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Variation in basic Density and Anatomical properties of Eucalyptus Tereticornis sm. Clones

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Abstract

The basic density, anatomical properties of certain clones of Eucalyptus tereticornis developed by ITC Bhadrachalam were reported. The five clones represented by four trees each of four and half years old, were from Sarapaka, Andhra Pradesh. There was clone-to-clone variation for all the properties studied except for vessel length, fibre diameter and fibre percentage. The girth was positively correlated with ray and parenchyma percentage and negatively with vessel percentage. Basic density was positively correlated with fibre length and vessel diameter and negatively correlated with vessel frequency.

Keywords: Girth, basic density, clones, vessel morphology, fibre morphology, interrelationship.

Introduction

Eucalyptus tereticornis, known as Mysore gum in India and forest gum in Australia, is one of the most extensively planted eucalypt species in India. It is planted to meet the ever increasing demand for pulp wood and solid wood requirements of the Industry. ITC, Bhadrachalam Paper Boards Ltd., Andhra Pradesh, has come out successfully, after a number of trails, with some commercial clones of this species with improved productivity[1,2]. There are only a few studies made on assessment of wood quality of *Eucalyptus tereticornis* from India belonging to different ages and localities of ordinary seed source [3-10] initiated work on the assessment of the wood quality of *Eucalyptus tereticornis* clones. In the present paper where studies made on basic density, and anatomical properties of five commercial clones of ITC, Bhadrachalam which are about 4-5 years of age and grown in a clonal demonstration plot under rain fed conditions at Sarapaka, Andhra Pradesh are presented.

Material and Methods

Materials for this study were four trees from each of the five clones of ITC, Bhadrachalam numbered 3,4,6,7 and 10. These clones planted at an espacement of 1m x 1m except one clone (clone 10) where the espacement was 3m x 2m in red soil under rainfed conditions at Sarapaka, Andhra Pradesh, India trees were cut at 10 cm above ground level and 1m length billets up to the height of 3m were collected for Investigation. The average mid-girths of the billets of the different clones were 43.5 cm (clone 3), 31 cm (clone 4), 38 cm (clone 6), 33 cm (clone 7), 42 cm (clone 10). At the time of felling, the trees were four and half years old. From each billet a part (0.25 cm) of it was cut and set aside for paper and pulp studies and 5 cm thick discs were cut to study percentage of heartwood and sap wood, general features and gross structure. From the remaining part 2.5 cm wide radial strips were prepared. From these strips 1 cm on either side of the pith was removed and from the remaining lengthwise sticks were prepared. From these sticks 11 blocks were made and 10 blocks were used to find the basic density which was determined by using oven-dry weight / green volume of the sample. The eleventh block was used for anatomical studies. Only one side of the radius was sued for the study as our earlier findings showed non-significant difference on both sides of the pith[10]. Microslides of cross section of 20 µm were cut using Reichert sliding microtome. The sections were stained with Safranin-Haematoxylin. The stained sections were passed through alcohol-xylol series and mounted with DPX mounting medium. Frequency of vessels /mm^2 for each tree was determined from randomly selected ten fields on the cross section. Tissue proportions were determined from cross sections as per the procedure followed by Rao R.V.[11]. Accordingly an eleven point micrometer scale was placed tangentially on the cross section and type of cell on the numbered point on the scale was identified and recorded. The total score for each cell type was obtained by running the slide from one end to the other, both in tangential and radial direction. For each tree 30 such fields were chosen randomly. Silvers taken from 1cm^3 blocks from billets of each clone and macerated with 30% nitric acid and a few crystals of potassium chlorate[12]. Fibre and vessel dimensions were measured from the macerated material. Thirty measurements per tree for each of the fibre and vessel characteristics were taken. Fibre wal thickness was calculated by deducting the fibre lumen diameter from the fibre diameter. One-way ANOVA and Tukey's test was performed to compare the clones. A simple correlation coefficient was performed to examine the inter-relationships among the anatomical properties, girth and basic density.

Results and Discussions

The results of basic density and anatomical observations pertaining to five clones are given in table-1. The same letters followed by the values in the Table do not differ significantly.

