Influence of Saline Water on the Survival, Growth and Development of Chiku (Achras Zapota L.) Saplings

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Abstract
Open field pot experiment was conducted to evaluate the influence of saline water having Ec_{iw} 0, 2, 4, 8 and 12 (ds m^{-1}) on the growth and development of chiku plants at early stage. The data on growth and growth traits were noted for two times i.e. after three and six months planting. Ion (Na^+ and K^+) analysis were done using the sap extracted from youngest fully expanded leaves sampled after six months of planting. It is obvious from the data recorded after three months of planting that compared to canal water, chiku plants irrigated with 2, 4, 8 and 12 EC_{iw} water presented in plant height, number of leaves, number of branches and stem girth $plant^{-1}$ 6, 18, 19 and 26%, 25, 35, 47 and 51%, 44, 55, 55 and 66% and 15, 21, 26 and 42% decrease respectively. After six months of stressing same plants displayed 20, 29, 30 and 40%, 44, 45, 60 and 74%, 33, 50, 58 and 66% and 15, 15, 26 and 36% reduction respectively. As associated to freshwater irrigated plants, the chiku plants getting 2, 4, 8 and 12 Ec_{iw} (dS m^{-1}) water had 0, 11, 11 and 22% more Na^+ 21, 32, 37 and 51% lower K^+ in the leaf sap. Developed concentration of K^+ resulted in lower K^+/Na^+ ratio in the leaf sap. It is determined from this study that chiku (*Achras zapota* L.) is a salt-tolerant plant species particularly at initial growth stage, it can positively be grown with saline water having EC_{iw} up to 08 (dS m^{-1}).
Keywords: Saline, Chiku, Plants, Seedlings, growth and reduction

Introduction

Food demand of ever increasing population is causing serious pressure on natural resources including fresh water (Gupta 1990). This suggests that the low quality water should be exploited for crop production. Application of poor quality groundwater in crop production without knowing its adverse effect on soil and plants can be harmful. There are several reports which indicate that plants vary in tolerance to water salinity. Some plants are much more tolerant to water salinity than others (Gupta, 1990). Reports also exist on variation among the different growth stages of same species for salt tolerance. Some plant species have been reported as tolerant to salinity at later growth stages and sensitive to salinity at initial or early growth stages. Among the trees, variations for salt-tolerance have also been found in several fruit tree species, like mango (Duran *et al*., 2004), guava (Cavalcante *et al*., 2007), date palm (Alhammadi *et al*., 2012), jujube (Sohail, 2009), acacia (Craig *et al*., 1991) and chiku (Mickelbart and Marler, 1996). Chiku is an important fruit tree of the family Sapotaceae originated from Mexico and Brazil (Banderia *et al*., 2003). Cultivation of chiku in Pakistan is on very small scale mainly due to climatic conditions required by the tree. There are several reports which indicate that chiku requires humid climate with temperature even up to 44 ˚C. In Pakistan extreme humid climate exists mainly in coastal belt of Sindh and Baluchistan. Where the shortage of fresh irrigation water is major problem hence the growers are mainly using poor quality groundwater in fruit orchards, without proper knowledge and information. It has been reported by several workers (Mickelbart and Marler, 1996; Heaton *et al*., 1999) that the chiku has ability to thrive on drought and root zone salinity. However, the detailed information on the salinity tolerance of chiku seedlings in Sindh region is lacking. Therefore, in this study it was planned to irrigate chiku saplings with saline water of different EC levels. In the Sindh province the problem of freshwater availability is getting much more serious than elsewhere in the country. There seems to be several factors responsible for that. Particularly in lower Sindh, the sea water intrusion is a major cause, the situation in the coastal region is getting even worst. Due to unavailability of freshwater, especially canal water, farmers of these areas are using saline groundwater for irrigation since long.

In fact, researchers have even suggested not to use saline ground water in crop production, without having proper knowledge of plant species, that either they are salt-tolerant or sensitive in nature. Particularly at what stage they are tolerant to salinity. A plant tolerant to salinity at later stage may not with stand salinity at early stages. Furthermore, continuous application of saline water to plants increases salinity status of soil, that causes serious stress to plants in the form of osmotic and ion toxicity, it is thus important that saline water should not be continuously applied to plants for a large period of time. Understanding the adverse effects of saline water on various traits of plant species is important and would tell us either it should be applied to a particular plant or not. In addition to that comparison should also be done between fresh and saline waters. That would answer the question that is it economical to apply saline water? In recent year the Centre for Bio saline Agriculture has been working to screen out some salinity tolerant plant species under field and controlled conditions. Evaluating salinity tolerance of local fruit trees would not only be a way to increase the list of salt tolerant plant species, but it would also help the farmers to raise their income by utilizing poor quality groundwater of the area.

