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Clonal variation in selected wood anatomical properties and specific gravity of *Eucalyptus tereticornis* Sm. from two localities in Karnataka

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Abstract

Background: A native of Australia and the East Indies, *Eucalyptus* was introduced to many parts of the world and today ranks as one of the most ubiquitous trees. *Eucalyptus tereticornis* Sm. known as Mysore gum in India is one of the most extensively cultivated Eucalypt species to meet the ever increasing demand of paper and pulp, and wood based industries. The supply to the wood based industries has always fallen short of their requirements. **Aim:** Due to shortage of raw materials from forests, industries have started their own plantations. Clonal technology has proved to increase the productivity. Like ITC Bhadrachalam clones in Andhra Pradesh, in Karnataka, Grasim industries, a unit of Harihar PolyFibers has raised the clonal material for increasing the productivity to meet the demand for paper and pulp industries. **Methodology:** The present study involves clonal variation in selected wood anatomical properties and specific gravity of two-four year old clones of *Eucalyptus tereticornis* Sm. raised in farmer's field under irrigated (Mandya) and rainfed (Kolar) conditions. **Results:** Clonal material raised under rainfed conditions showed higher specific gravity compared to irrigated conditions.

Keywords: *Eucalyptus tereticornis,* specific gravity, Fiber morphology, Runkel ratio.

1. Introduction

Due to short rotation period and easy adaptability to a wide variety of soils and climatic factors *Eucalyptus tereticornis* Sm. is one of the most extensively cultivated species in India under major afforestation programmes. Eucalyptus plantations are raised with an objective of providing raw material for the pulp and paper industry, wood based industries and also to meet the fuel wood requirement. There are many wood properties like cellular, chemical and anatomical characteristics of the wood within and among the trees, of which specific gravity or wood density is by far the most important. The importance of specific gravity has been emphasized by many investigators, Van Buijtenen (1982) and Bamber and Burley (1983), who state "Of all the wood properties density is the most significant in determining end use". Most pulp and paper properties are directly related to wood specific gravity (Barefoot *et al*. 1965, Artuz-Siegel *et. al*. 1968). *Eucalyptus* is one of the species, which produces quality pulpwood for paper and newsprint making. Two species namely *Eucalyptus tereticornis* and *Eucalyptus camaldulensis* were planted extensively depending upon the soil, rainfall and temperature. These two species are highly suitable to semi-arid conditions. The productivity of Eucalyptus pulp wood plantations is 5 to 6 cubic meters per ha per year or 40 tones per ha at 7 years rotation when raised through ordinary seeds. Whereas the productivity of plantations raised through improved seed or clonal source is reported to be 10 to 25 cubic meters per ha per year.

In the present study, two commercial clones of *Eucalyptus tereticornis* aged about 4 years raised by Grasim industries, a unit of Harihar polyFibers, from two localities in Karnataka state have been chosen. Of the two localities, Locality-I (Mandya) is irrigated while Locality-II (Kolar) is rain fed. The pith to periphery variation is investigated with respect to specific gravity and Fiber properties.

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2. Material and Methods

2.1 Materials

The material for this investigation was 4-year-old clones of *Eucalyptus tereticornis* Sm. raised at Mandya and Kolar by Grasim industries, a unit of Harihar polyfibers. The Grasim clones randomly selected from the plantation were GR-3andGR-283 each represented by5 ramets (trees).

The area of plantation of these clones was 5-20 acres. Spacing of these clones in the plantation was 1.75m x 1.75m. The annual rainfall of Mandya was 700mm and that of Kolar was 760mm (Average from planting till cutting at the time of collection). Of the two plantations, Locality I (Mandya) was irrigated, while Locality II (Kolar) was Rain fed. Mandya region was found at an elevation of 2500ft MSL, while Kolar was found at an altitude of 2727ft MSL. Mandya region showed red gravelly, red sandy loam and red sandy soils, while Kolar region showed red loamy, red sandy loam and lateritic soils. The type of water in Mandya was alkaline type and that of Kolar was potable in general.

2.2 Methodology

Each tree was cut at 10cm above ground level. 1 foot long billets were obtained at three heights- bottom, middle and top position. Each billet was cut into a plank from which three radial strips (pith, middle and periphery/ bark) were obtained. Each of these strips were cut into five equal sized blocks (1cm x1cm) for anatomical studies and specific gravity measurements.

