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BRIEF COMMUNICATION

Effect of water stress on photosynthesis and growth in two teak phenotypes

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Abstract

Two teak (*Tectona grandis* L.f.) phenotypes differing in their leaf length/breadth ratios were subjected to water stress by withholding water supply for three weeks. Growth rates of whole plants, developing leaves (1st and 2nd from shoot apices), and 2nd and 3rd internodes were higher in broad leaved (BL) phenotype than in narrow leaved (NL) phenotype before and after imposing water stress treatment. However, the effect of water stress on these parameters was higher in the BL phenotype than in the NL one. Diurnal course of net photosynthetic rate (P_N) of 3rd or 4th leaves from shoot apices measured under well-watered conditions was higher for the NL than BL phenotype. P_N, stomatal conductance (g_s), and transpiration rate (E) in both phenotypes were negatively affected by water stress and their decline under water stress was significantly higher in the BL than NL plants.

Additional key words: leaf growth; net photosynthetic rate; stomatal conductance; *Tectona grandis*; transpiration rate.

Photosynthesis and growth of many crop and tree species (Rajendrudu and Naidu 1998) are affected by water stress. Genetic differences in response of P_N and growth to water stress have been demonstrated for most crop species, but are scanty for tropical forest tree species. This is why we investigated genetic differences in photosynthetic potential and growth responses to water stress between two newly identified teak phenotypes differing in their leaf length/breadth ratios.

Three-month-old teak seedlings grown from stumps in polyethylene bags were obtained from forest nursery of Tirumala Tirupati Devasthanams, Tirupati, India. The experimental plot (60×15 m) was located at 15 km from the University campus

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(latitude 13°33'N, longitude 70°28'E). Plants were watered regularly once in 2-3 d, and fertilized bimonthly with 50 g per plant of N-P-K commercial fertilizer. During the experiment, day temperatures ranged from 32 to 43 °C and night temperatures from 19 to 27 °C, daily maximum and minimum atmospheric relative humidities from 63 to 76 % and from 31 to 42 %, respectively. Plants grew under natural irradiance [maximum was about 1500 μmol(quantum) m^{-2} s^{-1} at the top of canopy on a clear sunny day]. Plants grown upto 5 months in the middle of the experimental plot (of about 1.5-2.0 m height and with 10-12 pairs of leaves) were subjected to water stress by withholding watering for three weeks.

Measurements of plant height from 0.25 m above the soil surface to shoot apices, of leaf (1st and 2nd developing leaves from shoot apices) growth in length, and of length of 2nd and 3rd internodes from shoot apices were made during a week before imposing water stress treatment and during the 2nd week after withholding regular watering. Diurnal course of P_N was measured in control and water stressed plants. Earlier studies showed that P_N of teak was low in immature leaves, increased basipetally on shoot, and peaked in leaves (3rd and 4th from shoot apices) which had recently reached full expansion; thereafter P_N declined in lower crown leaves (Rajendrudu and Naidu 1997). Therefore, we measured P_N in 3rd and 4th leaves from shoot apices. A portable open gas exchange measuring system (model *LCA-3, ADC,* Hoddesdon, England) was used for P_N and water vapour exchange in attached leaves of teak under field conditions. Photosynthetic leaf chamber model *PLC-3(B)* (*ADC*) was clipped on to the selected attached leaf which was exposed to full natural solar irradiance [1100-1300 μmol(quantum) m^{-2} s^{-1}]. Atmospheric air containing concentrations of CO_2 of 345 cm^3 m^{-3} and of O_2 (21 %) was allowed to pass through photosynthetic chamber at a rate of 5 cm^3 s^{-1} without changing its relative humidity. Measurements were repeated at least on three different plants for each phenotype, both before and after imposing water stress to plants.

