Clonal variability for water use efficiency and carbon isotope discrimination ($\Delta^{13}C$) in selected clones of a few Eucalyptus species

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Background

Eucalyptus, one of the fast growing tree species extracts water from a depth of up to 15 meters (Peck and Williamson, 1987). As a prolific producer of biomass/ wood (Calder et al., 1997), eucalyptus has been included as commercially important tree species under various afforestation programmes in many parts of the world although there is a controversy regarding the reported reduction of stream flow associated with this species. Therefore in this scenario, it is necessary to make an attempt to use selections with reduced water use or to select and develop high water use efficient clones to cultivate under water limited environments.

Objectives

The major objective was to assess the eucalyptus clones for variability in WUE and to determine the relationship between WUE and carbon isotope discrimination ($\Delta^{13}C$) for large scale screening and selection for high WUE.

Methodology

Nine clones of *Eucalyptus urophylla*, five clones of *E. pellita* (both procured from Mysore paper mills, Bhadravathi, Karnataka, India) and two hybrids (procured from ITC India Ltd) totaling to 16 entries were subjected to gravimetric measurement to determine WUE. Ten ramets of each clone were planted in cement cisterns containing planting mixture and weighing approximately around 100 kgs were placed under a rain out shelter (ROS). After measuring the initial biomass of a few representative plants (destructive sampling of 3 ramets), pots were weighed everyday and the amount of water lost over a period of 24 hours was replaced to bring the soil to field capacity. This exercise was continued for about 100 days and end of which, the plants were harvested and the final biomass was quantified. Similarly, at the end of the experimental period, the cumulative water added (CWA) to each pot from the beginning of the experiment until the end was computed. For evaporative loss correction, empty pots without plants which were weighed everyday were also maintained all through the experimental period. The evaporative loss so obtained was deducted from the cumulative water added to arrive at the cumulative water transpired (CWT). Similarly, the initial biomass of the plants measured at the time of commencement of the gravimetric experiment was deducted from the final biomass to arrive at the Delta (differential) biomass. The ratio of D-biomass to CWT therefore forms WUE of the clone.

As gravimetric approach is time consuming, laborious, tedious and cannot be followed for large scale screening, an alternate approach is required to screen and identify high water use efficient clones. In recent times, carbon isotope discrimination approach is emerging as a strong tool to screen for WUE in plants (Farquhar et al., 1989). However, before adopting this approach for large scale screening of germplasm lines/ clones, the relationship between actual WUE and $\Delta^{13}C$ needs to

be established. In this direction, an attempt was also made to determine the relationship between WUE and $\Delta^{13}C$ in Eucalyptus. Stem wood samples were collected, dried, powdered and carbon isotope fractionation was determined using Isotope ratio mass spectrometer (IRMS) for the $\Delta^{13}C$ study component.

Results and Discussion

The results of the study indicated a significant clonal variability for WUE in Eucalyptus clones. Accordingly, the WUE measured ranged from 1.44 g/kg to 3.39 g/kg with a mean WUE of 2.28 g/kg (Table 1). This range of WUE is almost similar to that of C_3 crop plants and hence, it may not be appropriate to consider Eucalyptus as water spenders, in terms of biomass production. Of the three different species of Eucalyptus used for assessing the clonal variability, the clones of *E. urophylla* were found to be more water use efficient than hybrids and *E. pellita* (Fig 1). *E. urophylla,* apart from being a good pulp yielder, also appears to be water use efficient and hence, these clones can possibly be popularized under conditions where improved WUE is desired.

A significant negative relationship was observed between actual WUE quantified gravimetrically and $\Delta^{13}C$ to indicate that, the clones that are more water use efficient tend to have less discrimination for ^{13}C carbon (Fig 2). Such a significant negative relationship has been shown earlier both in crop plants (Sheshshaayee et al., 2003) and tree crops (Raju, 2001; Mahadeva Murthy et al, 2006). Establishment of such a relationship will help in large scale screening and identification of WUE clones in Eucalyptus.

A significant positive relationship was also observed between WUE and total dry matter (TDM) in Eucalyptus (Fig 3). This signifies the mesophyll efficiency rather than stomatal regulation for WUE in Eucalyptus clones.

Conclusion

Clonal variability for WUE does exist in Eucalyptus and therefore, this variability can be exploited for eucalyptus tree improvement. Further, the negative relationship found between WUE and $\Delta^{13}C$ paves the way for screening large numbers of clones for WUE in the identification of superior clones with high WUE.

References

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Table 1: Clonal variations in WUE across Eucalyptus clones

	WUE (g/kg)
Min	1.44
Max	3.39
Mean	**2.28**
SD	0.56

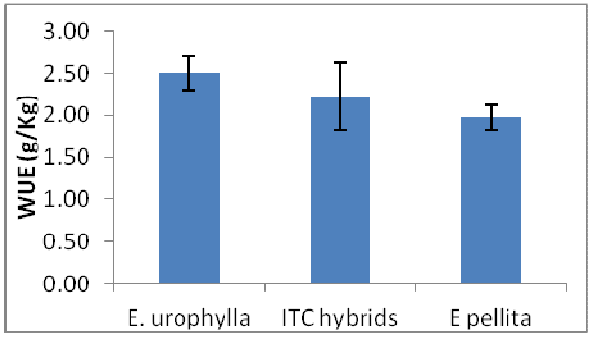

Fig 1: Water use efficiency in different species of Eucalyptus

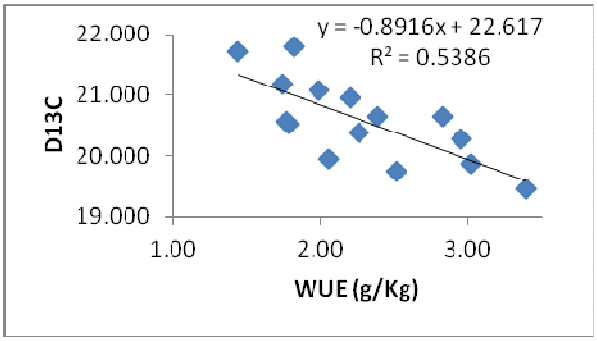

Fig 2: Relationship between $\Delta^{13}C$ and WUE in Eucalyptus

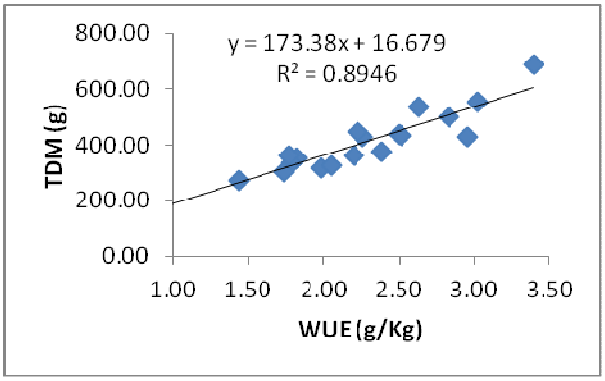

Fig 3: Relationship between WUE and TDM in Eucalyptus