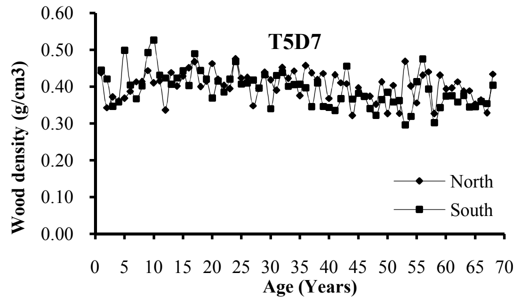

Fig 8

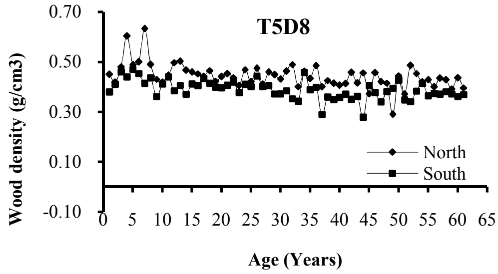

Fig 9

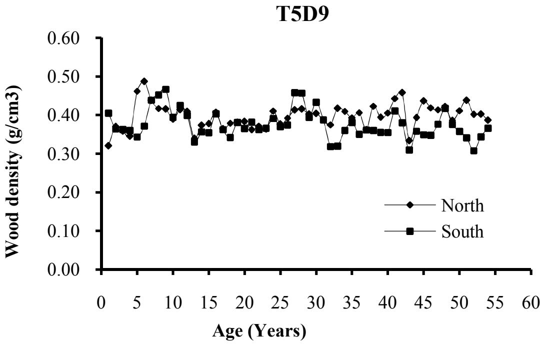

Fig 10

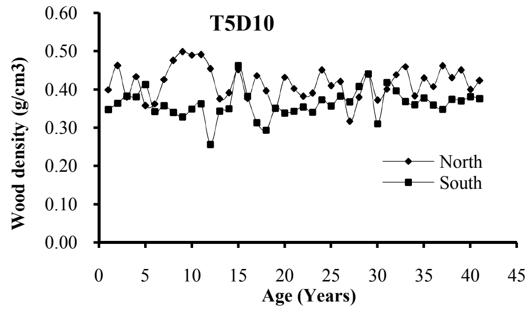

Fig 11

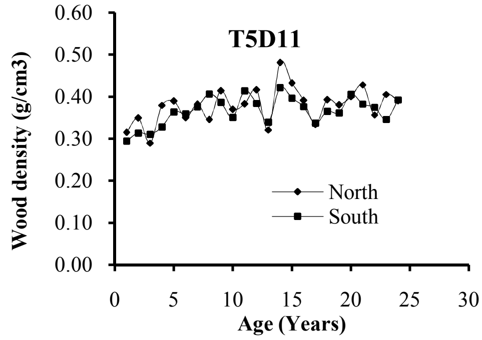

Fig 12

Figs 2-12 Radial patterns of wood density variation from pith to bark at breast-height and successive heights in Tree 5 of *Pinus merkusii.*

Thus, 15th ring was considered a boundary between juvenile wood (Zone - I; rings 1-15) and mature wood (Zone- II; rings 16 - bark). A positive and highly significant relationship between juvenile wood and mature wood was observed in Tree No. 2, 6 and pooled data. (Table 1)

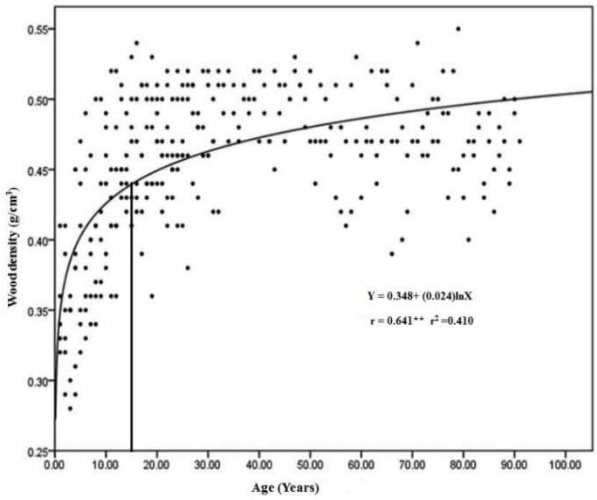

Fig 13 Scattered plot diagram of wood density for demarcation of boundary between juvenile wood and mature wood

