Print : ISSN 0970-7662
Online : ISSN 2455-7129

Journal of Tree Sciences
online available at www.ists.in

Volume 37 No. 2 December, 2018

Tracheid Length Variation in *Pinus kesiya* Royle Ex Gord. as Affected by Age, Distance From Pith, Growth Rate and Ring Width

B. R. Gogoi, M. Sharma and C. L. Sharma*

Wood Science and Forest Products Laboratory, Department of Forestry, North Eastern Regional Institute of Science & Technology, Nirjuli- 791109, Arunachal Pradesh, India
**Corresponding author email: cls_chaman@yahoo.co.in*

DOI: 10.5958/2455-7129.2018.00017.1

ABSTRACT

The present investigation was carried out on breast height cross sectional discs of straight trees of *Pinus kesiya* collected from Jaintia Hill district of Meghalaya. The objectives of study were to study radial variation in tracheid length from pith to bark and to find out its relationship with age, distance from pith, growth rate and ring width. A steep increase in tracheid length up to 10 years was observed which increased gradually afterwards. Tracheid length exhibited a statistically positive and highly significant relationship with age and distance from pith while its relationship with growth rate and ring width was highly significant and negative. The model developed reveals that age and distance from pith were the most important predictor of tracheid length. The boundary between juvenile wood and mature wood was marked at 10 years. A positive and highly significant relationship existed between juvenile and mature wood. The present study reveals the possibility of selection of trees with desirable tracheid length at an early age by tree breeders.

Key Words:

Breast height, Juvenile wood, Mature wood, Radial variation

INTRODUCTION

Pinus kesiya Royle ex Gordon is one of the most important fast growing, three needle pine. It occurs in India, Myanmar, Xizang and Yunnan in China, Laos, Vietnam, Thailand and Northern Philippines (Orwa et al. 2009). It has been introduced as an exotic promising species in many countries like Africa, South America, Central America, Australia, Malaysia, New Guinea, Zambia, Brazil, Zimbabwe, Madagascar, Malawi, Kenya, Uganda, Nigeria, Tanzania etc. (Srivastava and Bahar 2007; Orwa et al. 2009). Its natural stands are widely distributed in Khasi and Jaintia Hills of Meghalaya at an altitude of 800-1800 m. This tree has multiple uses. Each and every part of this tree is used by local people in Meghalaya. It produces an excellent timber which is stable after seasoning. Its wood is straight grained, moderately fine in texture, fairly heavy, relatively strong, hard, easy to saw and work with hand held or machine tools. The heartwood is yellowish to reddish brown and sapwood is cream white to white in colour. Locally, the timber is used

for house constructions, flooring, ceiling, paneling, furniture, telephone poles etc. (Purkayastha 1989; Srivastava and Bahar 2007). Nowadays, it is cultivated under plantation programmes by forest departments in North eastern states for reclamation of forest areas after shifting cultivation. The plantation is also under progress in Andhra Pradesh, Kerala, Orissa and Tamil Nadu states of India.

Tracheid length is the most important and highly variable wood characteristics. It is under strong genetic control and has a marked effect on product quality of solid products and the use of wood. An examination of literature reveals tracheid length varies from pith to bark (radial variations), along the stem from base to top (axial variations), from one side of the tree to the other side (circumferential variations) and even within a small sampling unit like an annual ring (Sharma and Sharma 2000; Zobel and van Buijitenen 1989). These wide variations create difficulty for accurate assessment of wood for specific purpose and also provide an opportunity to select superior or plus trees with wood of superior quality in tree improvement programmes (Zobel and Talbert 1984). Though tracheid length variations were examined within a single tree, within and between trees of *P. kesiya* grown in Zambia from Assam and Burma provenances (Burley 1969, 1970; Burley and Andrew 1970) and in Malawi with seed source from Zimbabwe (Missanjo and Matsumura 2016), but no efforts has been made to investigate tracheid length variation in naturally grown Khasi pine in NE India. Therefore, the present investigation was undertaken (a) to study radial variation in tracheid length and (b) to find out its relationship with age, distance from pith, growth rate and ring width.

