INT. J. BIOL.BIOTECH., 15 (2): 255-262, 2018.

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

Zahida N. Gohar[1], Uzma Asghar[2], Fahmida Perveen[2], Razia Sultana[3] and Rafiq Ahmad[1]

[1]*Department of Botany, University of Karachi, Karachi- 75270, Pakistan.*
[2]*Centre for Environmental Studies, PCSIR, Laboratories Complex Karachi, Shahrah-e-Dr. Salimuzzaman Siddiqui, Karachi-75280, Pakistan.*
[3]*Applied Chemistry Research Centre, PCSIR Laboratories Complex Karachi, Shahrah-e-Dr. Salimuzzaman Siddiqui, Karachi-75280, Pakistan.*

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).

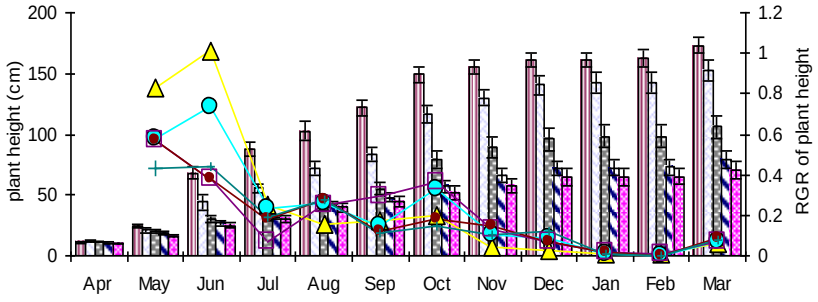

Fig. 1. Effect of saline water irrigation interval on height and RGR values of *Thespesia populnea*

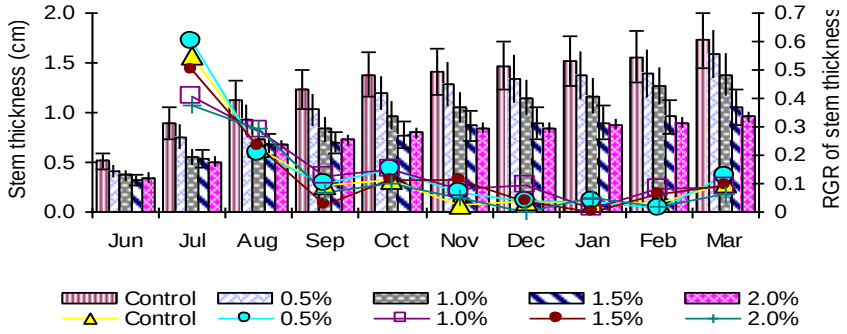

Fig. 2. Effect of saline water irrigation on stem thickness and RGR value of *Thespesia populnea*

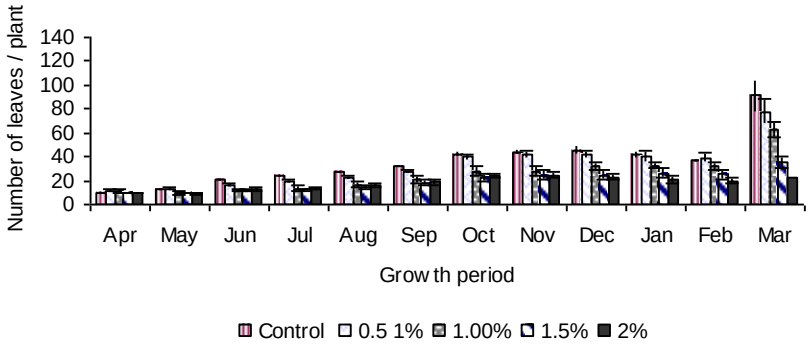

Fig. 3. Effect of saline water irrigation on number of leaves of *Thespesia populnea*