Basic density: Basic density differed significantly between the clones at 1% level Table-1 the highest basic density was recorded for clone 4 (0.583 g/ cm^3) and the lowest for clone 3 (0.514g g/cm^3)[13] also reported significant differences in basic density in two *E. Grandis x camaldulensis* clones Purkayastha S.K. et al.[3] showed that basic density (0.538 g cm^3 to 0.640 g cm^3) of 8 to 9 year old *Eucalyptus* hybrid (probably *E. tereticornis*) varied significantly among five localities. However, [5]found that the mean basic density of 1-year-old trees of *E. tereticornis* from Kerala was 2.6% greater than the overall mean density of five different plantations of 8 to 9-year-old trees as reported by Purkayastha S.K. et al.[3].

The present study, however, did not show higher value in any clone compared with the data provided by Bhat K.M. and K.V. Bhat.[5]. [14] Quilho T. and Pereira H showed that the wood basic density in *E. globulus* differed depending on the sites where they were grown. Best and worst sites produced higher and lower densities respectively and density was independent of growth rate. From the above discussion, it becomes evident that basic density varies with age and locality. Since these clones are primarily tried to meet the requirements of the paper and pulp industry, it is worthwhile to consider the suggestion of [15] who stated that basic density which was in the range of 480 to 570 kg m^3 was ideal for paper and pulp. The results obtained in this study have shown the suitability of raw material for paper and pulp where the required basic density is met with.

Vessel Characteristics: Average vessel frequency, Vessel diameter showed significant differences at 1% level between the clones Table-1. Whereas Vessel element length was non-significant. The average vessel frequency ranged from 14/ mm^2 (Clone 10) to 19/mm^2 (Clone 3). The average vessel diameter ranged from 111µm (clone 3) to 135 µm (clone 6). Clone 3 and 7 had significantly higher vessel frequency than the other three clones. However, the higher values obtained for Vessel frequency in the present study compared to what has been reported by Purkayastha S.K. [16] and Agrawal S.P. and L. Chauhan[17].

Fibre Characteristics: Fibre length, fibre lumen diameter, significantly differed between clones at 5% level and wall thickness at 1% level whereas fibre diameter was non-significant Table-1. Maximum fibre length found in clone 4 and minimum in clone 7. Clone 4 and 10 were significantly different from other three clone with regard to fibre length. Fibre lumen diameter was significantly higher in clone 3 and 4, wall thickness was significantly higher in clone 6,7and 10.

The fibre lengths published so far for this species were 880um [18] age not known), 742-804 um [3] 8-9 years), 750-820 um[19] 9 years), 660-790 um [4] 8-10 years), 738 um [6] 9-10 years). A comparison of the values obtained in the present investigation with those above shows that the mean fibre length of any clone is longer than what has been reported for trees of higher age group of ordinary seed source.

Tissue proportions: Significant clone-to-clone differences have been observed in vessel percentage, ray percentage, parenchyma percentage. However, variation in percentage of fibres remained non-significant. The vessel percentage ranged from 25.78 (clone 10) to 33.74 (clone 3), Parenchyma percentage ranged from 10.52 (clone 3) (clone 4) to 13.21 (clone 10). Whereas the ray percentage showed a range of 14.28 (clone 3) to 19.35) (clone 10). Percentage of fibres varied from 40.38 (clone 6) to 41.76 (clone 7). [20] Taylor F.W. has shown minor tree-to-tree differences with no obvious pattern of tissue type variation with height in E. grandis. [21] who reviewed the variation in wood anatomy of Eucalyptus showed a combined percentage of parenchyma and fibres constitute 70% whereas in the present study it was found to be less than 60%. Maeglin R.R. and J.T. Quirk[22] have shown that the tissue proportions vary in red and white oak groups, with reference to growth rate and site conditions Grzeskowiak V. et al.[13] have shown higher vessel percentage (18-21%) in one Eucalyptus grandis x urophylla clone and two E. gradis x camaldulensis clones compared to one E. grandis seedling and two other Eucalyptus clones (15-16%). A higher percentage of vessels was however found in this study. Age, locality, sampling position and procedures appear to be responsible for the variation in tissue proportions both within and among the species [20,23]

