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Soil salinity and water status affect growth of seedlings of *Butea monosperma*

P.J. RAMOLIYA, H.M. PATEL, N.K. THAKARAR & A.N. PANDEY*

Department of Biosciences, Saurashtra University, Rajkot 360005, India

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There are evidences that high concentrations of salts have detrimental effects on plant growth (Garg & Gupta 1997) and excessive concentrations kill growing plants (Donahue *et al.* 1983). However, plant species differ in their sensitivity or tolerance to salts (Brady & Weil 1996). It is reported that soil salinity causes greater reduction in shoot growth than in root growth (Ramoliya & Pandey 2003). Further, considering frequent droughts in dry regions, responses of roots and shoots of plants to soil salinity should be understood both under wet and dry soil conditions. *Butea monosperma* (Lam.) Taub. grows naturally by seed germination and is one of the dominant tree species in the vast area of Kutch (northern saline desert) of Gujarat state in India. However, the potential of this tree species to grow and survive in saline desert of Kutch is not known. The present investigation was carried out to understand the adaptive features of *B. monosperma* which allow it to grow and survive in saline and arid regions.

The present study was carried out at Naliya (23° 28′ N, 68° 80′ E) in Kutch. For the emergence and growth of seedlings the top 10 cm layer of soil was collected from a nearby field, air dried and passed through a 2 mm mesh screen. The soil is non-calcareous sandy loam containing 70.1% sand, 13.7% silt and 16.2% clay. The available soil-water between wilting coefficient and field capacity ranged from 7.6% to 22.4%, respectively. The total organic carbon content was 0.6%, pH 8.1. Electrical conductivity 4.1 dSm^{-1}, soil nitrogen 0.07% and phosphorus 0.01%. Annual rainfall is about 395 mm at Naliya. During the rainy season.

A mixture of NaCl, KCl, $CaCl_2$, $MgCl_2$, Na_2SO_4, K_2SO_4, $CaSO_4$ and $MgSO_4$ in a proportion of 3:3:1:1:1:1:1, was thoroughly mixed with soil to give electrical conductivities of 5.1, 6.2, 8.5 and 10.2 dSm^{-1} (control 4.1 dSm^{-1}). Five polyethylene bags for each level of soil salinity were each filled with 2 kg soil. Tap water was added to soils to the field capacity. After 6 days ten seeds were sown in each bag at a depth of about 8-12 mm on 24 June 2000. Bags were kept inside a wire-net cage of 10 x 10 m area which had its top covered by a thick and transparent plastic sheet. Immediately after sowing, soils were watered and thereafter watering was carried out on alternate days. Emergence of seedlings was recorded every day, over a period of 40 days. A linear model was fitted to cumulative proportion of seed germination and increasing soil salinity using the expression: $\sin^{-1}\sqrt{P} = \beta_o + \beta_1 X$ where, $\sin^{-1}\sqrt{P}$ is cumulative proportion of seed germination, X is soil salinity and β_o and β_1 are constants.

Soil of each concentration of salt was filled in 40 open-bottomed cylinders (10 cm diameter x 10 cm depth, PVC pipe) and bulk density was maintained at 1 g cm^{-3}. Tap water was added to soils up to field capacity. Seedlings of *B. monosperma* were planted. The bottom of each cylinder was fixed with a wire-net so that roots can easily pass through. About 95%, 81%, 65% 42% and 20% seed-

* *Corresponding Author:* e-mail: anpandey2001@yahoo.com; anpandey2001@rediffmail.com; Tel. (R) 0091-281-2572833, (O) 0091-281-2586419; Fax: 0091-281-2576347.

lings survived at 4.1, 5.1, 6.2, 8.5 and 10.2 dSm^{-1} salinity, respectively.

Thirty four seedlings in each soil salinity treatment were selected for two water treatments. Each cylinder on 14 July 2000 was placed on top of an identical cylinder filled with soil at similar concentration of salt and maintained at either field capacity (22.4% water: dry weight) or at 10% water content. The junction of upper and lower cylinders was sealed with waterproof adhesive tape. The soil surface in the upper cylinder was covered with an aluminum foil to prevent evaporation loss and both the cylinders together were wrapped with polyethylene sheet. Seventeen replicates for each of the two water treatments, factorialized with 4 grades of soil (4.1, 5.1, 6.2 and 8.5 dSm^{-1}) were prepared. This gave a total of 136 cylinders, which were arranged in 17 randomized blocks. Data were analyzed by two-way ANOVA. Salt concentration at which dry weight of leaf, stem, upper root and lower root components of seedlings was reduced to 50% (DW_{50}) was determined by fitting a straight line relationship between the response and salt concentration.

