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# EFFECT OF SALINE WATER IRRIGATION ON GROWTH AND WATER POTENTIAL OF *THESPESIA POPULNEA* (L.) SOL.EX CORREA

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## ABSTRACT

*Thespesia populnea* is a coastal salt tolerant plant in tropical countries. Salinity tolerance was examined in *T. populnea* irrigated with saline water. Seeds of *T. populnea* were sown in lysimeter under non saline conditions. Seedlings in each lysimeter were subjected to saline water irrigation at the age of 20 days. Three lysimeters each were irrigated with non-saline water (control, $EC_{iw}$: 0.4 $dS.m^{-1}$) and saline water prepared by dissolving different concentrations of sea salt, 0.5% ($EC_{iw}$: 6.2 $dS.m^{-1}$), 1.0% ($EC_{iw}$ 12.95 $dS.m^{-1}$), 1.5% ($EC_{iw}$: 18.9 $dS.m^{-1}$) and 2.0% ($EC_{iw}$: 24.76 $dS.m^{-1}$). Vegetative growth was recorded in terms of plant height, number of leaves, fresh and dry biomass per plant. Water potential was recorded in plants grown at different level of sea salt concentrations. Experimental data shows a reduction in vegetative growth proportional to salinity of irrigation. Water potential of plants decreased all the way with the increase in salinity of irrigation water. An increase was observed in total sugar with increase in salinity of irrigation medium. Concentration of $Na^+$ was increased in different plant parts with increasing salinity. The $K^+$ concentration was not much effected at different salinity levels. In spite of proportional reduction in growth of plants under increasing salinity levels the biomass could still provide some vegetative cover over barren saline land to improve environment.

**Key-words:** Saline water, vegetative growth, *Thespesia populnea*, Na/K ions, biomass.

## INTRODUCTION

*Thespesia populnea* is a coastal and moderately to highly salt tolerant plant in tropical countries. This species colonizes saline soils. *T. populnea* occurs in association with mangrove species (Satyanarayana *et al.,* 2002). This tree is reported capable of growing under sea water irrigation and regarded equivalent to mangrove (Aronson, 1989). Sun *et al.* (2004) reported that milo (*T. populnea*), can tolerate high salinity (up to 2.0%) and is also tolerant to 10g diesel/ Kg of soil alone or in combination with 1% salt. *T. populnea* can be grown for the improvement of saline soil (Bamrungruk and Yuanlae, 1990). *T. populnea* is a valuable fast growing plant and lopped for grazing. Young leavers and flower buds are edible. Leaves are good source of protein, calcium, and phosphorus. It is also used for various medicinal and industrial purposes (Chopra *et. al.,* 1956; Varier, 1997). The seeds of this plant are known to contain oil but not used on commercial scale.

Growth under saline condition is inhibited due to osmotic as well as ionic effects. Salinity causes reduced availability of water to the plants and results in decrease in leaf water potential of the plant. The decrease in water potential results in reduced growth rate (Yeo *et al.,* 1991). Plants vary widely in their tolerance to salinity. Plants maintain growth under saline condition through processes such as ion transport and their compartmentalization or synthesis of organic solutes and their accumulation (Story and Wyn Jones, 1975; Serrano and Gaxiola, 1994).

Increasing demand for plant products make it important to introduce new plant species capable of growing on marginal land and water resources and give economical returns. The vegetative growth performance of *T. populnea* under saline water irrigation has been studied up to one year in drum pot culture.

## MATERIALS AND METHODS

**Growth conditions**: Drum pot culture as designed by Boyko (1966) and further modified by Ahmad and Abdullah (1982) was used for this experiment. A set of 15 plastic drums installed at cemented platform in a slightly slanting position, having a basal outlet for draining the excess amount of water. They were filled with 300 Kg of coastal sand each. Additional amount of water was easily leached out from the drainage outlet. The practice of over irrigation avoided salt accumulation in the rhizosphere. Seedlings were raised in lysimeter under non saline conditions, those with equal height and number of leaves were selected and saline water irrigation was started at the age of 20 days.