2.3 Specific Gravity

Specific gravity measurements were carried out at 3 radial positions i.e., pith, middle and periphery at 3 heights, namely bottom, middle and top. For this purpose, 1foot long billet taken at 3 heights were cut into planks from which 5 blocks of approximately 1cm x 1cm were obtained. Further specific gravity was determined on the basis of oven dry weight and green volume (Sluder 1972) by mercury displacement method.

$$\text{Specific gravity} = \frac{\text{Oven dry weight of the sample}}{\text{Volume of the sample}}$$

2.4 Anatomical features

Anatomical features were studied at three heights (Bottom, Middle and Top) and three radial positions (Pith, Middle and Periphery). Anatomical aspects with respect to Fiber morphology were assessed based on Maceration technique.

2.5 Maceration

Radial chips from 1cucm blocks at each radial position (Pith, Middle and Periphery) along each height i.e, bottom, middle and top were taken for maceration. Schultz's method of maceration was followed. In this method, the radial chips were boiled in water till they settled down. Then the material was boiled in a mixture of 50% nitric acid and a pinch of potassium chlorate till the decolourisation of the chips. The resultant material was thoroughly washed in distilled water till the traces of acid were removed. Finally the macerated material was taken on a slide and stained with saffranin for observation and measurement of Fibers under the microscope.

The following anatomical features were studied using Image Analyser-

2.6 Fiber Morphology- Fiber Length (Fig.I)

Fiber Diameter

Fiber Lumen Diameter

Fiber Wall Thickness

3. Results and Discussions

Generally plantations of different species or the same species grown with known or unknown seed origin after certain age reflect variation in their tree form both in height, girth (diameter), bark thickness, heartwood percentage and specific gravity. The variation may be large due to interaction of the locality and seed origin. In anatomical properties, the variation is related to age as well as locality factor (Zobel and Buijtenen, 1989). In the present study, the height of the clones as measured has indicated significant variation within clone and between clones, although, as a population they were looking of the same height from a distance, so is the case with seed origin trees. This significant variation and differences in values may be due to juvenile factor (As the ramets were in active growing period). Furthermore, the Kolar clones are comparatively shorter than clones from Mandya.

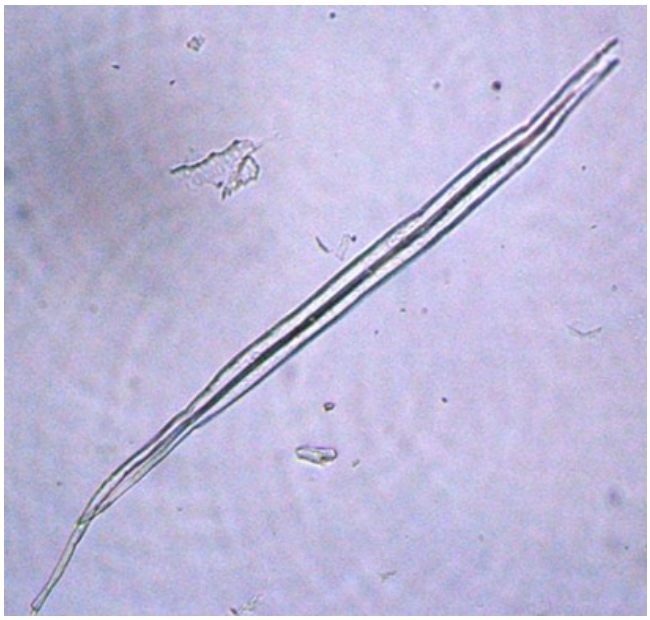

Figure 1: Fiber of *Eucalyptus tereticornis* under 10 X

There are no comparative data for ITC Bhadrachalam clones to find the differences among the clones from two different plantation sites (SreeVani, 2002).

Locality factor played a significant role for the variation apart from height position. The purpose of clonal propagation by vegetative method in this particular species is to increase the productivity per unit area of plantation while giving due importance to ensure that selected physical and anatomical properties (specific gravity, Fiber morphology) are not affected. Considering the better diametrical growth along with height, suggestive of higher biomass production, the clone GR-283 can be rated as best among the five selected clones and GR-3 can be rated as very poor, as the values are less than that of seed origin.

T-test for between locality variation in the clones and seed origin for various parameters showed the clone GR-283 with a maximum number of significant variations.

3.1 Specific Gravity

Eucalyptus species have occupied a prominent place in the paper and pulp industry and private sectors like ITC Bhadrachalam in Andhra Pradesh, Grasim Fibers in Karnataka and WIMCO in northern India have initiated research on clonal propogation of *Eucalyptus tereticornis* and *Populus* spp. to meet the requirement of their respective industries.

According to Ikemori *et.al*, (1986) the requirement of wood density for paper and pulp is in the range of 480 kg/m^3 to 570 kg /m^3(sp. gr. = 0.48-0.57). Considering the above factor, the specific gravity as obtained in the present study falls into the category of acceptance by pulp and paper industry. In this connection it may be mentioned that clone GR-3 although showed less height and low diameter has not got affected by specific gravity. Earlier studies made by SreeVani (2002), Rao *et.al*. (2002), Shashikala *et.al*. (2005) and Pande *et. al.* (2009, 2011) also report that clonal propogation techniques can be utilised for bringing uniform specific gravity in the clonal material.

