

ORIGINAL ARTICLE

**Effect of controlled irrigation on physiological and biometric characteristics in teak (*Tectona grandis*) seedlings**

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Effect of controlled irrigation in physiological and biometric characteristics in teak seedlings is monitored at Forestry College in Kerala, India. Six month old seedlings of Teak (*Tectona grandis* L. f.) were raised in polybags. Irrigation was done once in a week. Daily evapotranspiration was calculated and treatments IW/ET=1, IW/ET=0.6, IW/ET=0.3 were irrigated with 100, 60 and 30 per cent of cumulative evapotranspiration. A control without irrigation (IW/ET=0) was also maintained. Physiological as well as biometric observations were carried out at regular intervals. Canopy air temperature difference (CATD) was measured using a hand held infrared thermometer and it was observed that seedlings from well watered treatments (IW/ET=1 and 0.6) showed negative CATD whereas treatments IW/ET=0.3 and IW/ET=0 showed positive CATD throughout the growing period. Seedlings in the treatment IW/ET= 0 and 0.3 showed a significant reduction in relative chlorophyll content, seedling height, collar diameter, number of leaves, total dry weight and relative growth rate whereas in IW/ET=1 and 0.6 these parameters were higher and there was no significant difference observed between these two well watered treatment. In the case of root shoot length ratio and root shoot biomass ratio IW/ET=0 was superior over other three treatments.

*Key words: water stress, Tectona grandis, physiological characteristics, biometric characteristics*

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Water comprises 70 to 85 per cent of the fresh weight of most of the plants. It is a means and medium of transportation for food materials within the plant. It has been estimated that a leaf will exchange up to 100 per cent of its water in a single hour on a warm, dry, sunny day and an amount equivalent to 100 times of its fresh weight during the whole lifetime (Taiz and Zeiger 2006). When

plants loss more water from the aerial part, than they can replace via root uptake they exhibit water deficit, which can induce wilting, damage to cell membranes and ultimately, cell death. Plant water deficit can also impair cell division, plant growth, photosynthesis, respiration, and other physiological processes (Kozlowski *et al.*, 1991). Drought limits plant growth and field crops production more than

any other environmental stresses (Zhu 2002). Thus water limitation may prove to be a critical constraint to primary productivity under future scenarios of more arid climates due to global environmental change (Fischer *et al.*, 2001).

The effects of water stress in the growth and development of forest trees is described by many authors (James and Bell 2000; White *et al.*, 2000; Burgess *et al.*, 2001 etc.). Effect of water stress is more deleterious when trees are in its early stages of growth. Tremendous seedling mortality occurs annually during initial stages of seedling establishment because of recurrent and periodic or sustained internal water deficit (Kozlowski 1968).

Teak is one of the most important timber species that are widely used for raising plantations and afforestation purposes in India. It requires a relatively long nursery period lasting about one year. However, the species is still poorly studied in relation to its management in plantations and its physiological responses to environmental stresses. Standardization of nursery techniques is necessary for any afforestation programme as expenditure on nursery takes itself a major portion of plantation cost. The cost can however, be reduced by evolving suitable and desired nursery practices on scientific lines (Bahuguna and Lal 1992). Determination of optimal watering frequency and water requirement for teak seedlings is very essential. Hence the present study is oriented to study the effect of controlled irrigation in physiological and biometric characteristics in seedlings of teak.

#### **MATERIALS AND METHODS**

The experiment was carried out at College of Forestry, Kerala, India (10° 31'N latitude and 76° 13'E longitude with an elevation of about 22m above mean sea level) during 2010-2011. The study

area enjoys a warm humid tropical climate with distinct summer and rainy season. It had received a total rainfall of 3018.4 mm during 2010 and 87.5 mm till the end of March in 2011.

Six months old seedlings of teak were raised in polythene bags and grown under a rainout shelter. Irrigation was provided once in every seven days. Daily evapotranspiration was calculated and treatments IW/ET=1, IW/ET=0.6, IW/ET=0.3 and IW/ET=0 were irrigated with 100, 60, 30 and 0 per cent of cumulative evapotranspiration calculated on daily basis using FAO modified Penman's equation (Allen *et al.*, 1998).

The plants were evaluated each week in order to measure the effect of water stress in chlorophyll content using chlorophyll meter (SPAD-502, Minolta). Randomly selected ten mature leaves were used for this purpose. Relative growth rate was also estimated. Five plants were randomly taken out from each treatment combination biweekly beginning at 14 days after start of treatment and continued up to six months. Seedlings were destructively sampled. Stem, root and leaf portion were separated. Observations on height, collar diameter, number of leaves, root length, root shoot length ratio and root shoot biomass ratio were taken. Data obtained were subjected to statistical analysis using SPSS (v 17).