Interrelationship among girth, basic density and anatomical properties: Among the clones, a positive correlation Table-2 between girth and Parenchyma percentage (r=0.652) and girth and ray percentage (r=0.686) was found. In this study no correlation was found between girth and basic density. Similar type of observation was observed in E. grandis [24, 25] in younger plantations [26] E. tereticornis[3,5,10] and E. globules[14]. So far as basic density and its correlation with anatomical properties are considered, it was found that basic density has a positive correlation with fibre length (r=0.495), vessel diameter (r=0.620), and a negative correlation with vessel frequency (r=0.639). Opinions are divided regarding the correlations of basic density with anatomical properties in different species of Eucalyptus. Thus [20] reported basic density increasing with increase in fibre volume and decrease with increase in parenchyma volume. [13] have shown basic density having an excellent correlation with fibre lumen diameter across the six genotypes (one E. grandis seedling and five Eucalyptus clones). Furthermore, they also found that the density is positively influenced by vessel percentage. Where as in the present study as indicated earlier, the density is influenced by fibre length, vessel frequency, vessel diameter. [27] quoting [28] indicated that in hardwoods, vessel volume, ray volume, fibre diameter, wall thickness, fibre length and parenchyma cells all affect basic density. [29] also found that ray percent along with fibre wall thickness, percent wall material are strongly correlated to density in Japanese hardwoods. Among

the anatomical parameters negative correlations between vessel frequency and vessel diameter (r= -0.716), vessel percentage and parenchyma percentage (r=-0.847), vessel percentage and ray percentage (r= -0.864), fibre lumen diameter and parenchyma percentage (r=-0.505), wall thickness and vessel percentage (r=-0.521) were observed. The various correlations as found in the present study were suggestive of complex interrelationship existing among anatomical characteristics in these newly introduced clonal materials.

Conclusion

Significant variation in anatomical properties and basic density have been observed in five clones of four and half years old trees except vessel frequency. The girth has been found to have a positive influence on ray percentage and parenchyma percentage and basic density in turn is positively influenced by fibre length, vessel diameter and negatively by vessel frequency.

Table-1

Properties	3	4	6	7	10	CD	Significant at test
Basic density	0.514 (4.08) a	0.583 (5.66) b	0.550 (4.72) c	0.529 (5.86) d	0.541 (6.28) e	0.008	**
Fibre length (µm)	907 (7.86) b	948 (7.22) a	925 (8.67) c	886 (7.44) d	946 (7.57) a	12.63	*
Fibre diameter (µm)	12.54 (10.28)	12.73 (10.84)	13.01 (11.99)	13.08 (9.55)	13.06 (11.56)	-	NS
Fibre lumen diameter (µm)	7.89 (15.96) a	7.74 (14.85) a	7.33 (14.59) b	7.49 (15.35) b	7.33 (16.78) b	0.17	*
Wall thickness µm)	4.64 (39.65) b	4.98 (36.74) e	5.67 (21.86) a	5.59 (26.47) a	5.72 (21.50) a	0.145	**
Vessel frequency /sq.mm	19 (10.10) a	15 (13.22) b	15 (17.68) b	18 (20.11) a	14 (23.81) b	0.68	**
Vessel diameter (µm)	111(9.96) a	127 (10.83) b	135 (12.59) c	115 (13.01) d	121 (12.67) e	3.27	**
Vessel element length (µm)	393 (10.10)	392 (13.22)	399 (17.68)	379 (20.11)	389 (23.81)	-	NS
Percent vessels	33.74 (28.57) a	33.66 (29.20) a	29.04 (30.26) b	32.33 (30.90) c	25.78 (35.22) d	1.12	**
Percent parenchyma	10.52 (65.11) a	10.52 (88.87) a	12.56 (54.69) a, ab	11.20 (57.41) a, ab	13.21 (56.54) ab	2.19	**
Percent fibres	41.46 (23.25)	40.86 (23.17)	40.38 (26.15)	41.76 (25.00)	41.61 (26.96)	-	NS
Percent Rays	14.28 (47.05) a	14.99 (45.16) ab	18.21 (39.37) c	14.65 (43.34) a, ab	19.35 (44.75) d	0.55	**

Values in the parenthesis indicate CV %, NS = not significant * Significant at 5% level ** Significant at 1% level
The values sharing common alphabet do not differ significantly at 0.05 probability level.