In the present study, radial variation within the clones did not show a definite pattern with respect to Specific gravity. There was a fluctuation in Specific Gravity from pith to periphery. Non-significant interclonal variation with respect to Specific Gravity was observed. This kind of fluctuation was also reported in *Eucalyptus saligna* by Panshin and De Zeeuw (1980) and Ohbayashi and Shikura (1990). Purkayastha et al. (1982) had shown an increase in Specific Gravity from pith to outwards in *Eucalyptus*. Increase in specific gravity from pith to bark was also reported in *Eucalyptus grandis* (Hans *et al*. 1972) and *Eucalyptus camaldulensis* (Jain and Arora, 1995).Shashikala *et.al.* (2009) reported significant variation in both radial and axial direction in *Eucalyptus citriodora*.The continuous increase in specific gravity from pith to periphery with a definite trend was reported in the clone of *Populus deltoides* (Gautam, 2010).

Specific Gravity was found to vary between the localities (Fig II). The range of Specific Gravity as observed is suitable for pulping and manufacture of paper.

3.2 Fiber properties

Considering the Fiber length required for paper and pulp industry, the T-test conducted between two localities clone wise has shown non-significant variation with the exception of GR-283. This indicates when all these clones if used together, perhaps may produce the paper quality of same nature. This is purely an anatomical observation. However the paper technologist may throw further light on this aspect.The following paragraphs will throw further light on variations in Fiber length both in seed origin and clonal material indicating different views.

Radial variation and vertical variation with respect to Fiber diameter was found to be non-significant among the clones. Fiber diameter was found to increase from pith to periphery. Variation in Fiber diameter was found to be significant between locality.

Radial variation within the clones showed a decrease in Fiber lumen diameter from pith to periphery with a few exceptions. Vertical variation within the clones showed a decrease in Fiber lumen diameter from bottom to top with a few exceptions. Interclonal variation and between locality variation for Fiber lumen diameter were found to be significant.

Radial variation within the clones showed an increase in double wall thickness from pith to periphery. Vertical

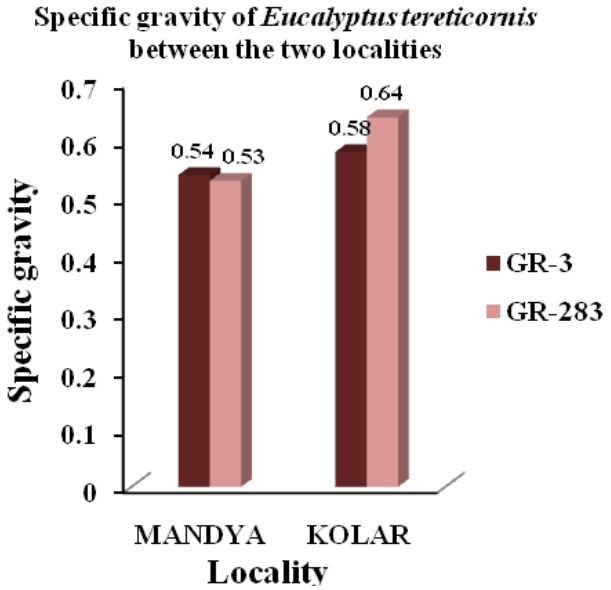

Figure II: Comparison of Specific gravity of *Eucalyptus tereticornis* clones from Mandya and Kolar