MATERIAL AND METHODS

Five trees with straight boles, uniform crown and no major visible defects were randomly selected from pine forest of Jaintia Hill district of Meghalaya. The geographical co-ordinates of the selected site taken with GPS were N25°29'628" and 92°10'304". The age of the selected trees ranged from 41-46 years with average height and diameter of 23±2.45m and 31.07±1.36 cm, respectively. The north side of each tree was marked with a nail before felling. The cross sectional discs of about 10cm thickness were taken at breast height (1.37m above ground). The cross sectional discs packed in polybags were brought to laboratory for further processing.

The discs were smoothened to end grain with the help of an electric planer and were photographed. A single radial direction (North direction) was sawn out from bark to pith from the selected discs (Gogoi et al. 2017). Small thin slivers taken from radial side of all annual rings from bark to pith were macerated with Franklin's solution. A random sample of 50 unbroken tracheids were measured with the help of an ocular micrometer fitted in one of the eye pieces of research microscope at 40X. Thus, a total of 213 annual rings were rings were studied for the present investigation.

The graphs were plotted by using Origin 8.0 software package. The statistical analysis was performed with SPSS 18.0 software package.

RESULTS AND DISCUSSION

Variation in tracheid length is related to cambial age and change in cambial activity due to environmental conditions (Panshin and de Zeeuw 1980). Tracheid length increases rapidly first and then increases either gradually or remains more or less constant in most of the softwoods species Mäkinen et al. 2002, Buksnowitz et al. 2010; Beaulieu 2003; Sadegh and Kiaei 2011; Sharma and Sharma, 2000; Bouslimi et al. 2014). Similar pattern of tracheid length variation is observed in plantation grown *Pinus kesiya* by Burley (1969) and Missanjo and Matsumura (2016). However, the age up to which tracheid length increases steeply varies from species to species. The present results given in Fig. 1 showed steep increase in tracheid length up to 10 years and gradual increase afterwards except Tree 1 and Tree 5. The present results are in agreement with the findings

of Sharma and Sharma (2000), Buksnowitz et al. (2010), Bouslimi et al. (2014). There was steep increase in tracheid length at 35th ring and 42nd ring afterwards in Tree 1 and 5 which may be due to presence of false rings near the bark in these trees.