#### **RESULTS AND DISCUSSION**

##### **Chlorophyll content**

Chlorophyll content was found to be minimum in non-irrigated IW/ET=0 followed by treatment IW/ET=0.3 (Figure 1). Treatment IW/ET=0 showed 17 per cent reduction and in IW/ET=0.3, the reduction was 8 per cent in relative chlorophyll

content. In well watered treatments IW/ET=1 and IW/ET=0.6 it was higher and were on par. Severe drought causes rupture of chloroplast and disintegration of chlorophyll molecules. Decreased or unchanged chlorophyll level during drought stress has been reported in many species, depending on the duration and severity of drought (Beltrano and Ronco 2008; Nikolaeva *et al.*, 2010). Many of the existing reports suggest that mild stress will not affect chlorophyll content (Manes *et al.*, 2001; Duan *et al.*, 2005; and Yanbao *et al.*, 2006). So it can be assumed that irrigation at IW/ET=0.3 impose severe stress in teak seedlings to impart chlorophyll content.

#### Height

From the height data it has been observed that seedlings from treatments IW/ET=1 and IW/ET=0.6 had showed more height compared to other two treatments (Figure 2). In IW/ET=0 and IW/ET=0.3, seedling height was less. This indicates irrigation at level IW/ET=0.3 was not enough to provide sufficient water supply for the growth of seedlings. When evaporation exceeds water supply, it creates drought stress which is characterized by the reduction of cell water content, diminished leaf water potential and turgor loss, closure of stomata and decrease in cell enlargement and growth. Many reports suggest the negative impact of water stress in plant growth (Anjum *et al.*, 2003; Bhatt and Rao 2005; Kusaka *et al.*, 2005; Shao *et al.*, 2008). It has been also observed that in severe water stressed seedlings of treatments IW/ET=0 and IW/ET=0.3 had allocated more biomass towards roots than to shoots.

#### Collar diameter

Water stress in seedlings caused reduction in collar diameter. It varied from 8.5 mm in well

watered IW/ET=1 to 6.6 mm in treatment IW/ET=0. The observation on collar diameter was given in Figure 3. Collar diameter was maximum in treatment IW/ET=1. This might be due to more availability of water. In treatments IW/ET=0.3 and 0, water stress might influence the physiological processes and may result in poor performance of seedlings. It is known that high soil water availability facilitate nutrient accumulation, leaf growth, leaf area and number of leaves which converted more solar energy and fixed more CO<sub>2</sub> to produce more photosynthates, and thus greater growth and biomass production (Ceulemans *et al.*, 1993). Sufficient soil water availability higher irrigation probably maintained cell turgidity and increased in leaf size and the overall biomass (Souch and Stephens 1998).

#### Number of leaves

Severely water stressed teak seedlings (IW/ET=0 and IW/ET=0.3) showed a significant reduction in number of leaves from the second fortnight of treatment (Figure 3). Number of leaves in seedlings of other two treatments (irrigation at IW/ET=1 and irrigation at IW/ET=0.6) was high and showed no significant variation among each other most of the time. Performance of IW/ET=0 and IW/ET=0.3 in terms of number of leaves were on par.

#### Root shoot length and biomass ratio

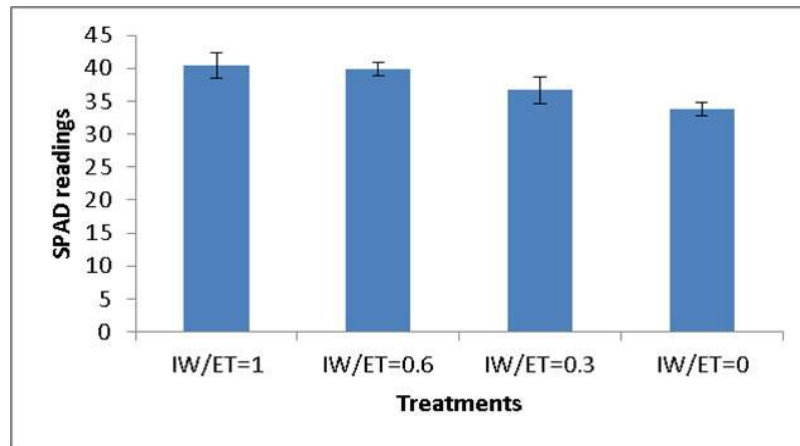
Teak seedlings of treatment IW/ET=0 was superior throughout the experimental period in terms of root shoot length and biomass ratio (Figure 4). No significant difference was observed among the other treatments. Root shoot ratio appears to be governed by a functional balance between water uptake by the root and photosynthesis by the shoot increased root growth. This functional balance is affected by water stress

and more biomass is allocated towards roots to increase more water absorption.