Table 1 Relationship between juvenile and mature wood with wood density

Tree No.	Correlation coefficient (r)	Coefficient of determination (r^2)	Regression constant (B_o)	Regression coefficient (B_1)	Standard error (Sb_1)
Tree-1	0.167^{ns}	0.028	0.246	0.405^{ns}	1.699
Tree-2	0.995^{**}	0.991	0.036	1.181^{**}	0.080
Tree-3	0.991^{ns}	0.992	0.959	-1.373^{ns}	0.188
Tree-4	0.186^{ns}	0.034	0.491	-0.214^{ns}	0.801
Tree-5	0.405^{ns}	0.164	0.264	0.411^{ns}	0.309
Tree-6	0.791^{**}	0.625	0.066	0.917^{**}	0.237
Pooled	0.514^{**}	0.264	0.191	0.612^{**}	0.173

The levels of significance used are
ns = non- significant
* = significant at $p\leq 0.05$ level
** = highly significant at $p\leq 0.01$ level

DISCUSSION

Radial variation in wood density is of key importance to understand its variation within tree. It is also important for an assessment of utilization patterns and best age of harvest (Zobel and van Buijtinen, 1989). A perusal of literature reveals that different patterns of wood density variation from pith to bark was observed by number of researchers. Abdel-Gadir and Krahmer(1993) observed initial decline in wood density up to 10 rings, a rapid increase upto 30 rings and gradually increase thereafter in *Pseudotsuga menziesii*. On contrary to it, Koubaa *et al*., (2005), Park *et al*., (2009) and Yamashita *et al*., (2010) reported higher wood density near the pith, rapid decrease in transition zone with gradual increase in mature wood in *Picea mariana, Pinus banksiana, and Picea koyamae.* Increase in wood density from pith to bark was reported in number of *Pinus* and other conifer species by Beet *et al*., 2007 (*Pinus radiata*), Jyske *et al*., 2008 (*Picea abies)* Sadegh and Kiaei, 2011 (*Pinus eldarica*), Hashemi and Kord, 2011 (*Cupressus sempervirens*), Gűller *et al*., 2012 (*Pinus brutia*), de Melo, 2015 (*Pinus taeda*), Kimberely *et al*., 2015 (*Pinus radiata*). A few workers like Lin and Lin (2013) and Udoakpan (2013) reported decrease in wood density in conifers, According to Zobel and van Buijtenen (1989), hard pines show uniform pattern of wood density variation with low density near the pith with rapidly increase throughout the juvenile wood followed by constant density, although fluctuating from year to year. The present investigation revealed two types of patterns of variation in wood density from pith to bark. In Tree no.1-4 and 6 there was irregular increase in wood density variation at breast height and all successive heights whereas, there was decrease in wood density in rings present near the pith and gradual irregular increase afterwards in Tree 5. The present investigation is in confirmation of with the findings of Beet *et al*., 2007; Kiaei *et al*., 2011, Gűller *et al*., 2012; Park *et al*., 2009; de Melo, 2015; Auty *et al*., 2014; Missanjo and Matsumara, 2016. The presence of wide rings with less percentage of latewood in rings near the pith attribute towards decrease in wood density. Though the samples were taken from the straight trees but a few cross-sectional discs were eccentric with small amount of compression wood. Irregular variation in wood density having fluctuations from year to year may be due to presence of compression wood and false latewood in some of annual rings. The rings were narrow towards the bark and had more latewood than early wood. Hence the density was more towards the bark in *Pinus merkusii*. Similar patterns of wood density variation at different heights were observed as at breast height and is in accordance with the findings of Gartner *et al.* (2002), Koga and Zhang (2004), Jyske *et al*. (2008), Beet *et al*. (2007).

Since it is difficult to identify the boundary between juvenile wood and mature wood in cross-section, several methods like visual examination of pith to bark profile over tree age (Clark and Saucier1989); Gompertz function (Hodge and Purnell, 1993); linear regression model (Sadegh and Kiaei, 2011), logarithmic curve (Nawrot *et al*.2014), piece wise linear regression model (Abdel-Gadir and Krahmer, 1993), non-linear mixed effect model (Mutz *et al*.2004; Auty *et al*.2014). The age of demarcation between juvenile wood and mature wood depends on cambial activity and varies from species to species. In the present study, logarithmic regression model was applied to demarcate the boundary between juvenile and mature wood. The present finding showed a highly significant correlation coefficient($r=0.641^{**}$) with steep increase in density upto 15th ring and more or less constant afterwards. Hence, the boundary between juvenile wood and mature wood can be marked at 15th ring in *Pinus merkusii*. Hence, wood of rings1-15 can be as juvenile wood (Zone-I) and wood of rings 16-bark as mature wood (Zone-II).