Materials and methods

This pot study was conducted in an open field at the Centre for Bio-saline Agriculture, Department of Soil Science, SAU, Tando jam. One year old chiku tree saplings were purchased from a commercial nursery located at Hyderabad city. The large cemented round pots which is capacity of 60 kg soil/pots were selected and used in the study with three replications and Completely Randomized Design (CRD). Saline water treatments, initially for one week saplings in all pots were irrigated with canal water, later they were stressed as per following planned irrigation water treatments, T_1 = Canal water (control), T_2 = 02 ECiw (dS m^{-1}) water, T_3 = 04 ECiw (dS m^{-1}) water, T_4 = 08 ECiw (dS m^{-1}) water, T_5 = 12 ECiw (dS m^{-1}) water.

Soil sampling and analyses

Before filling in the pots, soil sampling was done for the analyses of texture through Bouyoucos hydrometer method (Reyan *et al*., 2001), organic matter % using Walkley and Black method (Rowell, 1994), lime contents ($CaCO_3$%) through acid neutralization method (Jackson, 1958), EC (dS m^{-1}), pH, pH_2 (H_2O) and EC_e (dSm^{-1}) using digital meters (Schott Lab 960, and Sartorius PB-11, respectively). The exchangeable sodium % (ESP) were estimated through formula (Rowell, 1994).

Plant data generated/recorded

The plant data on growth and development traits were recorded for two times during the study first after three and second after six months of planting viz: Plant height (cm) $plant^{-1}$, Stem girth (cm^2) $plant^{-1}$, Number of branches $plant^{-1}$ and Number of leaves $plant^{-1}$.

Leaf sampling for sap extraction and analysis of Na^+ and K^+ concentrations and K^+/Na^+ ratio

The top fully mature leaves were sampled from each sapling for cell sap extraction and analysis of Na^+ and K^+ using flame photometer (USDA, 1956). The K^+/Na^+ ratio was also calculated from the values of Na^+ and K^+.

Statistical analysis

The plant data on the above traits were exposed to statistical analysis, using appropriate procedures "Statistix 8.1 version" (copyright 2005 Analytical Software, USA) for the (CRD) design using means of Least Significant Difference (LSD) method was used to test the probability <0.05 level by the difference between saline irrigation treatments.

Results

The data related to the physico-chemical properties of the soil used in the pots are given in the Table-1. The results showed that the soil selected for the experiment was clay loam in texture, calcareous in nature, low in organic matter content, salt-free, normal in reaction and had no salinity and/or sodicity problem.

Table-1:- Some physico-chemical properties of the experimental soil

Mechanical analysis			Textural class	EC	pH	$CaCO_3$	O/M	ESP
Sand	Silt	Clay						
………(%)………				(dS m^{-1})		……….(%)………		
24.4	46	29.6	Clay loam	0.56	7.8	8.9	0.82	8.7

The results related to the effect of saline water on growth and development traits, plant height (cm) $plant^{-1}$, number of leaves $plant^{-1}$, number of branches $plant^{-1}$ and stem girth (cm) $plant^{-1}$ of chiku saplings for two times i.e. after three and six months of planting are presented in the Table-2. It is evident from the results that increasing EC_{iw} of irrigation water significantly ($P<0.05$) decreased the plant height (cm) $plant^{-1}$, number of leaves $plant^{-1}$, number of branches $plant^{-1}$ and stem girth (cm) $plant^{-1}$ of chiku saplings. Compared to control (Without salt water), the plants irrigated with 02, 04, 08 and 12 EC_{iw} (dS m^{-1}) water showed 6, 18, 19 and 26% reduction in height recorded after three months of planting, and after six months were 20, 29, 30 and 40%, in number of leaves per plant 25, 34, 47 and 51% at first stage after three months and at second stage after six months had 44, 45, 60 and 74% reduction, in number of branches 44, 55, 55 and 66% at first stage and at second stage plants had 33, 50, 58 and 66% reduction and in stem girth (cm) of chiku plants at first stage 15, 21, 26 and 42% reduction after three months of planting, while after six months of planting, plants showed 15, 15, 26 and 36% reduction respectively.

