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PHYSIOLOGICAL BEHAVIOUR VIS-A-VIS WATER LOGGING CONDITIONS IN SOME TREE SPECIES

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SUMMARY

Strip plantations of two rows of ten trees species (*Eucalyptus tereticornis* clone-10, *Eucalyptus tereticornis* clone-130, *Eucalyptus tereticornis* clone-3, *Eucalyptus* hybrid clone (*Eucalyptus tereticornis* x *Eucalyptus camaldulensis*), *Tamarix aphylla*, *Prosopis juliflora*, *Callistemon lanceolatus*, *Melia azedarach*, *Terminalia arjuna* and *Pongamia pinnata)* each 60 meters apart were raised on field bunds at the CCS Haryana Agricultural University, Hisar animal fodder production farm area, comprising of about 30 acre of water-logged pasture land along with the Balsamand canal. To monitor water table fluctuations immediately beneath the plantations due to evapotranspirational-drainage (ED), observation wells were dug on each of the bund between the two rows of trees. Morpho-physiological ED traits like tree height, diameter at breast height (DBH), leaf area index (LAI), stomatal density, stomatal conductance (gs), transpiration rate, potometric water loss (PWL), relative water content (RWC), excised leaf water loss (ELWL) and dimensions of the water conducting elements (tracheids and vessels) were also studied. Palpable fluctuations in the water table immediately beneath each plantation on a 24 hour diurnal cycle were observed and the magnitude of depression of water table beneath each plantation was taken as the ED potential of tree species. Amongst the different tree species ED, as determined by decline in water table beneath the plantation, was in the order of : *Eucalyptus* Clone-10 (42.00mm) ≈ *Eucalytpus* hybrid (41.75mm) > *Eucalyptus* Clone-130 (22.50mm) ≈ *Tamarix aphylla* (22.00mm) > *Prosopis juliflora* (19.25mm) > *Eucalyptus* Clone-3 (16.50mm) > *Callistemon lanceolatus* (11.75mm) ≈ *Melia azedarach* (11.50mm) > *Terminalia arjuna* (5.50mm) ≈ *Pongamia pinnata* (5.25mm). Correlation analysis of ED potential with other parameters showed that ED potential had a significant positive correlation with LAI. Tree height, DBH, stomatal density and leaf transpiration rate also bore a significant positive correlation with ED potential. However, correlation trends with other physiological traits like PWL, RWC, ELWL and length and width of water conducting elements were not consistent. Our results indicate that species like *Eucalyptus tereticornis* clone-10 and *Eucalyptus* hybrid are fast EDs primarily due to their ability to display large leaf area as compared to slow EDs like *Terminalia arjuna* and *Pongamia pinnata* where leaf area development is poor.

Key words: **Evapotranspirational drainage, physiological traits, trees, water logging, water table**

INTRODUCTION

Arid and semi-arid domains world wide, including north-west India, are underlain with brackish water (Garg and Gupta 1997). Introduction of canal irrigation and intensive agriculture in these areas has resulted in a rise in groundwater table leading to waterlogging and salinity (Ritzema *et al.* 2008, Crosbei *et al.* 2008). From

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the techniques of surface or subsurface drainage, the focus on the mitigation of waterlogging is now shifting on evapotranspirational drainage (ED) or biological drainage potential of strategically planted tree species (Denecke 2000, Kapoor 2002, Ram *et al*. 2002, INCID 2003, Ram *et al*. 2007 and Angrish *et al*. 2008). Whilst consumptive use of water by trees and consequent lowering of water table of waterlogged soils through ED is an established concept, there is paucity of information on the comparative ED potential of different tree species. Much authentic information is not available on the comparative ED potential of different tree species or their clones under identical set of conditions. Moreover, there is a lack of information on the structural and physiological traits that may account for the differential ED potential amongst tree species. With these points in background, the present study aimed at the evaluation of ED potential of ten tree species raised under identical field conditions. Some of the subtle ED traits, considered vital for ED efficiency, were also studied and correlated with the ED potential.