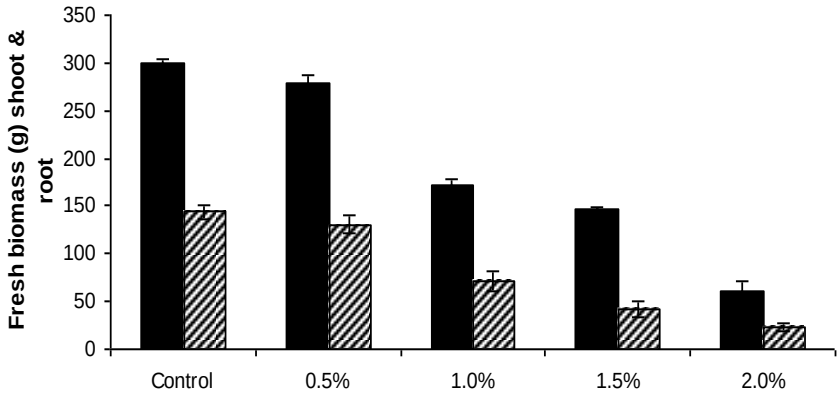

Fig. 4. Effect of saline water irrigation on fresh biomass of one year old *Thespesia populnea* plant

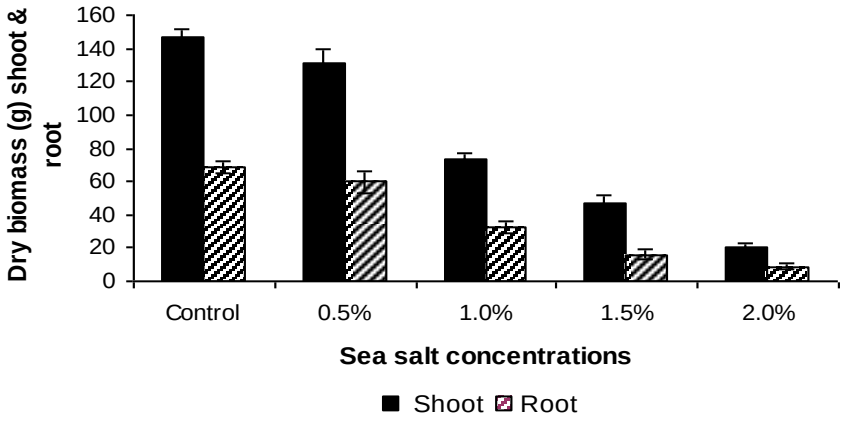

Fig. 5. Effect of saline water irrigation on dry biomass of one year old *Thespesia populnea* plant.

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

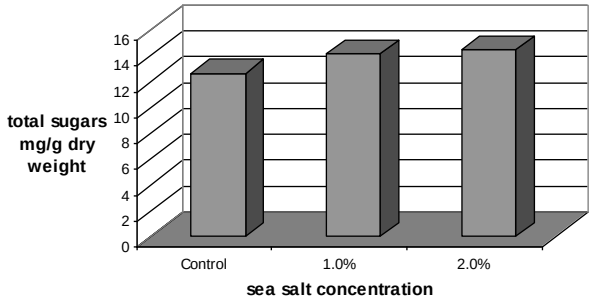

Fig. 6. Concentration of total sugars in *Thespesia populnea* irrigated with different concentrations of sea salt.

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

REFERENCES

Ahmad, R. and Z. Abdullah (1982). Biomass Production of food and fiber crops using highly saline water under desert conditions. In: *Biosaline research: A look to future* (San Pietro, A., Ed.), pp. 149-163, Pierum press, New York.

Alshammary, S.F. (2008). Effect of saline irrigation on growth characteristics and mineral composition of two local halophytes under Saudi environmental conditions. *Pakistan Journal of Biological Sciences*, 11(17): 2116-2121.

Aronson J.A. (1989). HALOPH: a data base of salt tolerant plants of the world. *Office of Arid Land Studies*. pp. 77. The University of Arizona, Tucson, Arizona.

Bamrungruk, N and P. Yuanlae (1990). Improvement of saline soil by growing and selection salinity plant in North-East of Thailand (*Casuarina equisetifolia*, *Callophyllum inophyllum*, *Thespesia populnea*, *Avicennia marina*, *Sesuvium portulacastrum*). *Journal of Science and Technology*, 5(1-3): 43-53.

Ben Amor, N., B.H. Karim, A. Dabez, C. Grignon and C. Abdelly (2005). Physiological and antioxidant responses of the Perennial halophyte *Crithmum maritimum* to salinity. *Plant Science*, 168: 889-899.

Boyko, H. (1966). *Salinity and aridity*. Dr. W. Junk Publ. The Hague.

