Relationship Between Basic Density And Different Types Of Anatomical Characteristics Ratios Of Eucalyptus Tereticornis Sm. Clones

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Abstract: The basic density, and some of the anatomical properties of five 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. Significant variation have been found among the clones except fibre length/vessel element length. Basic density was found no effect on any of the fibre characteristics reported in this paper. 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. Mainly these clones are primarily tried to meet the requirements of paper and pulp industry.

Key Words: Basic Density, fibre characteristics, clones, paper and pulp.

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 [3,4,5,6,7,8,9]. [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 some 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.

Materials 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.

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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 used 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. Silvers taken from 1cm^3 blocks from billets of each clone and macerated with 30% nitric acid and a few crystals of potassium chlorate[11]. Fibre and vessel dimensions were measured from the macerated material. Thirty measurements per tree for each of the fibre and vessel characteristics were taken. Tissue proportions like fibre, vessel, parenchyma and rays were determined by placing eleven point ocular micrometer scale tangentially on the cross section from permanent mount on the numbered point on the scale was identified and recorded. The total score of each cell type was obtained by running the slide from one end to the other both in tangential and radial direction[12]. For measuring microfibrillar angle[13]technique was followed. Small blocks from each position for each clone were oven dried at 100^o C to induce checking in the cell walls. They were resoaked to saturation and redried to enhance checking. Radial sections of 15µm thick were cut from the blocks and stored in 50% ethyl alcohol. Sections were dropped in absolute alcohol to ensure complete dehydration. They were then treated with 2% solution of iodine-potassium iodide and 60% nitric acid. The fibril angles were visible as elongated dark crystals of iodine filling the cracks in parallel lines. Angle was measured using image analyzer in an interactive measurement mode. Thirty measurements were taken for each height position. 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. The Runkel ratio was determined by dividing double wall thickness with fibre lumen diameter. This is an important parameter, which often is taken into consideration in paper and pulp studies. The shape factor was determined using the formula $d^2 – l^2/d^2 + l^2$ where d, l, represents fibre diameter, fiber lumen diameter. The average values obtained for fibre length and diameter were used to calculate the fibre length/fibre diameter ratio to find out the variation. The average values obtained for fibre length and vessel element length were used to calculate the fibre length/vessel element length ratio. The average values of percentage of fibres and vessels which were determined for tissue proportions were used for finding out the fibre%/vessel%.

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.

1. 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/cm^3). [13]also reported significant differences in basic density in two *E. Grandis x camaldulensis* clones. [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[3]. The present study, however, did not show higher value in any clone compared with the data provided by[5]. [14] 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.

2. Runkel ratio:

Runkel ratio significantly differed between clones at 1% level. Maximum Runkel Ratio was found in clone 10 (0.81) and minimum in clone3 (0.63). Runkel Ratio which is an important parameter in paper and pulp studies.

3. Shape factor: A significant variation existed among the clones which was at 5% level . Maximum Shape factor was found in clone 10 (0.52) and minimum in clone 3 (0.42). It is important to mention that lower the values of Shape factor better the strength of the paper.

4. Microfibrillar angle: Microfibrillar angle significantly differed between the clones at 5% level. The variation among the clones was found to be small. Maximum Microfibrillar angle was found in clone 3,4,7 and minimum in clone no.6 and clone 10. Microfibrillar angle is one of the important characteristic which determines the strength of the wood.

5. Fibre length / Fibre diametre: Significant differences existing among the clones at 1% level. Where maximum ratio was found in clone 4 (74.79) and minimum in clone 7 (67.79). The higher the ratios greater will be the expected fibre flexibility which is expected to give better tensile and tear property of the paper.

6. Fibre lenth / Vessel element length: It is another index used in the assessment of quality of paper and pulp. The ratio was found non-significant among the clones. Whereas maximum ratio was found in clone 10 and minimum observed in clone 3.

7. Fibre % / Vessel %: Percentage of fibre and vessel ratio was found significantly different at 1% level between the clones. Maximum ratio was observed in clone 10 and minimum in clone 3 and clone 4.