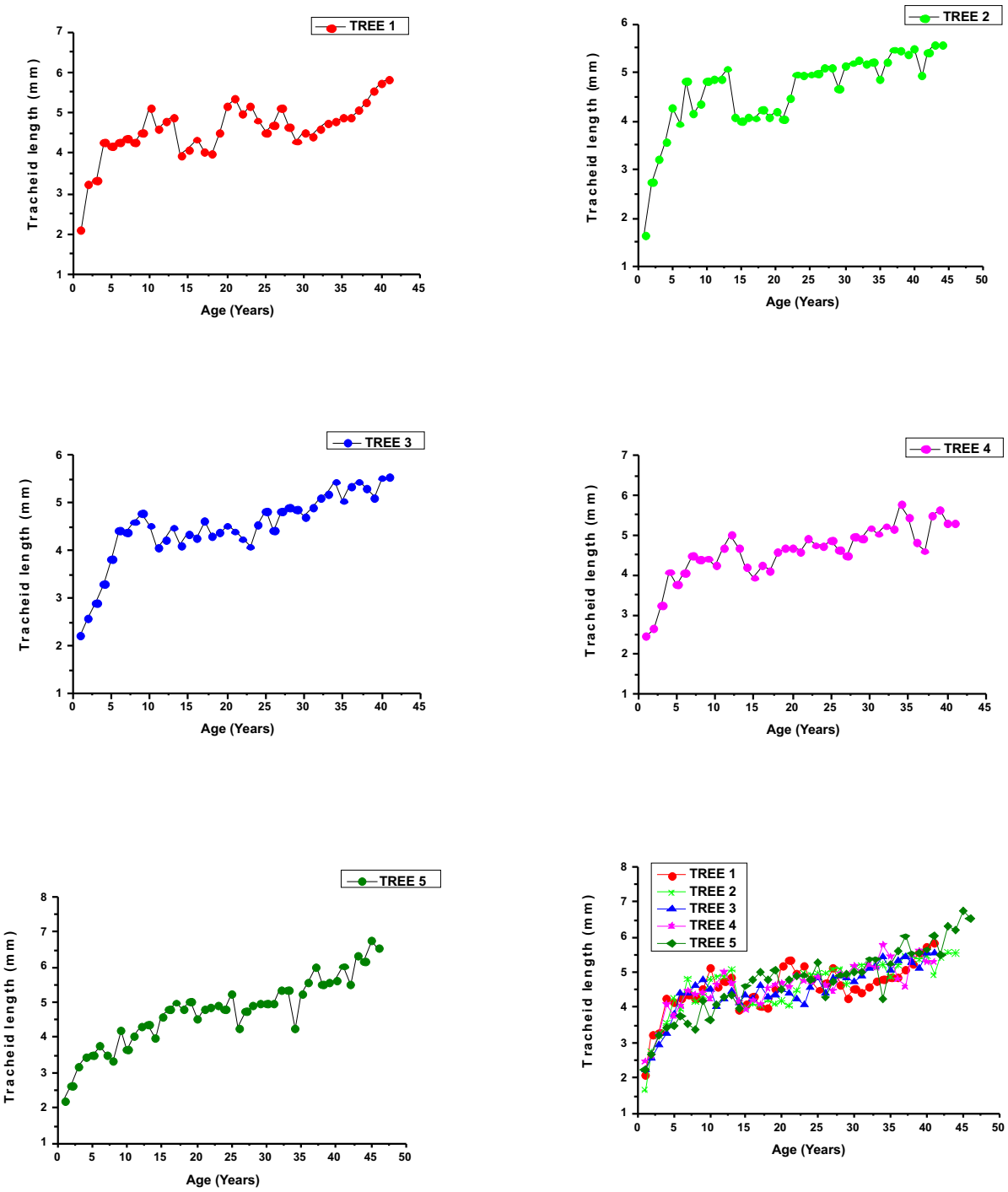

Fig 1: Tracheid length variation at breast height level in selected trees

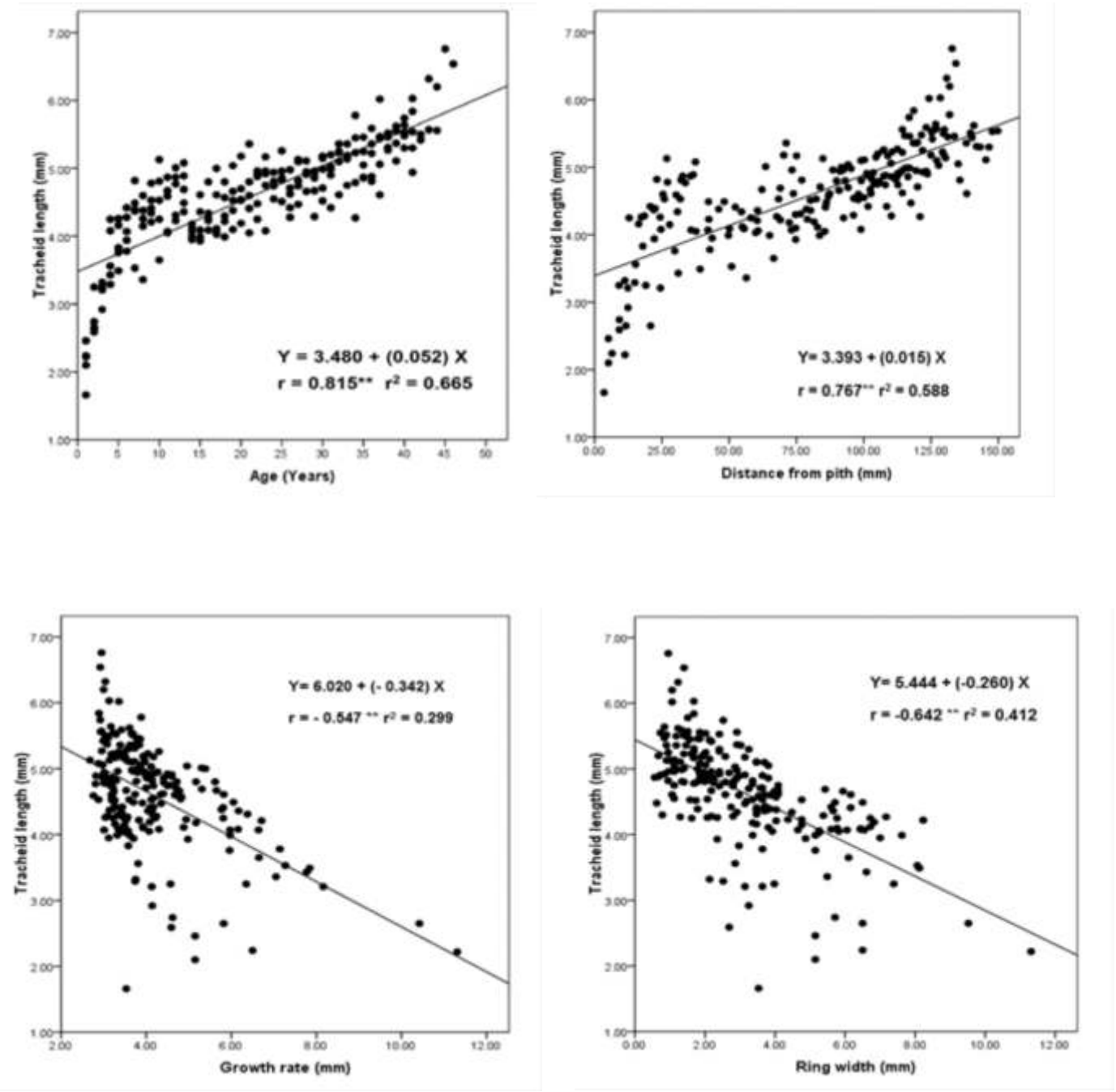

Fig. 2: Relationship of age, distance from pith, growth rate and ring width with tracheid length

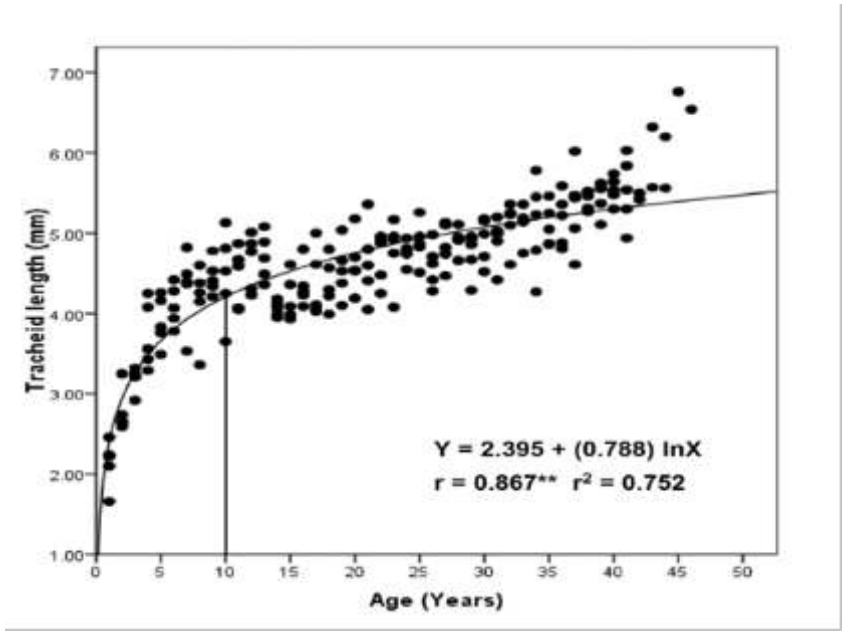

Fig. 3: Scattered plot of tracheid length for demarcation of boundary between juvenile wood and mature wood

Table 2: Relationship between juvenile wood and mature wood

Correlation coefficient	Coefficient of determination	Regression constant	Regression coefficient	Standard error
r	**r^2**	**B_0**	**B_1**	**Sb_1**
0.904*	0.818	2.749	0.608	0.166

Significance level
*=Significance at 0.05 level

A limited information is available on relationship of tracheid length with age, distance from pith, ring width and growth rate. Sharma and Sharma (2000) reported positive and significant relationship between tracheid length and independent variables namely age, distance from pith and growth rate. On contrary to it, Beaulieu (2003) and Fujiwara and Yang (2000) reported negative relationship between tracheid length and growth rate. The present study revealed a statistically highly significant positive relationship of tracheid length with age and distance from pith and negative relationship with growth rate and ring width for all trees and the pooled data (Fig. 2).