Bray, E.A. (1997). Plant responses to water deficit. *Trends in Plant Science*, 2(2): 48-52.

Chopra R.N., S.L. Nayar and I.C. Chopra (1956). *Glossary of Indian Medicinal Plants. New Delhi.* Council of Scientific and Industrial Research. 329p.

Cristiano, G., S. Camposeo, M. Fracchiolla, G. A.Vivaldi, B. De Lucia and E. Cazzato (2016). Salinity differentialy affects growth and ecophysiology of two mastic tree (Pastacia lentiscus L.) Accessions. *Forests*, 7(8): 156. doi:10.3390/f7080156

Crammer, G.R., J. Lynch, A. Laüchli and E. Epstein (1987). Influx of Na^+, K^+ and Ca^{+2} into roots of salt stressed cotton seedlings. *Plant Physiol*., 83: 510-516.

Dawalibi, V., M.C. Monteverdi, S. Moscatello, A. Battstelli and R. Valentini (2015). Effect of salt and drought on growth, physiological and biochemical responses of two *Tamarix* species. *iForest* (early view): e1-e8 [Online 2015-03-25] URL: http://www.sisef.it/iforest/contents/?id=ifor1233-007

Duncan, D.B. (1955). A multiple range and multiple F-test. *Biometrics*. 11: 1-42.

Flanangan, L.B. and R.L. Jefferies (1988). Stomatal limitation of photosynthesis and reduced growth of the *Haloplantago maritime* L., at high salinity. *Plant, Cell and Environment*, 11: 239-245.

Glames, J., J. Cifre, H. Medrano and J. Flexas (2005) Modulation of Relative growth rate and its components by water stress in Mediterranean species with different growth forms. *Oecologia*, 145: 21-31

Gomes, K.A. and A.A. Gomes (1976). *Statistical procedures for agricultural research with emphasis on rice*. International rice research institute. Los. Famos, Phillipines. pp. 294.

Hassine, A. B. and S. Luttus (2010). Differential responses of salt bush *Atriplex halimus* L. exposed to salinity and water stress in relation to senescing hormones abscisic acid and ethylene. *Journal of Plant Physiology*, 167: 1448-1456.

Ishikawa, S and N. Kachi (2000). Differential salt tolerance of two Artimisia species growing in contrasting coastal habitats. *Ecol Res*., 15(3): 241-247.

Khan, D., R. Ahmed and S. Ismail (1987). Germination, growth and ion regulation in *Prosopis juliflora* (Swartz) DC. Under saline conditions. *Pak. J. Bot*., 19(2):131-138.

Khan, M.A., I.A. Ungar and A.M. Showalter (2000). The effect of salinity on growth, water status and ion content of a leaf succulent perennial halophyte, *Suaeda fruticosa* (L.) Forssk. *Journal of Arid Environments*, 45: 73-84.

Khosravinejad, F., R. Heydari and T. Farboodnia (2009). Effect of salinity on organic solute content in barley. *Pakistan Journal of Biological Sciences*, 12(2): 158-162.

Koyro, H.W. (2006). Effect of salinity on growth, photosynthesis, water relations and solute composition of potential cash crop halophyte *plantago coronopus* (L). *Environmental and Experimental Botany*, 56: 136-146.

Mehari, A., T. Ericsson and M. Weih (2005). Effect of NaCl on seedling growth and biomass production and water status of *Acacia nilotica* and *A. tortilis*. *Journal of Arid Environment*, 62: 343-349.

Minhas, P.S. Singh, Y.P. Tomar, O.S. Gupta and R.K. Gupta (1997). Effect of saline irrigation and its schedules on growth, biomass production and water use by *Acacia nilotica* and *Dalbergia Sissoo* in a highly calcareous soil. *Journal of Arid Environments* 36: 181-192.

Moghaieb, R.E.A., H. Saneoca and K. Fujita (2004). Effect of salinity on osmotic adjustment, glycenebetaine accumulation and the betain aldehyde dehydrogenase gene expression in two halophytic plant, *Salicornia europaea* and *Suaeda maritima*. *Plant Science*, 166: 1345-1349.

Naidoo, G. (1987). Effect of salinity and Nitrogen on growth and water relations in the mangrove, *Avicennia marina* (Forsk) Vierh. *New Physiol*., 107: 317-325.