Considering the importance of *Eucalyptus* fibres as raw material for paper and pulp the different types of ratios like Runkel ratio, fibre length/fibre diameter, fibre length length/vessel element length, fibre %/vessel %, and shape factor as determined from the basic data on fibre morphology, vessel morphology and tissue proportions have indicated that the strong relationship either negative or positive with respect to any of the two factors as shown in Table.2 and also the rate of growth having influence on this factors . The most striking positive correlations are Runkel ratio and shape factor; Microfibrillar angle and fibre %/vessel %; shape factor and fibre %/vessel %. It can been seen that greater the length and width ratio of the fibre greater will be the fibre flexibility and better the chance of forming better tear and tensile property of paper[16]. The low Runkel ratio values obtained in the present study compared to the published data[17] is indicative of the differences existing due to age. Besides, the variation in fiber lumen diameter in relation to fiber diameter determines the wall thickness, which may be another reason for the variation in Runkel ratio. These two observations considering the suggestion of[18] that for the properties required by the paper industry for the trees of future plantations where the Runkel ratio should be less than 1. So far as Runkel ratio is considered the approximate limits of appears to be from 0.25 to 1.5 for a species[17], which can produce pulp of reasonable quality. The data obtained in the present investigation showed significant variation existing among the clones. It was shown that[16] that greater flexibility as indicated by Runkel Ratio will lead to better mechenability as the wet resistance / dewatering ratio increase. The results obtained in the present investigation may prove to be suitable which follow the suggested criteria. Thus utilization of clonal material will prove to be a boon to paper and pulp industry in bringing uniformity in the quality which can be manufactured and the results obtained is a proof in this direction. Furthermore, it can be seen when such differences exists the expected quality of the paper would be accordingly. If alone this factor is taken in to consideration although these clones are expected to produce pulp of reasonable quality one can expect variation when all this clones together are used for pulping. From among the five clones, clone 10 has a higher value (0.81) indicating its superiority over others.

Interrelationship between girth, basic density and some anatomical properties:
Basic density in any clone as seen in the present study is shown not to affect much in pulp yield. Infact a preliminary study made by[19] and[20] of clonal material of *Eycalyptus territicornis* showed pulp yields ranging from 46.47% (clone 6), 49.89% (clone 3) and 43% (clone 10), 48% (clone 6) respectively. Runkel ratio correlated with shape factor at 1% level where as girth shown positive correlation with fibre% / vessel% and negative correlation with microfibrillar angle at 1% level. In turn shape factor positively correlated with fibre% / vessel% and negatively with microfibrillar angle at 1% level. Fibre% / vessel% negatively correlated with microfibrillar angle. The various correlations as found in the present study were suggestive of complex inter relationship existing between anatomical properties in these newly introduced clonal materials.

Conclusions
Significant variation in some of the anatomical properties and basic density were observed in five clones of four and half years old trees except for fibre length/vessel element length ratio. Basic density showed no influence by any of the characteristics studied. The girth had a positive influence on fibre% / vessel% ratio and negative influence on microfibrillar angle. Shape factor, fibre% /vessel% was negatively influenced by microfibrillar angle. In turn shape factor had shown positive influence on fibre% / vessel% ratio.

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TABLE-1
Basic density and some of the anatomical properties of *Eucalyptus tereticornis* Sm. Clones.

Properties	3	4	6	7	10	CD	Signify-cant 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	**
Runkel ratio	0.63 (52.38) c	0.68 (48.52) d	0.79 (27.84) ab	0.78 (41.02) a	0.81 (29.62) b	0.029	**
Shape factor	0.42 (35.71) c	0.44 (31.81) d	0.51 (15.68) ab	0.5 (22.00) a	0.52 (18.26)b	0.031	*
Fl/Fd	72.55 (6.24) abc	74.79 (6.00) bc	71.24 (6.33) a	67.79 (4.11) d	72.45 (2.85) ab	3.21	**
Fl/Vel	2.32 (12.12)	2.43 (9.05)	2.38 (19.31)	2.35 (6.38)	2.45 (12.70)	-	NS
F%/V%	1.40 (49.28) c	1.4 (63.57) d	1.6 (58.12) a	1.53 (57.51) a	1.94 (62.88) e	0.08	**
MFA	19 (23.13) a	19 (16.92) b	18 (11.11) c	19 (10.52) d	18 (12.22) e	0.27	*

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	Runkel ratio	Shape factor	Fl/ Fd	Fl/ Vel	F%/ V%	MFA
Girth	1							
Basic density	-0.262	1						
Runkel ratio	0.294	0.003	1					
Shape factor	0.352	0.007	0.990 **	1				
Fl/Fd	0.026	0.397	-0.405	-0.373	1			
Fl/Vel	-0.014	0.105	0.168	0.170	0.090	1		
F%/V%	0.737 **	0.059	0.441	0.518 *	-0.042	0.148	1	
MFA	-0.675**	0.067	-0.419	-0.454 *	-0.033	0.071	-0.523*	1

*Significant at 0.05 level
** Significant at 0.01 level

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