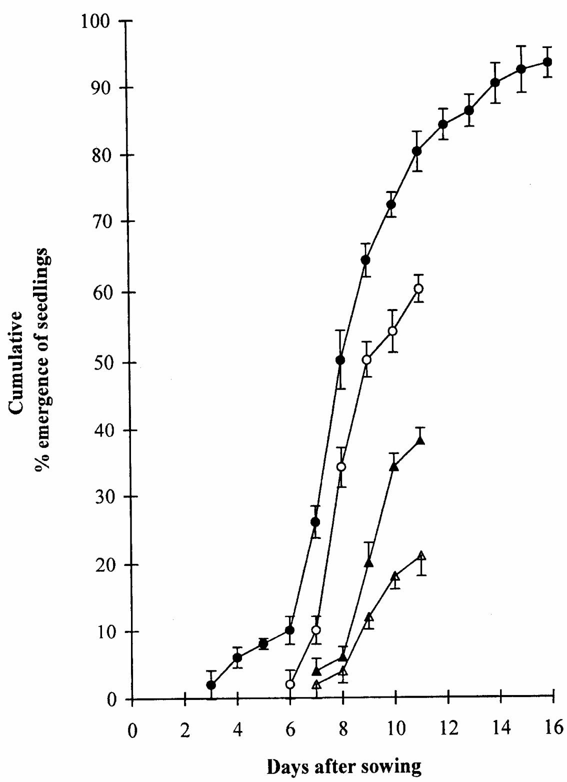

Fig. 1. Cumulative emergence of seedlings of *Butea monosperma* in response to soil salinity. 4.1 dSm^{-1} (•), 5.1 dSm^{-1} (O), 6.2 dSm^{-1} (▲), 8.5 dSm^{-1} (Δ).

Additional seedlings grown on soils with 4.1 and 8.5 dSm^{-1} conductivity and under field capacity treatment were used to determine certain physiological attributes. Fifteen days before the termination of the experiment water loss during 24 h through transpiration was determined following Ramoliya & Pandey (2003). Relative water content (RWC) of leaves was determined following Barrs & Weatherley (1962). For the stomatal study, a collidion solution was applied to the upper and lower leaf surfaces at mid day and then the dry films were removed and the stomatal number and size of the stomatal aperture were determined under the microscope.

Seedlings began to emerge 2 days after sowing and 93% seed germination was obtained over a period of 16 days under control (4.1 dSm^{-1}) salinity conditions (Fig. 1). There was a significant reduction in germination of seeds ($P<0.01$) with increasing salt stress. A negative relationship between percentage seed germination and concentration of salt was obtained according to the following expression: $Y = 109.3 - 10.2X$, ($R^2_{Adj} = 0.85$, $P<0.01$), where, Y is $arcsine^{-1}$ (degrees) of proportion of cumulative seed germination and X is salt concentration. Salinity induces changes in the activities of many enzymes (Dubey & Rani 1990) in germinating seeds.

The low water treatment significantly reduced ($P<0.01$) shoot height, leaf area and root length of seedlings (Table 1). Increasing concentration of salt in soil also retarded ($P<0.01$) elongation of stem and root of seedlings. However, the effect of salt was more pronounced under low water treatment. There was a negative linear relationship ($P<0.01$) between shoot height and increasing salt concentration and also between root length and salt concentration under both moist and low water treatments (Table 1). Seedlings began to wilt when soil with 8.5 dSm^{-1} conductivity in the upper cylinders above the dry subsoil dried to 6.7%, below the permanent wilting percentage (values for residual soil moisture are not shown). Tap roots contain milky juice which may create an osmotic gradient and roots of *B. monosperma* can extract water from highly dry saline soil. Leaf expansion was significantly reduced ($P<0.01$) by increasing concentration of salt under both moist and low water treat-

ments. A negative relationship was obtained between leaf area and salt concentration ($P<0.01$) under moist and low water treatments. Greater decrease of moisture in soils contained in upper cylinders than that under moist treatment suggests that root extension into the dry subsoil depended on the moisture content in the upper cylinders. Rapid root extension ensures the existence of plants in dry habitats (Etherington 1987).

Dry weight significantly decreased ($P<0.01$) for leaf, stem, shoot, upper root, lower root and total root of seedlings in response to low water treatment and increasing concentration of salt (Table 1). A negative relation was obtained between dry weight of different tissues (leaf, stem, shoot, upper root, lower root and total root) and salt concentration ($P<0.01$) under both moist and low water treatments. Percentage relative weight of tissues of salinized plants compared to control plants were computed as (salinized tissues dry weight/control dry weight) x 100. Values of percentage relative weight varied from 93.6 to 85.2 for young (lower) roots, from 92.1 to 84.8 for stem, from 91.0 to 77.2 for old (upper) roots and 89.2 to 72.9 for leaf under moist treatment in respect to increasing soil salinity from 5.1 to 8.5 dSm^{-1}. As has been estimated using regression equations given in results, the salt concentration in moist soil at which dry weight will be reduced to 50% of those of control plants (DW_{50}) were around 12.2, 18.6, 13.8 and 18.8 for leaf, stem, old (upper) root and young (lower) root tissues, respectively.

Results for dry weight and relative weight of tissues suggest that young (lower) roots and stem exhibited least decline in dry weight and were most resistant to increasing salt stress. Young roots and stems were successively followed by old (upper) roots and leaves in the order of salt resistance. The most sensitive leaf tissue, resistant young root and stem tissues suggest that *B. monosperma* has mechanism of salt exclusion by root tissues to prevent upward movement of ions from soil solution to leaves. Results indicating low tolerance for salinity (8.5 dSm^{-1}) and reduction in growth of leaf, stem and root tissues of *B. monosperma* with increasing salt stress suggest that this tree species is salt excluder.

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