Nedjimi, B. and Y. Daoud (2006). Effect of $NaSO_4$ on growth water relations, proline, total soluble sugars and ion content of *Atriplex halimus subsp. Schweinfurthii* through in vitro culture. *Anales de Biologia*, 28: 35-43.

Nieva, F.J.J., E.M. Castellanos, M.E. Figueroa and F. Angile (1999). Gas exchange and Chlorophyll fluorescence of C3 and C4 saltmarsh species. *Photosynthetica*, 36: 397-406.

Rawat, J.S. and S.P. Banerjee (1998). The influence of salinity on growth, biomass production and photosynthesis of *Eucalyptus camaldulensis* Dehnh. and *Dalbergia sissoo* Roxb. Seedlings. *Plant and Soil*, 205: 163-169.

Rodriguez, P.A. Torrecillas, M.A. Morales, M.F. Ortuno and M.J. Sanchez-Blanco (2005). Effect of NaCl salinity and water stress on growth and leaf water relations of *Asteriscus matimus* plants. *Environmental and Experimental Botany*, 53: 113-123.

Satyanarayana, B., A.V. Raman, F. Dehairs, C. Kalavati and P. Chandramohan (2002). Mangrove floristic and zonation patterns of Corinaga, Kakinada Bay, East coast of India. *Wetlands Ecology and Management*, 10: 25-39.

Serrano, R. and R. Gaxiola (1994). Microbial models and salt stress tolerance in plants. Crit.Rev. Viegas, R.A., *Plant Sci*., 13: 121-138.

Storey, R. and R.G. Wyn Jones (1975). Betaine and chlorine levels in plants and their relationship to NaCl stress. *Plant Sci. Lett*., 4: 161-168.

Silveira, J.A.G., S.A. M. Araujo, J.P. M.S. Lima and R.A. Viegas (2009). Roots and leaves display contrasting osmotic adjustment mechanisms in response to NaCl-salinity in *Atriplex nummularia. Environmental and Experimental Botany*, 66: 1-8.

Sun, D. and G.R. Dickinson (1995). Survival and growth responses of a number of Australian tree species planted on a saline site in tropical North Australia. *Journal of Applied Ecology*, 32: 817-826.

Sun, W.H., J.B. Lo, F.M. Robert, C. Ray and C-S. Tanang (2004). Phytoremediation of petroleum hydrocarbons in tropical coastal soils. 1. Selection of promising woody plants. *Environ Sci & Pollut Res*., 11(4): 260-266.

Tazi, M.R., A. Boukroute, A. Berrichi, Y. Rharrabti and N. Kouddane (2018). Growth of young argan tree seedlings (*Argania spinosa L.* Skeels) in northeast of morocco under controlled conditions at different NaCl concentrations. J. Mater. Environ. Sci., 9 (1): 212-218. https://doi.org/10.26872/jmes.2018.9.1.24

Varier P.S. (1997). *Indian medicinal plants: A compendium of 500 Species*. Vol. 5. Orient Longman Ltd. Madras, India.

Vicente, O., M. Boscaiu, M.A. Naranjo, E. Estrelles, J.M. Belles and P. Soriano (2004). Responses to salt stress in the halophyte *Plantago crassifolia* (Plantaginaceae). *Journal of Arid Environments*, 58: 463-481.

Viegas, R.A., J.A.G. Silveira, A.R.L. Junior, J.E. Queiroz and M.G.M. Fausto (2001). Effect of NaCl salinity on growth and inorganic solute accumulation in young cashew plants. *Braz. J. Agric. Eng*., 5: 216-222.

Villagra, P.E. and J.B. Cavagnaro (2005). Effect of salinity on the establishment and early growth of *Prosopis argentina* and *Prosopis alpataco* seedlings in two contrasting soils: Implications for their ecological success. *Austral Ecology*, 30: 325-335.

Yemm, E.W. and A.J. Willis (1956). The estimation of carbohydrate in plant extract by Anthrone. *Biochem. Jour*., 57: 508.

Yeo, A.R., K.S. Lee, P. Izard, P.J. Boursier and T.J. Flowers (1991). Short- and long-term effect of salinity on leaf growth in rice (*Oryza sativa* L.). *Journal of Experimental Botany*, 42: 881-889.

(*Accepted for publication March 2018*)