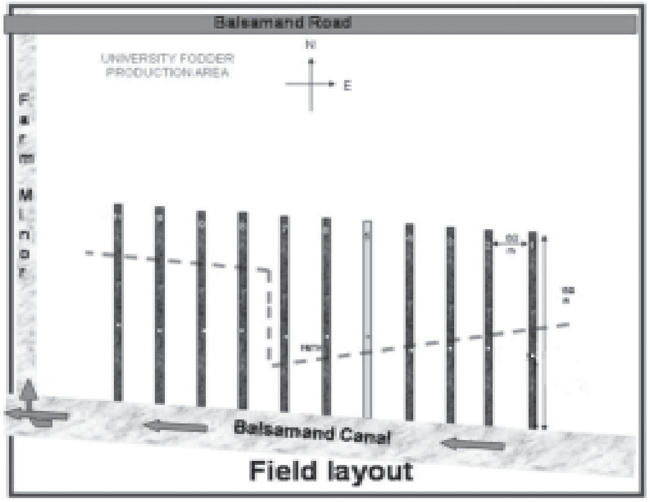

Fig. 1. Field layout of ED plantation. Bars denoted with numbers are bunds on which strip plantation of 1, *Melia azedarach*; 2, *Eucalyptus Clone-10*; 3,*Terminalia arjuna*; 4, *Pongamia pinnata*; 5, *Control*; 6, *Tamarix aphylla*; 7, *Callistemon lanceolatus*; 8, *Eucalyptus Clone -130*; 9, *Eucalyptus Clone-3*; 10, *Eucalyptus hybrid* and 11, *Prosopis juliflora* have been raised. Square dots indicate position of observation well between the tree rows (Fig. not to scale)

MATERIAL AND METHODS

Field site description: The experimental site comprised of about 30 acres of waterlogged land at the CCS Haryana Agricultural University farm square number 1799-1800 along with the Balasamand canal which flows nearly in the east west transact. With a long term view of reclaiming this abandoned waterlogged site ED plantations have been raised as strip plantations on field bunds which are about 60 m apart from each other (Fig. 1). The field bunds are 2.90 m broad at base, 2.60 m broad at top, about 0.45m in height and extend to about a length of 150 m from north to south. Two rows of trees are planted on each bund with a row to row distance of 1.3 m. Plant to plant distance is 1.5 m in *Eucalyptus* and 3 m in other species. Observations reported in this paper were made in August and September, 2007 when the trees were about three years old.

Observation wells have been installed at a distance of about 60 m from north of Balsamand canal in the east-west transact. To monitor the fluctuation of water table immediately beneath the strip plantations, one well lies immediately between the two rows on each bund. One bund has been kept fallow for the purpose of acting as control. Starting from east to west, the tree strips are : i) *Melia azedarach* (Bakain), ii) *Eucalyptus* clone-10 (Safeda), iii) *Terminalia arjuna* (Arjuna), iv) *Pongamia pinnata* (Papri) v) fallow bund (Control), vi) *Tamarix*

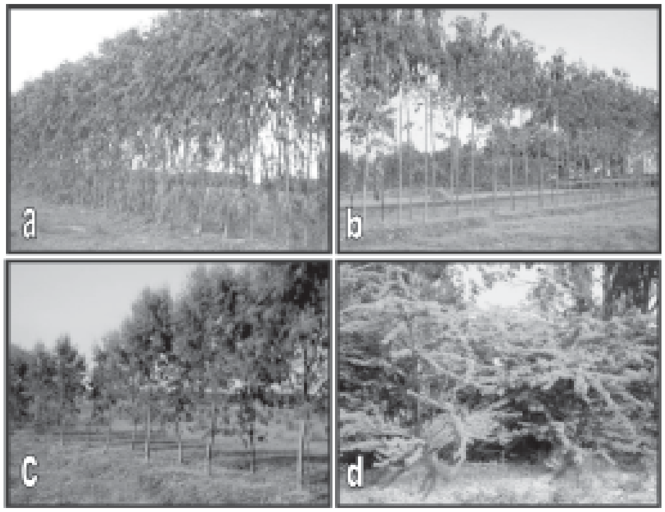

Fig. 2. Strip plantation of some representative tree species on ridges at the field site: (a) *Eucalyptus tereticornis* C-10, (b) *Eucalyptus tereticornis* C-3, (c) *Tamarix aphylla* and (d) *Prosopis juliflora*. Note the marked leaf area difference between C-10 and C-3 of *Eucalyptus tereticornis.*