This practice could avoid adverse effect of salinity during seed germination and would be equivalent of transplantation of healthy seedlings at saline substrate. Concentration of sea salt was gradually increased in irrigation water till it reached to the desired salinity of each treatment. Each drum was irrigated with 10-15 liter of tap water/salt solution at various intervals. Irrigation water of different sea salt concentrations was used to develop various salinity levels of rooting medium.

**Plant growth:** Plant height, stem thickness and number of leaves were recorded every month. Water potential of the plants was determined at grand period of growth. Fresh and dry biomass was recorded at harvest after the end of experiment.

**Water potential:** Leaf water potential of *T. populnea* was determined with the pressure chamber ARIMAD2 using compressed air. Upper part of the third twig containing four to five leaves were taken between 12.00 – 13.00 hours and kept them covered in a wet cloth. Water potential was recorded one day before irrigation and next day after irrigation in each treatment under different irrigation intervals.

**Sugar content:** Leaf samples were collected at grand period of growth for estimation of total sugars. Carbohydrate was estimated in the fully expanded $4^{th}$, $5^{th}$, and $6^{th}$ leaves, taken from the plant undergoing various irrigations at grand period of growth as described by Yemm and Willis (1956).

**Inorganic solutes:** Analysis of $Na^+$ and $K^+$ was performed in different parts of the plants harvested at grand period of growth. Leaf, stem and root of plants undergoing various treatments were dried in hot air cabinet and 0.5g of dry sample was taken in china crucible and placed in oven for making ash. Solution of ash was made in 50 ml of de-ionized water. Concentration of $Na^+$ and $K^+$ was determined in samples using flame emission spectrophotometer (Model Coleman SI-Ca; Perkin-Elmer, Oak Brook, III., USA).

**Statistical Analyses:** Data sets were subjected to analysis of variance (ANOVA).The follow up of (ANOVA) include least significant difference (LSD) as out lined by Gomes and Gomes (1976) and Duncan's Multiple Range Test (DMRT) was also used to compare the treatment means (Duncan, 1995).

## RESULTS

**Growth of *Thespesia populnea*:** Plant height and stem diameter decreased in response to increasing salinity in irrigation water in comparison with control (Fig. 1 and 2).

First peak of relative growth rate of *T. populnea* was noticed during May and June in all plants irrespective of salinity of irrigation water. Next peak of relatively higher RGR, (though less than $1^{st}$ one) occurred during October. Growth in terms of stem diameter more or less followed the same trend as plant height (Fig. 2).

Number of leaves per plant in general increased with increase in age. However a significant decrease proportionate to increasing salinity was evident (Fig. 3).

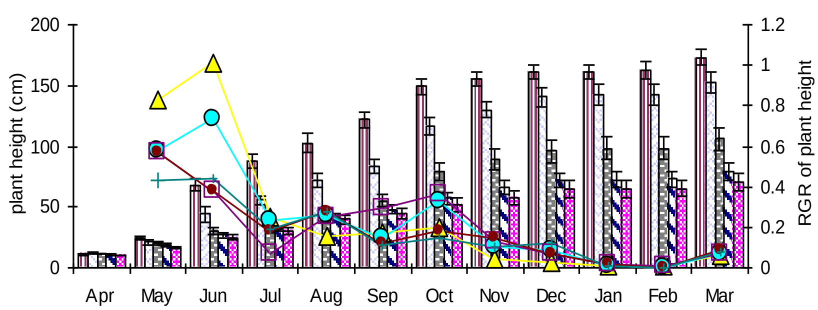


Fig. 1. Effect of saline water irrigation interval on height and RGR values of *Thespesia populnea*