Table-2
Correlation Co-efficient among girth, basic density and anatomical properties

	Girth	Basic density	Fibres				Vessels			Tissue proportions (%)			
			Length (Fl)	Diameter (Fd)	Lumen Diameter (Wt)	Wall thickness (Fld)	Frequency (Vf)	Diameter (Vd)	Length (Vl)	Vessels (V%)	Parenchyma (P%)	Fibres (F%)	Rays (R%)
Girth	1												
Basic density	-0.262	1											
Fibre length	0.016	0.495*	1										
Fibre diameter	-0.051	0.070	0.297	1									
Fibre Lumen diameter	-0.371	0.057	0.265	0.228	1								
Wall thickness	0.255	0.007	0.030	0.627**	-0.615**	1							
Vessel frequency	-0.302	- 0.639**	-0.399	-0.123	0.403	-0.420	1						
Vessel diameter	0.028	0.620**	0.371	0.076	-0.362	0.347	-0.716**	1					
Vessel length	0.034	0.186	0.123	-0.254	0.053	-0.250	-0.031	-0.011	1				
Vessel %	-0.793**	-0.111	-0.248	-0.182	0.467*	-0.521*	0.684**	-0.314	-0.071	1			
Paren-chyma %	0.652**	0.127	0.251	0.044	-0.505*	0.444*	-0.566**	0.364	0.095	-0.847**	1		
Fibre %	0.170	-0.215	-0.237	0.023	0.030	-0.004	0.036	-0.341	-0.333	-0.199	-0.175	1	
Ray %	0.686**	0.249	0.400	0.234	-0.414	0.520*	-0.718**	0.510*	0.258	-0.864**	0.793**	-0.260	

n = 20* Significant at 0.05 level, ** Significant at 0.01 level

References

1. Lal P., Kulkarni H.D. and Srinivasa K., *Eucalyptus* improvement programme of ITC Bhadrachalam Paper Boards Ltd. Pp. (57-63) in Vivekanandhan, K. *et al.*(Eds.) *Proceedings of the Production of Genetically Improved Planting Materials for Afforestation Programmes,* 18-25 June, Coimbatore**(1993)**

2. Lal P., Kulkarni H.D. and Srinivasa K., Venkatesh K.R. and Sanhakumar P., Genetically improved clonal planting stock of *Eucalyptus* – A success story from India. *Indian Forester,* **123**, 1117-1138 **(1997)**

3. Purkayastha S.K., S.P. Agrawal P. Farooqui, R.D. Tandon, L. Chauhan and Neelam Misra., Evaluation of wood quality of *Eucalyptus* plantations in various states, Final Technical report of project no. Inn. FS-66, 85 **(1979-1980)**

4. Sharma Y.K. and Bhandari K.S., *Eucalyptus* for pulp and paper making. *Indian Forester,* **109**, 944-950 **(1983)**

5. Bhat K.M. and K.V. Bhat., Wood properties of 1year old *Eucalyptus tereticornis* Sm. *Aus. For. Res*., **14**, 129-133 **(1984)**

6. Bhat K.M., Can plantation grown *Eucalyptus* meet wood quality requirements of the industries? *Eucalyptus* in India: Past, Present and Future (Eds.J.K.Sharma *et.al.*), Kerala Forest Research Institute, Peechi : 422-430 **(1986)**

7. Bhat K.M., T.K. Dhamodaran and K.V. Thulasidas., Wood property variation of 3-year-old trees among four Eucalypt species grown in Kerala, *J. Ind. Acad. Wood Sci*., **18(2),** 7-12 **(1987)**

8. Bhat K.M., Wood quality improvement of *Eucalyptus*. in India: assessment of property variation, *J. Ind. Acad. Wood Sci*., **21(2)**, 33-40 **(1990)**

