CHAPTER-6

Summary and conclusion

Present study is directed towards the testing of plus trees of *Eucalyptus tereticornis* of different provenances for the screening on the basis of growth and wood traits. The material was procured for testing from provenance cum progeny trial of *Eucalyptus tereticornis* laid out in 2002 at Forest Research Institute, Dehradun (Uttarakhand) campus. Forty seven different plus trees were selected from 13 provenances representing 91 families from Australia and Papua New Guinea (PNG) viz. Orobay to Emo (PNG), Sirinumu Sogerri Plat (PNG), Warwick, Queensland (Australia), Yurammie, SF, New South Wales (NSW), Buckenbowra SF (NSW), Selection flat SF559 (NSW), Credition SF, Queensland (Australia), Cardwell, Queensland (Australia), Mitchell River MT Molloy, Queensland (Australia), Mill stream archer creek, Queensland (Australia), Helenvale, Queensland (Australia), Walsh River, Queensland (Australia), Burdekin River, Queensland (Australia) were evaluated so we can get the material having desirable wood properties for different products for different tree improvement programs.

In view of the above, the objectives of the study are as follows:

- To study intra and inter tree variation for wood specific gravity, fiber and vessel dimensions.
- To study the impact of growth parameters on wood specific gravity, fiber and vessel dimensions.
- To screen different plus trees on the basis of wood properties and growth for the production of quality planting stock for commercial deployment.

The study material for wood anatomical studies was collected from four-year-old provenance trial of *Eucalyptus tereticornis*. Forty seven (47) plus trees were selected using basic index method for studying genetic variations. The plus trees were harvested at 15 cm above the ground to produce coppice shoots for propagating them clonally. At the time of coppice, discs were collected from three uniform heights *i.e.* (i) base (ii) 4 m (iii) 8 m to
analyze intra-tree variation. Each disc was further divided into three directions viz. north, north-east and south-west. Each direction was further divided into 3 pith to periphery radial locations. Physical properties such as specific gravity, anatomical properties etc. were investigated. Maceration technique was used following Schultz's method. From the macerated material, 25 observations on fiber length, fiber diameter, wall thickness, vessel element length, were taken. Collected data on wood anatomical properties were statistically analyzed for mean and SEM. Data for tissue proportion and vessel element diameter were taken from cross section under compound microscope and fibril angle was determined using Polarized Microscope. Wood anatomical data obtained was used to determine pulp and paper ratios. The data obtained were statistically analyzed using SPSS (version 10.0) Multivariate analysis to test the within- (both vertical and horizontal) and inter-tree (progeny) variations. Finally, variance ratio (F) test was used for the test of significance. Duncan test (subsets) was used for grouping of different trees (progenies) based on wood element’s dimension and specific gravity. The cluster analysis was done on the basis of wood traits viz. fiber-length, - diameter, wall-thickness, Runkel Ratio, Shape factor and ratio of fiber length and diameter using SPSS (10.0). Pearson correlation was also determined among different wood traits and also with growth parameters in all trees (progenies) of *Eucalyptus tereticornis* to understand the inter-relationship among different wood traits and with the growth parameters.

Within tree vertical variation were significant for most of the wood anatomical traits, except for fiber diameter (in T1 and T3), wall thickness (T2 and T3), vessel element diameter (in T2) and non-significant for specific gravity. Within tree fiber, vessel properties gradually increased from base to top up to a certain heights (D II) and finally decreased at the top while specific gravity showed a slightly decreasing trend from bottom to the top. Directional variations were found non-significant for all wood anatomical traits and specific gravity. Within tree vertical and directional variations were found non-significant for all pulp and paper making ratios.

Within tree radial variations were also found significant for most of the wood anatomical traits, except for fiber diameter (T1 and T2), fiber wall thickness (T2), vessel element length (T2), vessel element diameter (T1) and specific gravity (T3). Fiber dimensions, vessel element length and specific gravity showed a gradual increase from pith
to periphery while vessel element diameter increased from pith to a certain radial position and then decreased towards the periphery. Within tree radial variation were found non-significant for almost all pulp and paper making ratios except for ratio of fiber length and diameter.

Intra- and inter-tree variations of wood traits and pulp and paper making properties for 15 trees were analyzed to see the extent of variations at vertical and horizontal as directional and radial position so that further reduction in sampling would be decided on the basis of level of significance (P>0.001). Fifteen trees out of 47 were selected randomly to analyze vertical, directional and radial variations. Horizontal directional variations were non-significant for the wood traits so discarded for further analysis of horizontal intra-tree variations in 47 selected trees.

Inter-tree variations were significant for all wood traits. Significant inter-tree variations in wood traits indicated that these plus trees of different progenies showed differences in different wood traits individually and collectively which might be due to their genetic differences. Fiber length, fiber diameter and vessel dimension showed gradual increase up to a certain heights and then declined towards the top of the tree. Fiber wall thickness showed a slight increase from the bottom to the top. Fiber length, fiber wall thickness and vessel dimension showed an increase from pith to periphery, while fiber diameter showed a slight decrease at periphery after a gradual increase from pith. Inter-tree variations were significant for all pulp and paper making ratios. Intra-tree vertical and radial variations were found significant for all pulp and paper making ratios in all 47 trees. All pulp and paper making ratios showed an increasing trend from bottom to the top of the tree and from pith to periphery.

