1. Introduction

In India, large scale plantations of different species of *Eucalyptus* are being raised in various states to meet the growing demand for its wood for different purposes. Besides its use in pulp and plywood, it has been found suitable for poles, crates, packing cases, agricultural implements, carts, tool handles, wall panelling, overhead power, telecommunication lines, etc. The essential oil obtained from the leaves and flowers of *Eucalyptus citriodora* Hk. and *E. globulus* Labill. is of great value in medicine and perfumery.

Due to factors like multiple uses, ecological compatibility, seed availability, ease of plantation establishment, site tolerance, disease resistance, stem form, growth vigour, etc., eucalypts are among the most favoured plantation species. The genus *Eucalyptus* consists of comprises of about 625 species and numerous varieties and hybrids, of which, over 100 are reported to be introduced in India.

2. Wood Structure and Identification

Owing to the different end uses of the woods of *Eucalyptus* species, it is imperative to establish the method of their correct identity, as apparently all eucalypt wood logs look alike. However, there are very few studies on identification of different species of *Eucalyptus* through their wood anatomy in India as well as in other countries. Also, the homogeneity in the microstructure does not provide much scope in delineation of woods of *Eucalyptus* species.

In India, the two most referred studies on the wood microstructure and ultrastructure of these species were carried out by Purkayastha (1982) and Agarwal and Chauhan (1988), respectively.

and categorised them in two broad groups on the basis of vessel arrangement and parenchyma distribution.

Agarwal and Chauhan (1988) studied wood structure of the above mentioned nine species both under light microscope (microstructure) and scanning electron microscope (ultra structure). They distinguished them on the basis of various anatomical characters, viz., vessel and parenchyma distribution, presence or absence of crystals in parenchyma, percentage of triseriate rays and vestured pit morphology as seen under scanning electron microscope. Their study shows that microscopic features do help in wood identification but it is the ultra structure of vested pits of vessels and fibres that has been found more useful in distinguishing different species. Thus, all the above mentioned nine species were classified into two broad groups based on percentage of solitary vessels and types of parenchyma as has been done by Purkayastha (1982), further separation of the species was made by difference in the vesture morphology of vessel and the fibre pits.

It was observed that vessels are mostly in radial multiples and occasionally in clusters and parenchyma is abundant, ranging from vasicentric to confluent and diffuse and sometimes aggregates in *E. maculata* (Fig. 1).

*E. piperita* has mostly solitary vessels, aligned in more or less oblique groups, parenchyma diffuse to aggregate (Fig. 2). The rays are generally uniseriate with biseriation in the middle portion.

In *E. globulus* (Fig. 3) and *E. torelliana* (Fig. 4), rays up to three to four seriate have been observed.

Crystals in parenchyma were reported to vary in their occurrence in different species. They were present in *E. calophylla, E. citriodora, E. maculata* (Fig. 5) and *E. tereticornis*

Crystals are either absent or rare in *E. camaldulensis, E. torelliana, E. globulus, E. grandis* and *E. piperita*.

The observation in the vesture morphology of intervessel (Fig. 6) and inter-fibre pitting under scanning electron microscope revealed vessel pits of *E. camaldulensis, E. grandis, E. tereticornis* and *E. torelliana* with coralloid-even (fine) vestures while those of *E. calophylla* and *E. maculata* were coralloid-uneven. The vessel pits of *E. globulus* and *E. piperita* were coralloid-warty and only those of *E. citriodora* were dendroid-warty. Results obtained in this study indicate the possibility of distinguishing woods of nine species of *Eucalyptus* through ultrastructure studies.

Considering the vast number of *Eucalyptus* species/hybrids and the studies carried out so far, it is evident that wood microstructures do not provide much scope in species identification. Wood identification, through ultra structure however, is not practical. Thus, future research should aim to develop molecular markers for delineation of *Eucalyptus* species/hybrids/clones.
Fig. 1. T.S. of *E. maculata* showing diagonal arrangement of vessels and vasicentric to confluent parenchyma.

Fig. 2. T.S. of *E. piperita* showing diagonal arrangement of vessels and diffuse to aggregate parenchyma.