aphylla (Farash/Salt cedar), vii) *Callistemon lanceolatus* (Bottle brush) viii) *Eucalyptus tereticornis* clone-130 (Safeda) ix) *Eucalyptus* clone-3 (Safeda), x) *Eucalyptus* hybrid clone (*Eucalyptus tereticornis* x *Eucalyptus camaldulensis*) (Safeda), xi) *Prosopis juliflora* (Mesquite) (Fig. 2). Clonal seedlings of *Eucalyptus tereticornis* clone 3, clone 10 and clone 130 were procured from Haryana Forest Department, Clonal Propagation Nursery, Seonthi, Kurukshetra. *Eucalyptus* hybrid clone was procured from Tissue Culture Nursery, Forest Research Institute, Dehradun. *P. juliflora* was raised from seeds collected from a single robust tree growing at Haryana Agricultural University, Hisar. All other species were procured from Haryana Forest Department nursery, Hansi.

Growth parameters and ED traits: Different growth parameters and physiological traits vital for water loss were recorded. Thus plant height was measured with clinometer and diameter at breast height (DBH) at 1.37 m above ground level in case of tall trees was determined. For this the girth (G) of the tree was measured with the help of a flexible tape. DBH was calculated using the equation: DBH = G/ π.

LAI was computed using Hemiview version 2.1(Delta-T Devices, UK). A hemispherical image of the tree canopy was taken with the help of fish eye lens fitted camera system of hemiview instrument. The hemispherical image was fed to a computer software system supplied by the Delta-T Devices, which interpreted the image for computation of Leaf area index using Beer's law as follow:

$$G(\theta) = e\text{-}K(\theta).L$$

Where,

G = Gap fraction

K (θ)=Extinction coefficient at angle θ

L = Leaf area index

θ = Zenith angle

Stomatal density was taken as number of stomata per unit area of the leaf. One celled thick epidermal peel was made from the abaxial and adaxial surface of the leaf with a sharp razor blade. The peel was mounted on a microscope slide and cover slip and observed under a microscope. The number of stomata was counted in 10 randomly selected fields at 10X/100X.

Stomatal conductance (gs) (mol m^{-2} $second^{-1}$) was obtained with portable photosynthesis system of ADC Bio Scientific Limited, U.K. This observation was taken in the morning in full sunlight around 11 AM. For taking the observations fully expanded leaf was selected. Transpiration rate (m mol/m^2/second) was also recorded by portable photosynthesis system of ADC Bioscientific Limited, UK.

For potometric water loss (PWL) measurements, cut end of fresh leafy twigs of each species were immersed in known volume of water. One set containing only water but no twig was treated as control for this experiment. All flasks containing twig as well as blank set were kept in net house for 24 h under ambient conditions of temperature and relative humidity. After 24 h the decrease in volume of water was measured. Leaves were detached from the shoot and total leaf area was measured by CI-203 portable laser area meter (CID Inc., USA). Leaves along with their shoots were also dried in an oven at 70° C for 24 h to obtain dry mass. Water loss was interpreted as ml cm^{-2} leaf area day^{-1} and ml g^{-1} dry mass day^{-1}.

For measurement of relative water content (RWC), leaf samples were collected and weighed for fresh weight. These were immersed in distilled water for 6 h and reweighed to obtain turgid weight. Subsequently leaf was dried in an oven at 65ºC to get dry weight. RWC (%) was computed using the equation:

$$\text{RWC (\%)} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{Dry weight}} \times 100$$

For excised leaf water loss (ELWL), tree leaf sample was immediately weighed to obtain fresh weight. Thereafter it was placed in an incubator at 28ºC at 50% relative humidity for 6 hours and weighed immediately thereafter. Subsequently the leaf was oven dried for 24 hours at 70ºC to obtain its dry weight. Formula used for its computation was:

$$\text{ELWL} = \frac{\text{Fresh weight} - \text{Weight after 6 hour}}{\text{Turgid weight} - \text{Dry weight}} \text{ x } 100$$

For the measurements of dimensions of tracheids and vessels, sapwood was extracted with the help of a sharp scalpel from the main stem at about 1.50 m and fixed in formalin-acetic acid. It was macerated in boiling 20% HNO_3 added with few crystals of $KClO_3$ (Prakash 1987). Length and width of the separated tracheids and vessels was measured microscopically using ocular and stage micrometer.