Pinus kesiya is a fast growing species and most of the annual rings near the pith were more than 12mm wide. The higher number of anticlinal divisions in annual rings increases the ring width and growth rate with decrease in tracheid length. The present investigation corroborates the findings of Beaulieu (2003), Fujiwara and Yang (2000), Herman et al. (1998), Saranpää et al. (2000), Mäkinen et al. (2007), Sadegh and Kiaei (2011).

Multiple linear regression analysis was carried out to see the relative effect of independent variables namely age, distance from pith, growth rate and ring width on tracheid length. The following model developed for estimation of tracheid length showed that age and distance from pith were the most important predictor of tracheid length.

Y = 4.413+ (0.019) X1 + (0.006) X2+ (-0.094) X3+ (-0.106) X4

Where,
Y = Tracheid length
X1 = Age
X2 = Distance from pith
X3 = Growth rate
X4 = Ring width

However, tracheid length was more affected by distance from pith than age and contrary to the finding of Sharma and Sharma (2000).

The presence of juvenile wood and mature wood is one of the reasons for heterogeneous wood structure resulting in problems with its rational processing. Therefore, it is important to identify the boundary between juvenile wood and mature wood for optimization of wood processing and utilization. The boundary between juvenile wood and mature wood is demarcated by linear regression model, non-linear and polynomial models and logarithmic models (Mutz et al. 2004; Koubaa et al. 2005; Nawrot et al. 2014). Also, the age for demarcation between juvenile wood and mature wood varies from species to species Sadegh and Kiaei 2011; Bouslimi et al. 2014; Mvolo et al. 2015; Missanjo and Matsumura 2016; Boruszewski et al. 2017). In the present study, the radial patterns of tracheid length variation from pith to bark were fitted with both linear regression and logarithmic regression model to demarcate the juvenile-mature wood boundary. The present study was well fitted with logarithm model with high correlation coefficient (r = 0.867**). The present study revealed steep increase in tracheid length up to 10years and was more or less constant afterwards (Fig. 3). Hence, the boundary between juvenile wood and mature wood can be marked at 10 years and wood up to 10 years is considered as juvenile wood and afterwards as mature wood. The present result is in agreement with the findings of Sharma and Sharma (2000) and Missanjo and Matsumura (2016). The relationship between juvenile wood and mature wood was statistically positive and significant (Table 1). Hence, juvenile wood tracheid length can be predicted from mature wood and vice versa. Further, mature wood in *Pinus kesiya* shows little variation in tracheid length as compared to juvenile wood like other conifers. Therefore, mature wood can be suggested for tracheid length comparison among Khasi pine trees.

CONCLUSION

Tracheid length increases steeply upto 10 years and gradually afterwards. Age and distance from pith are positively correlated with tracheid length. Also there exists a positive and highly significant relationship between tracheid length of juvenile wood and mature wood.

ACKNOWLEDGMENTS

The first author is thankful to University Grant Commission, India for financial support.

REFERENCES

Beaulieu J. 2003. Genetic variation in tracheid length and relationships with growth and wood traits in eastern white spruce *(Picea glauca)*. Wood Fib. Sci., 35: 609-616.

Bouslimi B., Koubaa A. and Bergeron P. Y. 2014. Anatomical properties in Thujaoccidentalis: Variation and relationship to biological processes. IAWA J., 35(4): 363-384.

Boruszewski P., Jankowska A. and Kurowska A. 2017. Comparison of structure of juvenile and mature wood of *Larix decidua* Mill. from fast-growing plantation in Poland. Bioresources, 12(1): 1813-1825.

Buksnowitz C., Teischinger A., Grabner M., Müller U and Mahn L. 2010. Tracheid length in Norway spruce *(Picea abies*(L.) Karst.) analysis of three databases regarding tree age, cambial age, tree height, inter-annual variation, radial distance to pith and log qualities. Wood Res., 55 (4): 1-14.