Fig. 3. T.L.S. of *E. globulus* showing bi- to tri-seriate rays.

Fig. 4. T.L.S. of *E. torelliana* showing tri-seriate rays.

Fig. 5. R.L.S. of *E. maculata* showing crystals in chambered parenchyma.

Fig. 6. T.L.S. of *E. piperita* showing inter vessel pits.
3. Wood Quality

In India, over the last few decades, silviculture and genetic engineering practices have been adopted to increase the productivity of eucalypt wood to meet the growing industrial and domestic demand. However, besides aiming to increase the productivity, it was important to assess the quality of wood produced and ways to have more uniform wood. Thus, a few wood quality assessment studies of plantations were carried out to establish effect of site, growth rate, fertilizers, weeding, intercropping, etc. on wood anatomy vis-a-vis wood quality.

Anatomical parameters that were found useful in wood quality assessment were specific gravity, sapwood-heartwood ratio, fibre characteristics (fibre length, fibre diameter, fibre lumen diameter and fibre wall thickness) and proportion of tissue.

The earliest wood quality assessment studies carried out by Purkayastha et al. (1979) on *E. tereticornis* plantations raised in different localities in north and south India concluded that coefficient of variation of specific gravity in five plantations was about nine per cent while no significant difference in fibre characteristics was observed in three out of four plantations. This study led to the fact that there is a wide scope of selection for tree breeders. Bhat (1990) in a similar study on *E. grandis* and *E. tereticornis* also suggested scope of reducing rotation age and accelerating tree growth without significantly affecting the wood properties through selection. Bhat and Bhat (1984) stated that faster growth in *E. tereticornis* is slightly related to lower wood density, about nine per cent. According to Pande (2006) faster growth has positive impact on fibre characteristics of *E. tereticornis* clones.

Bhat et al. (1990) studied wood density and fibre length of *E. grandis* and estimated average density as 495 kg m\(^{-3}\) with no significant increase up to nine years of age while fibre length increased consistently with age.

Sidhu and Rishi (1997) in their work on 18 years old *E. tereticornis* concluded that thickness of heartwood, bark and pith significantly decreases at higher bole heights from the base. Similarly, Shashikala et al. (2009) investigated variation in wood quality of 20 years old *E. citriodora* and also got similar.

Sharma et al. (2005) compared anatomy and properties of non-coppiced and coppiced (after first felling) wood of *E. tereticornis* and reported non-significant difference amongst them. This study is contrary to the study by Zobel and Van Buijtenen (1989) that states properties of coppiced wood different from those of the original trees in having lower wood density and longer fibres.

Sreevani and Rao (2013) and Rao et al. (2005) in their findings on *E. tereticornis* clones of ITC, Bhadrahalam concluded that intra-clonal variation was significant in basic density, fibre and vessel characteristics while variation in tissue proportion was non-significant. Inter-clonal variation was significant for all the parameters. On the contrary, Pande and Singh (2009) reported non-significant radial variation in wood
quality within the clones of *E. tereticornis*. However, they also found significant variation between the clones. The study also concluded that fibre length of four years clones is comparable to eight to 10 years old seedling raised plantations of this species.

Studies are well underway on wood quality assessment of promising hybrids of *Eucalyptus* developed by Forest Research Institute, Dehradun and few other organizations, which are planted at different sites and conclusive results are awaited.

The above studies are indicative of much scope for tree breeders to utilize the variability within wood quality parameters in different species/hybrids/ clones planted at different sites. Few studies have been carried out to establish effect of fertilizers, weeding, intercropping, site, growth rate on wood quality. Sankaran *et al.* (2008) in their study on *E. tereticornis* stressed upon weed management that increased yield by 76-149 per cent; nutrient addition improved tree volume by 20-50 per cent.

The above works are indicative of nature of studies being carried out under wood quality assessment of *Eucalyptus* species and their hybrids planted at different sites. However, the need of the hour is to develop validated growth models both in terms of biomass and wood quality for different species/hybrids/clones along with prediction of their responses to different silviculture treatments, environment and site conditions so as to cater to the needs of the plantation industry.

**References**