Relevant meterological parameters were obtained from the observatory of the Department of Agrometerology of the University located at a distance of about 600 m from the site. Average meterological parameters during the observations on 8-11th August, 2007 were: maximum temperature (34.9 ^{0}C), minimum temperature (26.9 ^{0}C), relative humidity (morning 83.5% and evening 65.8%), wind speed (6.8 km h^{-1}) and pan evaporation (6.5 mm day^{-1}). Likewise, these parameters, during the observations on 1-4th September, 2007 were maximum temperature (34.8 ^{0}C), minimum temperature (25.9 ^{0}C), relative humidity (morning 91% and evening 55%), wind speed (5.8 km h^{-1}) and pan evaporation (5.4 mm day^{-1}).

RESULTS AND DISCUSSION

Diurnal fluctuations of water table beneath the plantations: As a prelude to detailed observations a representative pattern of diurnal fluctuations of water table was required. Therefore only the *Eucalyptus* Clone-10 strip along with the control was selected for the observations. The results of two hourly fluctuation of water table, beneath the plantations are presented in Fig. 3a (mean of four days i.e. 8th, 9th, 10th and 11th August, 2007).

Fig. 3. (a) Diurnal fluctuation of water table (mm) in Eucalyptus C-10 and control (no plantation) bund. (b) Depression of water table (mm) beneath different tree plantations. (c) Height (cm) of different tree species. (d) Diameter at breast height (DBH) of different tree species. (e) Leaf area Index (LAI) of different tree species. (f) Cumulative stomatal density on both the leaf surface. Tree species are abbreviated as: A (*Callistemon lanceolatus*), B (*Eucalyptus Clone-3*), C (*Eucalyptus hybrid*), D (*Eucalyptus Clone-10*), E (*Eucalyptus Clone -130*), F (*Melia azedarach*), G (*Pongamia pinnata*), H (*Prosopis juliflora*), I (*Tamarix aphylla*), and J (*Terminalia arjuna*).

It is seen that in general, the water table beneath the *Eucalyptus* Clone-3 plantation was lower as compared to the control. Further, the control water table did not show any significant depression. However, the water table beneath the plantation showed interesting pattern of diurnal fluctuation. Starting midnight through the dawn (06.00 hrs) and even immediately thereafter upto 08.00 hrs, water table maintained a more or less constant level. However, towards forenoon i.e. 10.00 hrs, water table started receding and continued to do so till 18.00 hrs. The time 16.00-18.00 hrs is the time when peak depression of water table occurred due to the evapotranspirative demand of the above growing canopy. Therefore, a diurnal 'cone of depression' was found beneath the plantation as seen in Fig. 3a. Subtle diurnal fluctuation of water table under plantations due to variation in evapotranspiration have been observed by several workers (Johansson 1986, Mahmood *et al*. 2001, Gribovski *et al.* 2007). It is also established in literature that under shallow water table conditions a cone of depression is formed beneath actively transpiring deep rooted tree canopies (Heuperman *et al.* 2002).

A careful evaluation of Fig. 3a indicates that the cone of depression tends to disappear during the night time upto the next dawn. This observation is understandable in view of the fact that due to the decline in the solar radiation falling at top, there is a consequent decline of the canopy transpiration, which is further reflected as rise in the water table due to recharge from the surrounding waterlogged area.

Another interesting observation that emerges from review of data (Fig. 3a) is that while the solar radiation starts falling on the canopy at about 7.00 hrs and peaks during the noon up to 14.00 hrs, the actual start of the decline of the water table is initiated only after 8.00 hrs and peaks towards 16.00 hrs and 18.00 hrs. The relation between depression of the water table, rate of discharge, hydraulic conductivity, depth to barrier layer and distance between plantations can be described using equation developed by Donnan (1946) i.e. $R = (8\ K\ Y_0 h + 4\ K\ h^2)\ L^{-2}$ [Where, L = Distance between parallel plantation strips (m); R = Rate of recharge (m day^{-1}); Y_0 = Height of watertable above barrier layer under the tree plantations (m); K = Hydraulic conductivity of substrata; (m day^{-1}) and H = Head difference (m)]. Obviously the dynamics of water depletion or recharge (R) under a plantation is determined by several factors in which rate of recharge and hydraulic conductivity of soil play a pivotal role. In the present case the delayed onset of depression in watertable may be visualized as a function of reduced recharge between the plantations due to less hydraulic conductivity of the soil.