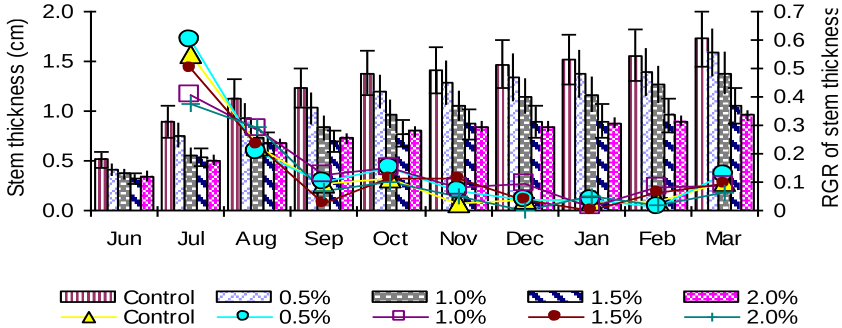


Fig. 2. Effect of saline water irrigation on stem thickness and RGR value of *Thespesia populnea*

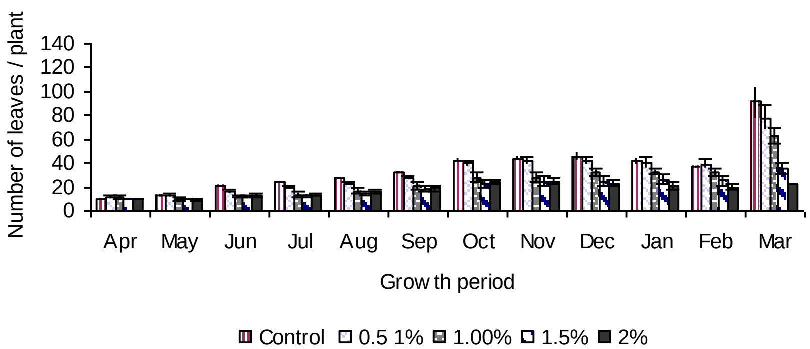


Fig. 3. Effect of saline water irrigation on number of leaves of *Thespesia populnea*

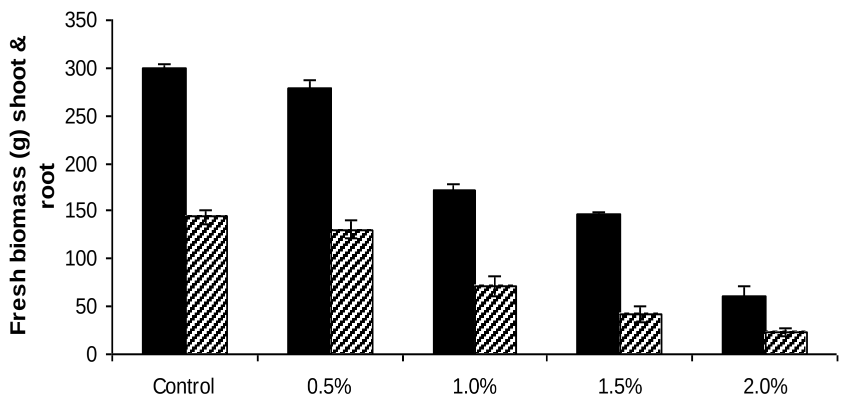


Fig. 4. Effect of saline water irrigation on fresh biomass of one year old *Thespesia populnea* plant