A positive and highly significant but moderate relationship between juvenile wood and mature wood indicates that wood density of both can be predicted from one another. The present investigation is in accordance with the findings of Sharma and Sharma (2007) and Koubaa *et al*, (2000). To determine the minimum number of juvenile wood rings required to predict mature wood density, each juvenile ring, mean of 2, 3, 4, 5, 6, 7 and 8 rings were compared with mean of mature wood. There was no significant relationship of these combinations with mature wood. Thus, it is evident from the present study that tree breeders can make the selection at an age of 15 years for genetic improvement of wood density and hence wood quality.

CONCLUSIONS

The present study on radial variation of wood density in *Pinus merkusii* shows gradual increase from pith to bark at breast height and successive heights. Astatistically positive and significant correlation exists between juvenile wood and mature wood density. The boundary between juvenile and mature wood can be marked at15th ring from the pith.

Acknowledgements

The authors are thankful to the Director, NERIST for providing laboratory facilities.

References

1. Abdel-Gadir, A. Y. and Krahmer, R.L. (1993): Estimating the age of demarcation of juvenile and mature wood in Douglas-fir. *Wood Fib. Sci*. 25(3): 342-249.
2. Auty, D., Achim, A., Macdonald, E., Cameron, A.D. and Gardiner, B.A. (2014): Models for predicting wood density variation in Scots pine. *Forestry*. 87 (3): 449-458.
3. Beets, P. N., Kimberley, M. O. and McKinley, R. B. (2007): Predicting wood density of *Pinus radiata* annual growth increments. *N.Z.J. For. Sci*. 37(2): 241-266.
4. Bouriaud, O., Bréda, N., Moguédec, G.L. and Nepveu, G. (2004): Modelling variability of wood density in beech as affected by ring age, radial growth and climate. Trees. 18(2): 264-276.
5. Bouslimi, B., Koubaa, A. and Bergeron, P. Y. (2014): Anatomical properties in *Thuja occidentalis*: Variation and relationship to biological processes. IAWA J. 35 (4): 363-384.
6. Chave, J., Coomes, D., Jansen, S., Lewis, S.L., Swenson. N.G. and Zanne A.E. (2009): Towards a worldwide wood economics spectrum. *Ecol.Lett.*12:351-366.
7. Clark III, A. and Saucier, J. R. (1989): Influence of initial planting density, geographic location, and species on juvenile wood formation in southern pine. *For. Prod. J*. 39:42-48.
8. deMelo, R. R. (2015): Radial and longitudinal variation of *Pinus taeda* L. wood basic density in different ages. Revista de Ciĕncias Agrárias/Amazon. *J. Agri. Env. Sci*. 58(2): 192-197.
9. Gartner, B. L., North, E. M., Johnson, G .R. and Singleton, R. (2002): Effect of live crown on vertical patterns of wood density and growth in Douglas-fir. *Can. J. Forest. Res*.32:439-447.
10. Gűller, B., Isik,K. and S. Cetinay. (2012): Variations in the radial growth and wood density components in relation to cambial age in 30-year-old *Pinusbrutia* Ten. at two test sites," *Trees*., vol. 26(3): 975-986.
11. Hashemi, S. K. and Kord, B. (2011): Variation of within-stem biometrical and physical property indices of wood from *Cupressus sempervirens* L. Bioresource. 6(2): 1843-1857.
12. Hietz, P., Valencia, R. and Joseph Wright, S. (2013): Strong radial variation in wood density follows a uniform pattern in two Neotropical rain forests. *Funct Ecol*. 27(3): 684-692.
13. Hodge, G. R. and Purnell, R. C. (1993): Genetic parameter estimates for wood density, transition age, and radial growth in slash pine. *Can. J. For. Res*. 23:1881-1891.
14. Jyske, T. H., Mäkinen, H. and Saranpää, P. (2008): Wood density within Norway spruce stems. *Silva Fenn.* 42(3): 439-455.
15. Kiaei, M., Khademi-Eslam, H., Hemmasi, A. H. and Samariha, A. (2011): Ring Width, Physical and Mechanical Properties of Elder Pine (Case Study on Marzanabad Site). *Cellulose Chem. Tech*. 46(1-2): 125-135.
16. Kimberley, M. O., Cown, D. J., Mckinley, R. B., Moore, J. R. and Dowling, L. J. (2015): Modelling variation in wood density within and among trees in stands of New Zealand-grown radiata pine. . *N. Z. J. For. Sci.* 45: 1-22.
17. Koga, S. and Zhang, S. Y. (2004): Inter-tree and intra-tree variations in ring width and wood density components in balsam fir (*Abies balsamea*). *Wood Sci. Tech*. 38(2):149-162.
18. Koubaa, A., Isabel, N., Zhang, S. Y., Beaulieu, J. and Bousquet, J. (2000): Phenotypic correlations between juvenile-mature wood density and growth in black spruce. *Wood Fib. Sci*. 32(1): 61-67.
19. Koubaa, A., Isabel, N., Zhang, S. Y., Beaulieu, J. and Bousquet, J. (2005): Transition from juvenile to mature wood in black spruce (*Picea mariana* (Mill.) B.S.P). *Wood Fib. Sci*. 37(3): 445-455.
20. Lego, K., Sharma, C. L. and Sharma, M. (2017): Wood density variation around the circumference in *Pinus merkusii* Jhungh & de Vriese. *Inter. J. Sc. Eng & Mgmt*. 2(11):2456-1304.
21. Lin, C. J. and Lin, F. C. (2013): Ring characteristics of 95-year old Japanese cedar plantation trees grown in Taiwan. *Sci. Res. Ess*. 8(8): 315-324.
22. Missanjo, E. and Matsumura, J. (2016): Wood Density and Mechanical Properties of *Pinus kesiya* Royle ex Gordon in Malawi. For. 7(7): 135(1-10).
23. Molteberg, D. and Høibø, O. (2007): Modelling of wood density and fibre dimensions in mature Norway spruce. *Can. J. For. Res*. 37(8): 1373-1389.
24. Mutz, R., Guilley, E., Sauter, U. H. and Nepveu, G. (2004): Modelling juvenile-mature wood transition in Scots pine (*Pinus sylvestris* L.) using nonlinear mixed-effects models. *Ann. Sci*. 61(8): 831- 841.