9. Singh S.V. and Naithani S., Pulpwood demand and quality assessment. IPPTA *Convention Issue,* 99**-**111. Indian Pulp and Paper Technical Association, Saharanpur, **(1994)**

10. Rao R.V., S. Shashikala, P. Sreevani, Vimal Kothiyal, C.R. Sharma and Piare Lal., Within tree variation in anatomical properties of some clones of *Eucalyptus tereticornis* Sm. *Wood Sci. and Technology*., **36(3)**, 271-285 **(2002)**

11. Rao R.V., D.P. Aebishcher and M.P. Denne., Latewood density in relation to wood fibre diameter, wall thickness and fibre and vessel percentage in *Quercus robus*. *IAWA Journal* **18(2),** 127-138 **(1997)**

12. Jane F.W., The structure of the wood. Adam and Charles Black. London, 427 **(1956)**

13. Grzeskowiak V., O.P. Turner and R.A. Megown, The use of densitometry and image analysis techniques to predict pulp strength properties in *Eucalyptus* plantations. Presented at TAPPSA conference 'African paper week 2000 and beyond" Durban. South Africa. 1-18 **(2000)**

14. Quilho T. and Pereira H., Within and between tree variation of bark content and wood density of *Eucalyptus globules* in commercial plantations. *International Association of Wood Anatomists Journal,* **22(3)**, 255-265**(2001)**

15. Ikemori Y.K., F.C.G Martins and B. Zobel., The impact of accelerated breeding on wood properties, Proc, 18th IUFRO World Cong. Div.5, Yugoslavia, 359-368 **(1986)**

16. Purkayastha S.K., Indian woods their identification, properties and uses Vol. IV. Controller of Publications. Delhi, 172 **(1982)**

17. Agrawal S.P. and L. Chauhan., On the structure and identification of Eucalyptus species. *Ind. For*. **114 (3)**, 145-151**(1988)**

18. Dadswell, H.E., The anatomy of Eucalypt woods. Tech. Pap. No.66, Div. App. Chem. For. Prod. Lab. CSIRO Australia, 28 **(1972)**

19. Laxmi Chauhan S.P. Agrawal and R. Dayal., Studies on the effects of spacing and application of fertilizers on wood quality in *Eucalyptus tereticornis* Sm. *Ind. For*. **109,** 901-908 **(1983)**

20. Taylor F.W., Variations in the anatomical properties of South African grown *Eucalyptus grandis Appita.* **27**, 171-178 **(1973)**

21. Wilkes J., Variation in wood anatomy within species of *Eucalyptus*. *IAWA Bulletin* n. s. **9(1)**,13-23 **(1988)**

22. Maeglin R.R. and J.T. Quirk., Tissue proportions and cell dimensions for red and white oak groups, *Can. J. For. Res*.,**14**, 101-106 **(1984)**

23. Hillis W.E., Wood quality and utilization, Pp 259-289. In Hillis, W.E. and Brown, A.G. (Eds), *Eucalyptus for wood production. Academic Press* **(1984)**

24. Bamber R.K., Floyd A.D. and Humphreys F.R., Wood properties of flooded gum, Australian Forestry, **33(1)**, 3-12 **(1969)**

25. Bamber R.K., Horne R. and Higgs A.G., Effect of fast growth on the wood properties of *Eucalyptus grandis, Australian Forest Research* **12**, 163-167 **(1982)**

26. Bhat K.M., K.V. Bhat and T.K. Dhamodaran., Wood density and fibre length of *Eucalyptus grandis* grown in Kerala, (India), *Wood and Fiber Sci*. **22(1)**, 54-61 **(1990)**

27. Zobel B.J. and J.B. Jett., Genetics of wood production. Springer-Verlag, New York, 337 **(1995)**

28. Schreiner E.J., Possibilities of improving pulping characteristics of pulp woods by controlled hybridization of forest trees, *Paper Trade Journal.,* **100(8)** 105-109 **(1935)**

29. Fujiwara S., K. Saneshima, K. Kuroda and N. Takamura., Anatomy and properties of Japanesehardwarde I. Variation of fibre dimensions and tissue proportions and their relation to basic density. IAWA Bulletin n.s., **12(4)**, 419-424 **(1991)**