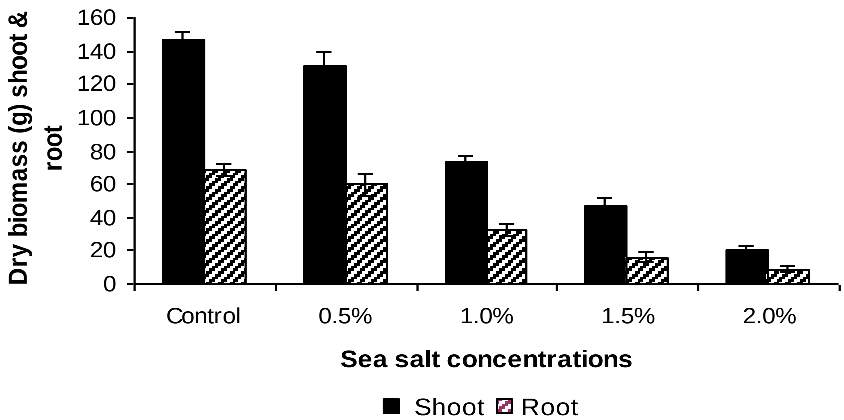


Fig. 5. Effect of saline water irrigation on dry biomass of one year old *Thespesia populnea* plant.

**Sea salt concentrations:** Fresh shoot and root biomass of plants decreased gradually in response to increasing salinity (Fig. 4). Dry biomass of shoot and root of plants followed almost the same trend as that of their fresh biomass (Fig. 5).

**Leaf water potential:** Leaf water potential (-MPa) determined by pressure bomb in one year old plant irrigated with various sea salt dilutions prior to irrigation and next day after the irrigation is presented in (Tables 1). The determination of water potential prior to irrigation at different irrigation intervals was done to observe this value in plants which have under gone two non irrigated days. The next value of water potential was taken second day after irrigation to observe effect of re-watering with different sea salt solutions at this parameter. Moisture content of leaves and soil was also noticed in terms of percentage at the time of determining water potential prior and after irrigation (Table 1). The values of water potential were more negative prior to irrigation than after the irrigation, which is well co-related with depletion of moisture content in leaves and soil prior to irrigation and increase in these values after the irrigation. There is definite increase of water potential with reference to increase in salinity of irrigation. The water content of the saline soil was more than control due to its retention by salts present in the soil matrix. Since the leaves developed thickness during the course of growth under saline water irrigation, their water content was found more than that of control (non saline) plants. Slight reduction in percentage of water at 0.5% ($EC_{IW}$: 6.2 $dS.m^{-1}$) and 1.0% ($EC_{IW}$: 12.96 $dS.m^{-1}$) level of sea salt irrigation is insignificant exception from the general trend.

Table 1. Leaf water potential of *Thespesia populnea* growing under different sea salt concentrations before and after irrigation

| Treatment | Water Potential (-MPa) | | Leaf moisture content percentage | | Soil moisture percentage | |
|---|---|---|---|---|---|---|
| | Before irrigation | After irrigation | Before irrigation | After irrigation | Before irrigation | After irrigation |
| Control ($EC_{iw}$: 0.4 $dS.m^{-1}$) | 2.0±0.1 | 1.2±0.06 | 60.5±1.1 | 67.7±0.8 | 5.6±0.3 | 8.4±0.4 |
| 0.5% (SS) ($EC_{iw}$: 6.2 $dS.m^{-1}$) | 2.2±0.2 | 1.7±0.07 | 61.1±1.0 | 72.0±0.4 | 8.8±0.6 | 12.1±0.3 |
| 1.0% (SS) ($EC_{iw}$: 12.95 $dS.m^{-1}$) | 2.8±0.1 | 2.1±0.07 | 67.0±1.5 | 72.0±0. | 9.5±0.5 | 12.3±0.38 |
| 1.5% (SS) ($EC_{iw}$: 18.9 $dS.m^{-1}$) | 3.0±0.3 | 2.6±0.10 | 68.0±1.5 | 73.4±0.4 | 10.2±0.4 | 11.1±0.37 |

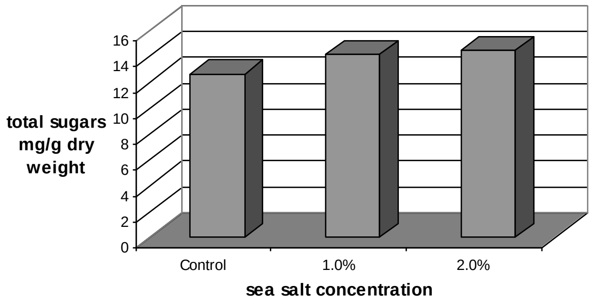


Fig. 6. Concentration of total sugars in *Thespesia populnea* irrigated with different concentrations of sea salt.