Burley J. 1969. Tracheid length variation in a single tree of *Pinus kesiya* Royle ex Gord. Wood Sci. Tech., 3(2): 109-116.

Burley J. 1970. Variation in wood properties of Pinus kesiya Royle ex Gordon (syn. *P. khasya* Royle; *P. insularis* Endlicher); eighteen trees of Burma provenance grown in Zambia. Wood Sci. Tech., 4(4): 255-266.

Burley J. and Andrew I. A. 1970. Variation in wood properties of *Pinus kesiya* Royle ex Gordon

(syn. P. khasya Royle; *P. insular* is Endlicher); six trees of Assam provenance grown in Zambia. Wood Sci. Tech., 4(3): 195-212.

Fujiwara S. and Yang K. C. 2000. The relationship between cell length and ring width and circumferential growth rate in five Canadian species. IAWA J., 21(3): 335-345.

Gogoi B.R., Sharma M., Sharma C.L. 2017. Intra-ring tracheid length variations in khasi pine *(Pinus kesiya* Royle ex Gordon) at breast height. Int. J. Life Sci. Res., 5 (3): 147-156.

Herman M., Dutilleul P. and Avella-Shaw T. 1998. Intra-ring variations of tracheid length in fast-grown versus slow-grown Norway spruce *(Picea abies).* IAWA J., 19(1): 3-23.

Koubaa A., Isabel N., Zhang S., 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.

Mäkinen H., Saranpää P. and Linder S. 2002. Effect of growth rate on fibre characteristics in Norway spruce *(Picea abies* (L.) Karst.). Holzforschung, 56(5): 449-460

Mäkinen H., Jaakkola T., Piispanen R. and Saranpää P. 2007. Predicting wood and tracheid properties of Norway spruce. For. Eco. Mgmt., 241(1): 175-188.

Missanjo E. and Matsumura J. 2016. Radial variation in tracheid length and growth ring width of *Pinus kesiya* Royle ex Gordon in Malawi. Int. J. Res. Agri. For., 3(1): 13-21.

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.

Mvolo C.S., Koubaa A., Defo M. and Cloutier A. 2015. Prediction of tracheid length and diameter in white spruce *(Picea glauca).* IAWA J., 36(2): 186- 207.

Nawrot M., Pazdrowski, W., Walkowiak, R., Szymaski, M. and Kazmierczak, K. 2014. Analysis of coniferous species to identify and distinguish juvenile and mature wood. J. For. Sci., 60(4): 143-153.

Orwa C., Mutua A., Kindt R., Jamnagass R. and Anthony S. 2009. Agroforestree Database: A Tree Reference and Selection Guide Version 4.0. Nairobi, Kenya: World Agroforestry Centre

Panshin A.Y. and de Zeeuw C. 1980. Textbook of wood technology. McGraw-Hill, New York, USA, 722p.

Purkayastha S. K. 1989. A manual of Indian Timbers. Sribhumi publishing company Calcutta, 614p.

Sadegh A.N. and Kiaei M. 2011. Formation of Juvenile/Mature Wood in *Pinus eldarica* and related wood properties. World App. Sci. J. ,12(4): 460-464.

Saranpää P., Pesonen E., Sarén M., Anderson S., Siiriä S., Serimaa R. and Paakkari T. 2000. Variation of the properties of tracheids in Norway spruce *(Picea abies* (L.) Karst.). In Cell and molecular biology of wood formation. Savidge, R. A., Barnett, J.R. and Napier, R. (eds). BIOS Scientific Publishers Limited. Oxford. Pp. 337–345.

Sharma M.B. and Sharma C.L. 2000. Radial pattern of first-formed early wood tracheid length variation from pith to bark in deodar *(Cedrus deodara* (Roxb.) Loud). Ind. For., 126(8): 861-864.

Srivastava R.K. and Bahar N. 2007. Pines of south-east Asia. International Book Distributors, 272p.

Zobel B.J. and Talbert J. 1984. Applied Forest Tree Improvement. John Wiley, New York, 505p.

Zobel B.J. and van Buijtenen J.P. 1989. Wood variation: its causes and control. Springer-Verlag, Berlin 363p.