Inter-tree variation in proportion of tissue and vessel frequency (mm^2) was significant except for ray (%). Radial variations were also significant for proportion of tissues. Most of parameters of proportion of tissues were found in higher side at pith position and also showing decreasing trend from pith to outer side, except for fiber and ray (%) where these showed lower values at pith position. Fiber (%) showed increasing trend from pith to outer side while in ray (%) increase up to a certain height and then stabilized. Vessel (%)
stabilized after initial decline, the fiber, ray, vessel and parenchyma volume was 44.43, 19.60, 18.52, 17.32 (%) respectively.

Correlation analysis of growth parameters, wood anatomical properties, specific gravity, pulp and paper making ratios and chemical properties indicated that DBH significantly positively correlated with height, D²H, fiber diameter and holocellulose(%) and significantly negatively correlated with specific gravity, Runkel ratio, shape factor, flexibility coefficient and wall ratio. Height significantly positively correlated with D²H, fiber diameter and significantly negatively correlated with only shape factor. D²H significantly positively correlated with only fiber diameter and significantly negatively correlated with Runkel ratio, shape factor, flexibility coefficient and wall ratio. Some of the wood traits were also influenced each other.

Inter tree variations in micro-fibril angle were non-significant for all trees, while variations in radial positions were found significant. MFA showed pith outwards increasing trend. It may be explained that lower age of trees of the present study showed non-stability of MFA in early phase of tree growth showing the impact of juvenile wood.

Conclusion

➢ In general, significant within tree variations both radial and vertical, for wood traits were reported. Horizontal directional variations were non-significant for all wood traits. Pith to outwards and bottom to top trend for wood traits was increasing.

➢ Significant within tree variations in wood traits showed that homogeneous wood properties could not be achieved from the 4 years seed raised progenies of Eucalyptus tereticornis because of the influence of juvenile wood.

➢ Inter-tree variations in wood traits indicated that these plus trees of different progenies showed differences in different wood traits individually and collectively which might be due to their genetic differences.

➢ Inter–tree variations in pulp and paper making anatomical properties and specific gravity indicated that these progenies were different form pulp and paper making ratios. Inter – tree variations of individual and collective wood traits and pulp and paper making ratios in
the progenies can be exploited for fiber, specific gravity and pulp and paper making ratios under breeding programs.

- T1 (09), T2 (27), T4 (112), T26 (101) and T28(28) trees were not only grouped in divergent clusters in most of the dendrograms but also showed better growth, fiber and pulp and paper making ratios. So, it is advisable that these progenies can be used in future hybridization programs for the development of new clones.

- Inter-tree variation in proportion of tissue and vessel frequency (mm\(^2\)) was significant except for ray (%). Radial variations were also significant for proportion of tissues. Most of the parameters of proportion of tissues were found in higher side at pith position showing decreasing trend from pith to outer side, except for fiber and ray (%) where these showed lower values at pith position. Fiber (%) showed increasing trend from pith to outer side while in ray percentage (%) increase up to a certain height then stabilized.

- Correlation analysis showed that DBH had positive impact on fiber diameter and holocellulose while negative impact on specific gravity, Runkel ratio, shape factor, flexibility coefficient and wall ratio. Tree height showed positive impact on fiber diameter while negative on shape factor. D\(^2\)H had positive impact on fiber diameter while negative on Runkel ratio, shape factor, flexibility coefficient and wall ratio. Some of the wood traits were also influenced each other.

- In the present study, higher percentage of lignin and more or less similar values of holocellulose as compared the values reported in literature were observed. The higher percentage of lignin in present study may be due to the differences in provenances and early age of the trees under present study. The comparable values of fiber, anatomical pulp and paper making ratios and chemical properties like holocellulose of plus trees of selected progenies under present study allow them as the future raw material for pulp and paper industry.

Within-tree vertical and radial variations in wood traits indicated the presence of juvenile wood at the age of four years in the seed raised plus trees of all the provenances of *Eucalyptus tereticornis*. As a result, the homogeneous wood properties could not be achieved by seed raised plantations of the species in question at the early phase of the tree growth.
This is also reported for other tree species. In contrary, the clonal plantation wood of *Eucalyptus tereticornis* did not shown within - and inter–ramet variations and indicated the absence of the properties of juvenile wood. Consequently, the homogeneous wood properties can be expected from the plantation of a particular clone even at the early phase of the tree growth (Pande and Singh, 2009). The study leads further scope for the variations studies in wood traits by raising clonal plantations at different locations of the selected progenies of species in question so that the wood properties of clonal plantation can be compared with seed raised progenies of the present study in view of the presence/ absence of the properties of juvenile wood.