25. Noguiera, F. M., Fearnside, P. M., Nelson, B. W., Barbosa, R. L. and Keizer, E. W. H. (2008): Estimates of forest biomass in Brazillian Amazon; new allomatric equations and adjustment to biomass from wood-volume inventories. *For. Ecol. Mgmt*. 256:1853-1867.
26. Park, Y. I. D., Koubaa, A., Brais, S. and Mazerolle, M. J. (2009): Effects of cambial age and stem height on wood density and growth of jack pine grown in boreal stands. *Wood Fib. Sci*. 41(4): 346-358.
27. Sadegh, A. N. and Kiael, M. (2011): Formation of Juvenile/Mature Wood in *Pinus eldarica* medw and Related Wood Properties. *World App. Sci. J.* 12(4): 460-464.
28. Sharma, M. B. and Sharma. C. L. (2007): Juvenile wood versus mature wood densities in *Cedrus deodara* (Roxb.) *Loud. Ind. For.* 133(2): 247-251.
29. Smith, D. M. (1955): A comparsion of two methods for determining the specific gravity of small samples of secondary growth, Douglas fir. U.S. For. Prod. Lab. Report No. 2033.
30. Udoakpan, U. I. (2013): An evalution of wood properties of *Pinus caribeae* (Morelet) in Oluwa Forest Reserve, Ondo State, Nigeria. Ethiop. *J. Env. Stud. Mgmt.* 6(2): 159-169.
31. Yamashita, K., Katsuki, T., Akashi, K. and Kubojima, Y. (2010): Wood properties of *Picea koyamae*: within-tree variation of grain angle, tracheid length, microfibil angle, wood density and shrinkage. *Bulletin. FFPRI*. 9:1-414.
32. Zobel, B. J. and van Buijtinen, J. P. (1989): Wood variation: its causes and control. Springer-Verlag, Berlin.

How to cite this article:

Lego K., Sharma M and Sharma C.L.2017, Radial Patterns of Wood Density Variation in Pinus Merkusii Jhungh & De Vriese. *Int J Recent Sci Res.* 8(11), pp. 21459-21464. DOI: http://dx.doi.org/10.24327/ijrsr.2017.0811.1078

****