Comparative ED potential of different tree species: As discussed in the previous section magnitude of depression of water table beneath each plantation during the diurnal cycle was taken as a criterion for the ED potential of different tree species. In the present studies comparative trend of the depression in water table are presented in Fig. 3b (mean of four days i.e. 1st, 2nd, 3rd and 4th September, 2007), which shows that maximum depression to the extent of 42 mm was observed in *Eucalyptus* clone-10 closely followed by *Eucalyptus* hybrid, *Eucalyptus* clone-130, *Tamarix aphylla* and *Prosopis juliflora* (41.75, 22.50, 22.00 and 19.25 mm respectively). *Eucalyptus* clone-3 (16.50 mm) and *Callistemon lanceolatus* (11.75 mm) were more or less at par followed by *Melia azedarach* (11.50 mm). Depression in species like *Pongamia pinnata* (5.25 mm) and *Terminalia arjuna* (5.5 mm) was minimal and comparable with the control. Therefore, the comparative bio-drainage potential of different tree species can be said to be in the order of *Eucalyptus* clone-10 ≈ *Eucalyptus* hybrid > *Eucalyptus* clone–130 ≈ *Tamarix aphylla* > *Prosopis juliflora* > *Eucalyptus* clone–3 > *Callestemon lanceolatus* ≈ *Melia azedarach* > *Terminalia arjuma* ≈ *Pongamia pinnata*.

Although a vast variety of data on tree water use based on porometric studies, sap flow studies, lysimetric studies, energy balance equation etc. is available in literature (Wullschleger *et al.* 1998) comparison of water use of different tree species under comparable set up conditions from the ground water table is not available. This is because experiments have rarely been designed specifically for such purpose. The present experimental design meets these objectives and hence the results obtained have a special significance.

According to Angrish *et al.* (2006) there is a need to quantify the ED potential of different tree species into fast biodrainers, moderate biodrainers and slow biodrainers. The fast biodrainers should be put in situation where water table is shallow and waterlogging problem is acute. On the other hand places where sweet ground water has gone very low, the prospects of planting fast biodrainers like *Eucalyptus* may not be environmentally sound. Tree species of low consumptive use of water are required here.

Tree growth and associated physiological traits: Various morphological and physiological traits considered vital for the bio-drainage potential of different tree species were also measured. Fig. 3c shows that *Eucalyptus* clone-10 maintained the maximum plant height reaching about 10 m followed by *Eucalyptus* clone-3 and *Eucalyptus* hybrid. Other highest rising species were *Tamarix aphylla* (5 m) and *Melia* *azedarach* (4.78 m). Species like *Prosopis juliflora* showed considerable lateral spread due to extensive branching though the height was moderate.

It was interesting to note that *Eucalyptus* clone-10 which had maximum height also maintained good DBH (Fig. 3d). However, DBH of speices like *Tamarix aphylla* were comparable to the other *Eucalyptus* species inspite of its shorter plant height. Other species like *Pongamia pinnata, Callistemon lanceolatus* and *Prosopis juliflora* maintained lower DBH values.

LAI was maximum in *Eucalyptus* hybrid and followed by *Eucalyptus* clone-10. This was closely followed by *Eucalyptus* clone-130 and *Tamarix aphylla. Eucalyptus* clone-3, *Prosopis juliflora* and *Melia azedarach* also showed considerable leaf area development (Fig. 3e). According to Jain *et al.* (2010) foliage density and leaf area index are important structural variables and their consideration is imperative for interpreting trophic relationships such as transpiration fluxes.

Stomatal density or cumulative number of stomata mm^{-2} leaf area, considering both, adaxial and abaxial sides, was noted in *Callistemon lanceolatus* (592) followed by the three *Eucalyptus tereticornis* clones and *Prosopis juliflora* (525 to 550). *Tamarix aphylla* had the least stomatal density in the range of 167 stomata mm^{-2} (Fig. 3f).

Different species showed considerable variation in the gs. It was in the range of 0.08 mol m^{2} s^{-1} in *Melia azedarach* and 0.42 mol m^{2} s^{-1} in *Eucalyptus* clone-10. In general *Eucalyptus* clone-10 (0.42 mol m^{2} s^{-1}) had highest gs, where as in *Tamarix aphylla*, its value was on the lower side (Fig. 4a). Transpiration rate (Fig. 4b) was lowest in *Melia azedarach, Tamarix aphylla, Pongamia pinnata* and highest in *Eucalyptus* hybrid.