**Sugar content:** Total sugars increased with increase in salinity of irrigation medium (Fig. 6).

**Mineral content:** Concentration of $Na^+$ increased in stem, root and leaves with increase in salinity of irrigation water (Table 2). Concentration of $K^+$ remained more or less equal to that of control in leaves under various salinity levels in the plants (Table 2). $K^+$ concentration decreased in stem and root under saline condition.

Table 2. Concentration of $Na^+$ and $K^+$ in plant parts irrigated with various sea salt concentrations

| | Leaf | | Stem | | Root | |
|---|---|---|---|---|---|---|
| | $Na^+$ meq/L | $K^+$ | $Na^+$ meq/L | $K^+$ | $Na^+$ meq/L | $K^+$ |
| Control<br>($EC_{iw}$: 0.4 $dS.m^{-1}$) | 4.19 a<br>±0.13 | 5.52 a<br>±1.0 | 0.99 a<br>±0.17 | 3.43 a<br>±0.10 | 1.42 a<br>±0.16 | 3.26 a<br>±0.17 |
| 1.0% (SS)<br>($EC_{iw}$: 12.95 $dS.m^{-1}$) | 8.49 b<br>±0.62<br>(+102.7) | 4.77 a<br>±0.04<br>(-13.5) | 2.38 a<br>±0.60<br>(+141.2) | 3.26 a<br>±0.80<br>(-4.7) | 3.26 b<br>±0.45<br>(+129.6) | 3.20 a<br>± 0.46<br>(-2.11) |
| 2.0% (SS)<br>($EC_{iw}$: 24.76 $dS.m^{-1}$) | 16.46 c<br>±1.44<br>(+293.1) | 5.49 a<br>±0.95<br>(-0.41) | 2.83 a<br>±0.54<br>(+186.7) | 2.84 a<br>±0.15<br>(-17.11) | 2.48 b<br>±0.06<br>(+74.5) | 2.83 a<br>±0.50<br>(-13.8) |

Figures in parentheses indicate % promotion (+) and reduction (-) over control.

## DISCUSSION

Investigation for growth of *T. populnea* in drum pot culture revealed reduction in plant height and stem diameter under saline water irrigation. Reduced plant growth under saline condition has been reported in *Tamarix* species (Dawalibi *et al*., 2015). Reduction in plant height, stem diameter, number of leaves and biomass has been noticed in *Dalbergia sissoo* and *Eucalyptus camaldulensis* (Rawat and Banerjee, 1998), and height, stem diameter and number of leaves in *Argania spinosa*, under saline condition (Tazi *et al*., 2018).

Relative growth rate of *T. populnea* was high from May to July (early seedling growth) after this period it generally decreased. The change of RGR with increase in age depends on growth form. Galmes *et al*. (2005) showed that highest increase occurred between early 2-3 months of growth in different plant species and change in RGR with increase in age depending upon different growth forms. Decrease in RGR and lower value of water potential has been reported in salt treated plants of *Asteriscus maritimus* (Rodriguez *et al*., 2005), in *Acacia nilotica* and *A. tortilis* (Mehari *et al*., 2005). Reduction in RGR under saline condition was attributed to decrease in net assimilation rate and specific leaf area ratio in *Artemisia stelleria* (Ishikawa and Kachi, 2000).

There appears decrease in number of leaves in present investigation with the increase of sea salt concentration in irrigation water. Reduction in number of leaves under saline condition has also been observed by others (Sun and Dickinson, 1995). Reduction in dry matter and leaf production due to salinity has been reported by (Flanangan and Jefferies, 1988) as well.