Table 1. Effect of water stress on the growth rate of leaf (1st or 2nd from shoot apices) [cm d^{-1}], length of 2nd and 3rd internodes [cm], and whole plant growth in height [cm d^{-1}] of broad-leaved (BL) and narrow-leaved (NL) phenotypes of teak. Measurements were made during a week before withholding regular watering (control) and during 2nd week after withholding watering to plants (water stress). Values are means ± S.D. of at least three measurements made on different plants.

Phenotype	Treatment	Leaf growth	Internodal length	Plant growth
BL	control	4.5 ± 0.22	17.5 ± 2.12	2.66 ± 0.21
	water stress	1.8 ± 0.30	9.2 ± 1.83	1.37 ± 0.25
NL	control	4.1 ± 0.36	11.3 ± 1.35	1.52 ± 0.20
	water stress	2.3 ± 0.15	7.8 ± 1.06	1.03 ± 0.19

Leaf length/breadth ratios calculated for individual leaves in each phenotype were similar irrespective of their age and position on the stem: they were between 1.25 and 1.37 for BL plants and between 1.52 and 1.69 for NL plants. This indicates inherent differences between the genotypes.

The growth rates of plants in height, of developing 1st and 2nd leaves from shoot apices, and of the 2nd and 3rd internode were higher for BL plants than for the NL ones both before and after imposing water stress (Table 1). The decline in growth by water stress was 60 % for leaves, 47 % for internodes, and 49 % for stem in BL plants while it was 44, 40, and 38 %, respectively, for NL plants (Table 1).

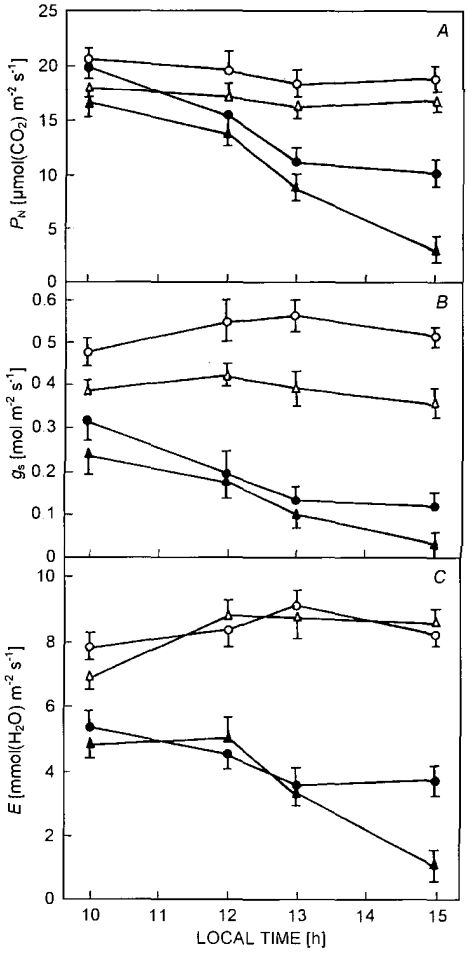

Fig. 1. The net photosynthetic CO_2 exchange, P_N (*A*), stomatal conductance, g_s (*B*), and transpiration rate, E (*C*) of 3rd or 4th leaves from shoot apices on 5-6 month-old selected broad (Δ, ▲) and narrow (○, ●) leaved phenotypes of field grown teak subjected to regular watering (Δ, ○) and water stress (▲, ●). Values represent means ± S.D of at least three replicated measurements made on different plants and at natural climatic conditions.

Diurnal course of P_N of 3rd or 4th leaves (from shoot apices) measured under well watered conditions was nearly the same for both phenotypes (Fig. 1*A*), but P_N of the NL plants was consistently higher than that of BL plants at all times of measurement

during the day. Although the effect of water stress on diurnal course of P_N was evident in both phenotypes, the decline in P_N was larger in the afternoon and was significantly higher for BL plants than for the NL ones (Fig. 1*A*). Similar to P_N, g_s and E also decreased more in the BL phenotype than in the NL one (Fig. 1*B,C*).

The greater relative decline in growth and P_N of the BL phenotype under water stress suggests a larger sensitivity to drought by these plants.

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