Tree shoots showed a considerable variation in PWL. Thus, the shoot transpirational water loss on the basis of leaf area was 0.008 ml water cm^{-2} leaf area day^{-1} in *Tamarix aphylla* to a maximum of 0.381 ml water cm^{-2} leaf area day^{-1} in *Eucalyptus* clone-130 (Fig. 4c). However, on dry weight basis minimum water loss of 5.20 ml water g^{-1} shoot dry weight day^{-1} was in *Terminalia arjuna* whereas the maximum water loss of 35.01 ml water g^{-1} shoot dry weight day^{-1} was again in *Eucalyptus* clone-130 (Fig. 4d). In general, *Eucalyptus* had higher transpiration rates as evident from high potometric water loss values, this was followed by species like *Callistemon lanceolatus, Prosopis juliflora* and *Melia azedarach*.

Fig. 4. (a) Stomatal conductance (gs) of different tree species. (b) Transpiration rate of different tree species. (c) Potometric water loss (PWL) of different tree species on leaf area basis. (d) Potometric water loss (PWL) of different tree species on dry weight basis. (e) Relative water content (RWC) of different tree species. (f) Excised leaf water loss (ELWL) of different tree species. Tree species are abbreviated as: A (*Callistemon lanceolatus*), B (*Eucalyptus Clone-3*), C (*Eucalyptus hybrid*), D (*Eucalyptus Clone-10*), E (*Eucalyptus Clone -130*), F (*Melia azedarach*), G (*Pongamia pinnata*), H (*Prosopis juliflora*), I (*Tamarix aphylla*), and J (*Terminalia arjuna*).

Species like *Eucalyptus* hybrid and *M. azedarach* showed relatively lower value of RWC, whereas those like *T. aphylla* had higher RWC values. It was interesting to note that RWC varied within the species i.e. being 80.08 in *Eucalyptus* hybrid, 86.80 in *Eucalyptus* Clone-10, 87.85 in *Eucalyptus* Clone-130 and 89.33 in *Eucalyptus* Clone-3 (Fig. 4e).

Observations recorded on ELWL of different tree species (Fig. 4f) showed considerable variation in the ELWL (%). The ELWL (%) was on the lower side in *Melia azedarach* (28.2) followed by *Tamarix aphylla* (31.0) and *Pongamia pinnata* (35.4). Interestingly all the clones of *Eucalyptus tereticornis* i.e. clone-10 (84.6), clone-3 (87.2), clone-130 (90.7) depicted higher values of ELWL.

Length of vessels varied considerately in the species (Fig. 5). While the longest vessels were found in *Melia azedarach* (409 µm), other species. like *Eucalyptus* hybrid, *Eucalyptus* Clone-10, *Eucalyptus* Clone-3, *Terminalia arjuna* and *Callistemon lanceolatus* also had long vessels. *Melia azedarach* which depicted largest vessel also had vessels of maximum width (113 µm). Pattern of width of vessels in other species was in the range of 57 µm in *Eucalyptus* Clone-130 to 83 µm in *Eucalyptus* Clone-3 and did not appear to have any correlation with vessel length.

Fig. 5. Length and width of tracheid and vessels of different tree species. Tree species are abbreviated as: A (*Callistemon lanceolatus*), B (*Eucalyptus Clone-3*), C (*Eucalyptus hybrid*), D (*Eucalyptus Clone-10*), E (*Eucalyptus Clone -130*), F (*Melia azedarach*), G (*Pongamia pinnata*), H (*Prosopis juliflora*), I (*Tamarix aphylla*), and J (*Terminalia arjuna*).

Tracheid length was on the higher side in *Eucalyptus* Clone-10 (593 µm), *Eucalyptus* Clone-3 (503 µm), *Eucalyptus hybrid* (453 µm) and *Callistemon lanceolatus* (430 µm) as compared to other species. Tracheids were of exceptionally small length in *Melia azedarach* (83 µm) which was having largest vessels also. Again this was followed by *Tamarix aphylla* (183 µm), *Pongamia pinnata* (251 µm), *Prosopis juliflora* (263 µm). Tracheid width was found to be in a narrow range of variation i.e. 20 µm in *Eucalyptus* C-10 to a maximum of 29 µm in *Terminalia arjuna*.

Correlation of traits with ED potential: It was considered imperative to workout the correlation coefficients of conventional growth parameters like plant height, DBH, LAI, as well as more subtle physiological traits like stomatal density, gs, transpiration rate, RWC, ELWL, PWL and sapwood anatomy with ED potential of different trees. For the sake of brevity the correlation coefficients between all these traits in different tree species and ED potential are presented in Table 1.