Biomass production in *T. populnea* in present investigation showed a gradual proportionate decrease under various salinity regimes with increasing salinity. Decrease in biomass under saline condition has also been reported in *Acacia nilotica* and *Dalbergia sissoo* (Minhas *et al.*, 1997), *Plantago cressifolia* (Vicente *et al.*, 2004), *Prosopis juliflora* (Khan *et al*., 1987; *Prosopis argentina* and *P. alpataco (*Villagra and Cavagnaro, 2005) and *Salvadora Persica* (Alshammary, 2008). Reduction in dry weight production of shoot and roots was assigned to less number of leaf, production and development of smaller leaves under saline condition (Flanagan and Jefferies, 1988).

Water potential of *T. populnea* decreased with increase in the salinity. Decrease in water potential with increasing salinity has been reported in *Spartina maritime, S. densiflora* **-** $C_3$ plants and *Arthrocnemum perenne* and *A. fruticosum* - $C_4$ plants (Nieva *et al*., 1999), *Suaeda fructicosa* (Khan, *et al*., 2000), *Plantago coronopus* (Koyro, 2006), *Prosopis Argentina* and *P. alptaco* (Villagra and Cavagnaro, 2005), *Pistacia lentiscus L.* accessions (Cristiano *et al*., 2016)

The situation of leaf water potential in *T. populnea* as presented before and next day after irrigation show release in pressure after irrigation which is accompanied with increase in moisture content both in leaves and soil. However, the pressure shows the gradual increase with increase in salinity of irrigation water.

The amount of total sugars increased with increase in sea salt concentration in the plants. Increase in amount of total sugars due to salinity has also been reported in *Atriplex halimus* (Nedjimi and Daoud, 2006) and in barley (Khosravinejad *et al*., 2009). Many compatible solutes are synthesized which can accumulate in the cells without disturbing the protein function and decrease osmotic potential and maintain water potential gradient and maintain cell turgor (Bray, 1997). Accumulation of soluble sugars as contributor to osmotic adjustment has been reported in response to salinity and water stress (Hassine and Luttus, 2010).

Although with increasing salinity the concentration of $Na^+$ was increased and the concentration of $K^+$ decreased but it still remained higher than the concentration of $Na^+$, showing a greater selectivity for $K^+$ uptake than $Na^+$ in the roots of the *T. populnea* plants. With increase in salinity *T. populnea* plants showed greater accumulation of $Na^+$ in leaves as compared to $K^+$ and resulted in decrease of $K^+/Na^+$ ratio in leaves. Plant growth under saline condition is maintained by the ion transport, and their compartmentalization, synthesis and accumulation of organic solutes (Viegas *et al.*, 2001). More accumulation of $Na^+$ in shoot as compared to roots and decrease in $K^+$ concentration in salt stressed *Crithmum maritimum* has also been reported by Ben Amor *et al.* (2005). Silveira *et al.* (2009) showed the similar pattern of ion accumulation in roots and leaves of *Atriplex nummularia* under saline condition as in *T. populnea* and indicated that $Na^+$ and $Cl^-$ mainly contributed in osmotic adjustment in leave where as $K^+$ mainly accounted for root osmolality in salt untreated plant which decreased at highest salinity level. The accumulation of ion such as $Na^+$ and $Cl^-$, in different parts provides the plants energetically a cheaper way for osmotic adjustment to low water potential in the soil rather than the synthesis of organic solutes under saline condition (Cramer, 1987).

The biochemical changes occurring under salt and water stress condition indicated that plants could adjust osmotically and become capable of surviving up to 2.0% ($EC_{iw}$: 24.76 $dS.m^{-1}$) salinity level. However, economically permissible growth of this plant under considerably high range of salinity is well established which makes it suitable for plantation under saline environment.

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