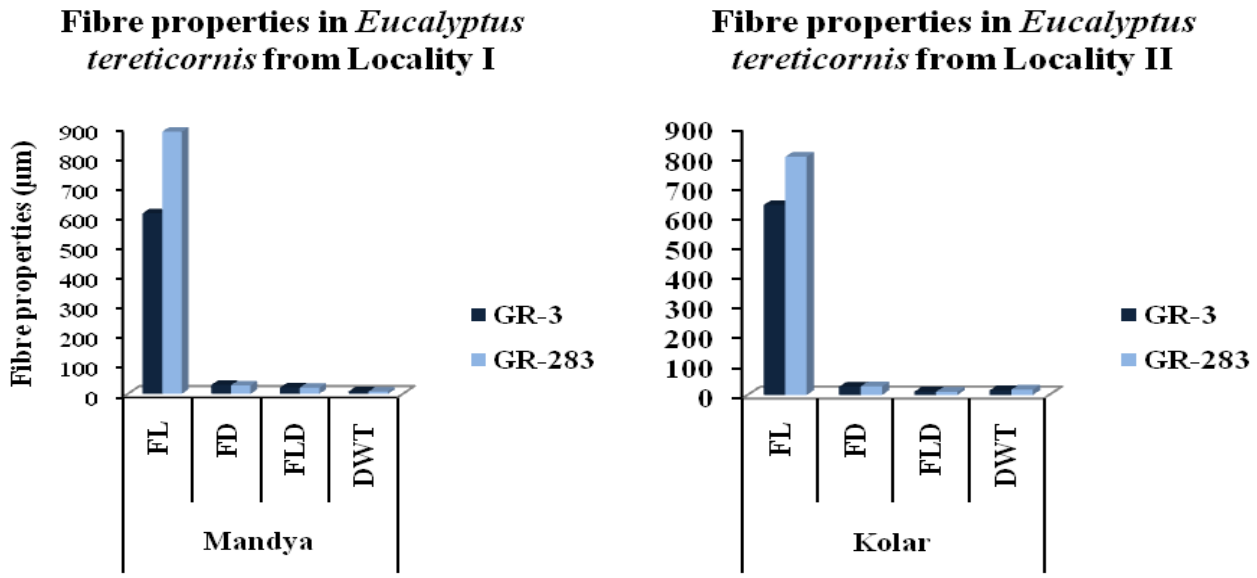

Figure III: Comparison of Fibre properties (µm) of *Eucalyptus tereticornis* clones from Mandya and Kolar

variation among the clones showed an increase in double wall thickness from bottom to top.Locality was found to have significant effect on double wall thickness.

Fiber Length showed a large variation between the clones and also between the localities (Fig III). Under irrigated conditions, a few clones performed better compared to rainfed conditions. The shortest Fiber was found in GR-3 for both the localities. Fiber Diameter showed a slight variation between the clones and between the localities. Narrow Fibers were found in Seed Origin (Kolar) and wider Fibers were found in GR-3 (Mandya). Fiber Lumen Diameter showed between clone and between locality variations. Lumen was narrow in the rain fed region compared to irrigated condition. Double Wall Thickness also showed variation wherein rain fed condition exhibited thicker walls.

3.3 Runkel ratio

(Runkel Ratio= 2 x cell wall thickness/Fiber lumen diameter)

The Runkel ratio is the ratio of Fiber cell wall thickness to its lumen that determines the suitability of a fibrous material for pulp and paper production. If a wood species has a high Runkel ratio, its Fiber will be stiff and less flexible and poor bonding ability. High Runkel ratio Fibers produce bulkier paper than Fibers with low Runkel ratio. For any wood species to be of good quality for pulp and paper production, its Runkel ratio must be = 1 (Kpikpi, 1992).

Radial variation among the clones showed an increase in Runkel ratio from pith to bark. Vertical variation also showed an increase in Runkel ratio from bottom to top in the clones with a few exceptions. Runkel ratio of 0.25 to 1.5 is considered to produce pulp of reasonable quality (Singh *et.al.* 1991). Interclonal variation was found to be

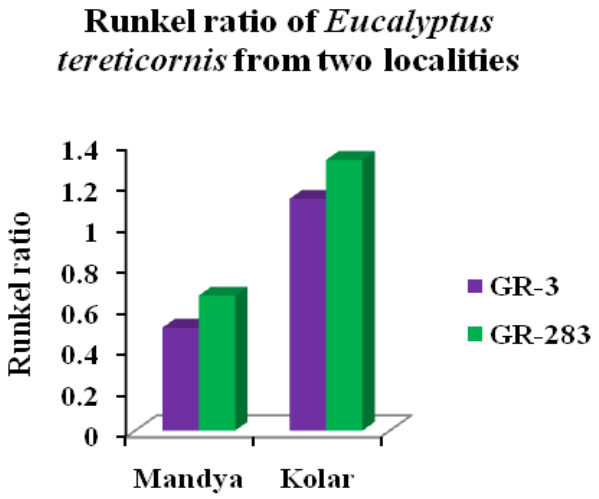

Figure IV: Comparison of Runkel ratio of *Eucalyptus tereticornis* clones from two localities

non-significant but between locality variations were found to be significant. In the current study Runkel ratio was found to be in the range of 0.502-1.32. Runkel ratio was found to be in the suitable range for paper and pulp industry both in the case of clones as well as seed origin. Runkel ratio varied between clones and between localities (Fig IV). Irrigated region showed a lower ratio compared to Rain fed region.

The present data with particular reference to Fiber Length has shown shorter Fibers (GR-3) than any other study made earlier. The paper and pulp properties may be expected to be not up to the expectation for this clone. GR-283 has shown better performance with respect to Specific gravity and Fiber properties.

Conflict of interest

The author's declares none.

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