A perusal of the data in Table 1 shows the significant positive correlations between ED potential and growth traits like plant height (r = 0.95) and DBH (r = 0.93). Chave *et al.* (2005) conclusively demonstrated that stem diameter followed by plant height were highly correlated with above ground biomass of tropical trees. This argument becomes more interesting as in present case the LAI was also positively correlated (r = 0.90) with ED potential. It would appear that attainment of a higher leaf area displayed on a thick tall stem contributed to higher ED potential in trees like *Eucalyptus hybrid* and *Eucalyptus* Clone-10, and *vice versa* as in *Pongamia pinnata* and *Terminalia arjuna*. Larcher (2002) opined that in tree systems the largest single contributors towards transpiration trait was the leaf area development.

Amongst other traits stomatal density (r =0.95), transpiration rate (r = 0.90) appear to be positively correlated with ED potential. Interestingly enough vessels length (r =0.89) and tracheids length (r =0.82) also had an overall positive correlation with the ED potential. Tracheids and vessels width, however, did not appear to have a consistent positive correlation with ED potential.

Table 1. Summary Table of correlation coefficients between different ED traits and ED potential of different tree species.

ED Potential (Tree species)	Height	DBH	LAI	Stomata density	gs	Transpiration rate	Potometric water loss		RWC	ELWL	Vessels		Tracheids	
							DW	AREA			length	width	length	width
Callistemon lanceolatus	0.992*	0.906*	0.982*	0.977*	0.910*	0.949*	0.966*	0.881*	0.197	0.809	0.990*	0.930*	0.881*	0.921*
Eucalyptus Clone-3	0.953*	0.878*	0.980*	0.881*	0.682	0.709	0.965*	0.900*	0.932*	0.919*	0.779	0.689	0.890*	0.947*
Eucalyptus hybrid	0.885*	0.979*	0.939*	0.922*	0.907*	0.827	0.934*	0.902*	0.785	0.976*	0.542	0.909*	0.604	0.972*
Eucalyptus Clone-10	0.935*	0.991*	0.964*	0.984*	0.991*	0.923*	0.916*	0.978*	0.963*	0.963*	0.932*	0.368	0.916*	0.518
Eucalyptus Clone-130	0.933*	0.899*	0.975*	0.948*	0.953*	0.978*	0.759	0.944*	0.943*	0.856	0.931*	0.842	0.30	0.880*
Melia azedarach	0.879*	0.929*	0.802	0.977*	0.661	0.931*	0.77	0.903*	0.928*	0.994*	0.953*	0.843	0.878*	0.801
Pongamia pinnata	0.988*	0.959*	0.752	0.966*	0.813	0.979*	0.975*	0.941*	0.911*	0.341	0.899*	0.277	0.839	0.375
Prosopis juliflora	0.958*	0.896*	0.970*	0.944*	0.812	0.932*	0.834	0.723	0.954*	0.834	0.966*	0.424	0.990*	0.793
Tamarix aphylla	0.996*	0.887*	0.814	0.937*	0.908*	0.940*	0.902*	0.968*	0.972*	0.886*	0.934*	0.878*	0.968*	0.698
Terminalia arjuna	0.977*	0.974*	0.909*	0.969*	0.799*	0.881*	0.771	0.975*	0.823	0.774	0.946*	0.635	0.885*	0.878*
Mean	0.950*	0.930*	0.909*	0.951*	0.844	0.905*	0.879*	0.912*	0.841	0.835	0.887*	0.680	0.815	0.778

*Significant at 5% level of significance

Concluding remarks: Soil ground water is a precious resource and its sustainable maintenance is also affected by the above ground vegetation or vegetation related practices being followed by human beings. Results obtained in the present study indicate that the extent of canopy development as indicated by parameters like leaf area development, predominantly govern the ED potential. Correlation coefficients of various ED traits also indicate that biodrainage potential also expectedly correlates significantly with parameters like stomatal density and transpiration rate. Very interestingly and paradoxically it has been discovered that parameters like tracheary element length correlates positively with ED potential whereas the width does not. Authors opine that ED potential of trees is an outcome of complex interaction of the studied and several others factors and this aspect of tree water use needs more intensive examination.

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