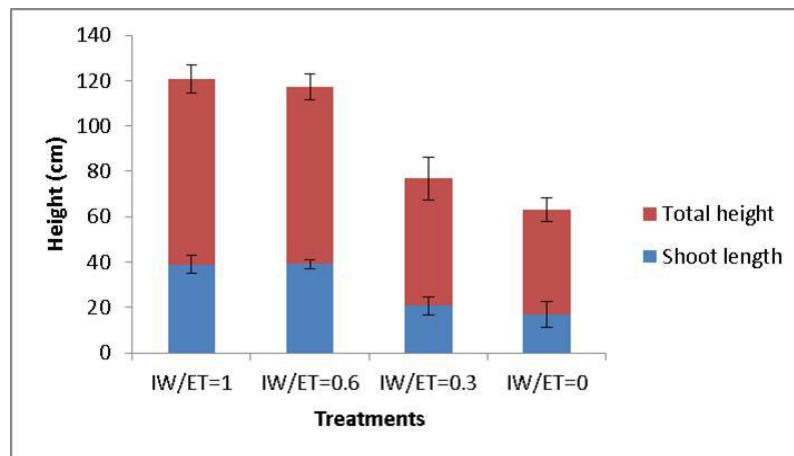
**Relative growth rate**

Different levels of irrigation had significant effect on relative growth rate of teak seedlings

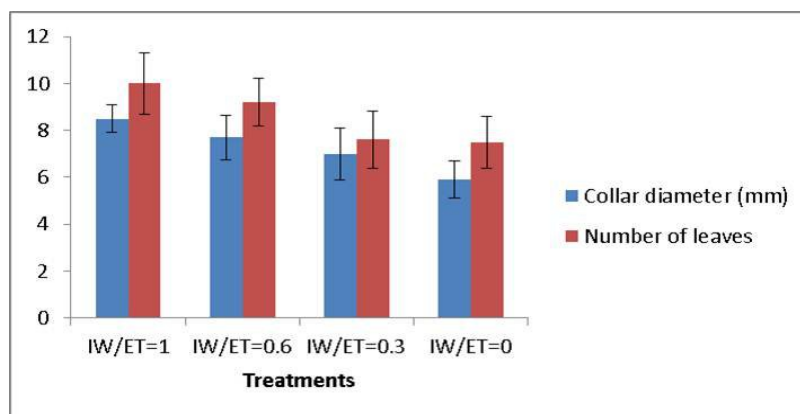
(Figure 5). It was more in well watered treatments (irrigation at IW/ET=1 and 0.6). For seedlings with irrigation at IW/ET=0.3 RGR was lower than well watered treatments. Non-watered IW/ET=0 seedlings showed minimum increase in growth.



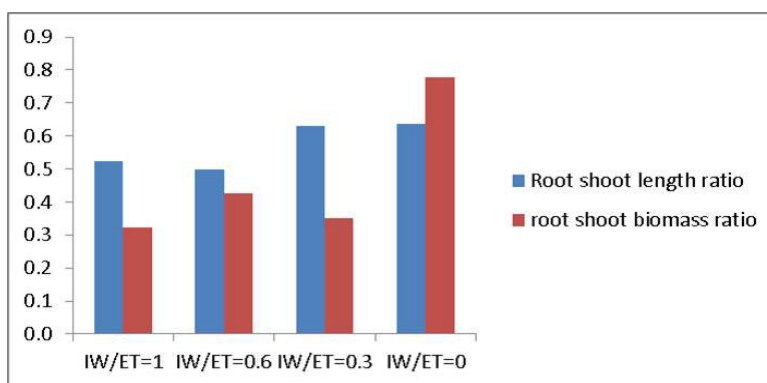
**Figure 1.** Relative chlorophyll content (SPAD unit) in teak seedlings under different irrigation regimes



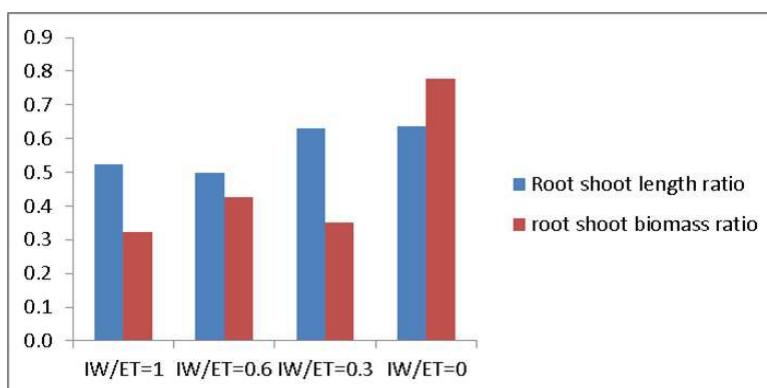
**Figure 2.** Height of teak seedlings under different irrigation regimes



**Figure 3.** Collar diameter and number of leaves of teak seedlings under different irrigation regimes



**Figure 4.** Root shoot length and biomass ratio of teak seedlings under different irrigation regimes



**Figure 5.** Relative growth rate of teak seedlings under different irrigation regimes

## CONCLUSION

These results suggest that water stress cause reduction in growth and affect physiological parameters in teak. Irrigation at IW/ET=0.3 at weekly interval is not enough to meet the water requirement of seedlings whereas irrigation at the rate of IW/ET=0.6 is sufficient. It was also concluded that there is no added advantage if we provide irrigation at the rate of IW/ET=1.

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