Table-2:- Effect of saline water on the early growth and development traits plant height (cm), number of leaves, number of branches and stem girth (cm) plant^{-1} of chiku saplings

Saline ECiw (dSm^{-1}) Water levels	Plant height (cm) observations		Stem girth (cm^2) observations		Number of branches plant^{-1} observation		Number of leaves plant^{-1} observations	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
0	76.0^a	98.7^a	1.86^a	1.87^a	8.67^a	12.3^a	70.3^a	121.7^a
2	70.8^a	78.7^{ab}	1.60^b	1.63^{ab}	4.67^b	8.33^b	52.3^b	68.0^b
4	61.8^b	70.0^b	1.46^{bc}	1.60^{ab}	4.33^b	6.33^{bc}	46.0^{bc}	67.0^b
8	61.2^b	69.3^b	1.37^c	1.40^{bc}	3.67^b	5.67^{bc}	37.3^c	48.0^c
12	55.8^b	58.3^b	1.10^d	1.20^c	3.00^b	4.67^c	34.3^c	31.3^c
LSD (0.05)	6.5510	6.5510	0.2153	6.5510	3.3873	2.7790	12.213	16.884
SE±	2.9401	2.9401	0.0966	2.9401	1.5202	1.7790	5.4813	7.5777

The data on the concentration of Na^+ determined in the leaf sap are plotted against EC values of saline water in the (Figure-1). The concentration of Na^+ determined in the leaf sap of chiku saplings was significantly affected ($P<0.05$) by water salinity. In the treatment where the chiku saplings. were irrigated with 12 EC_{iw} (dS m^{-1}) water, the Na^+ concentration in leaf sap remained highest (22.22 %); whereas the Na^+ concentration determined in the leaf sap obtained from control plants was lowest (11.11 %).

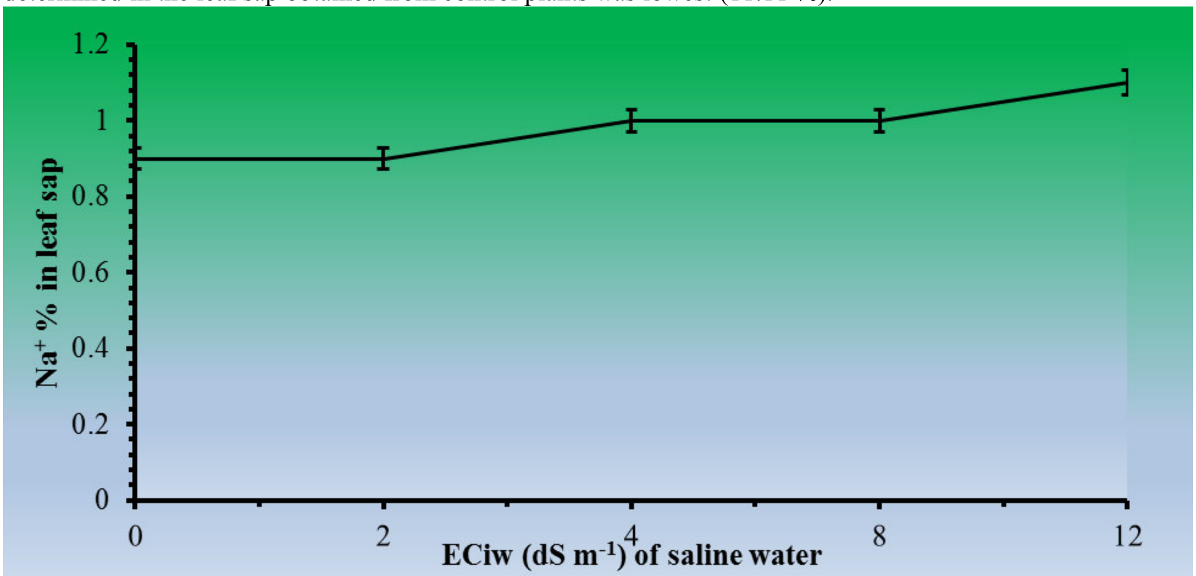

Figure-1:- Effect of saline water on the concentration of Na^+ determined in the fully mature leaf sap of chiku saplings

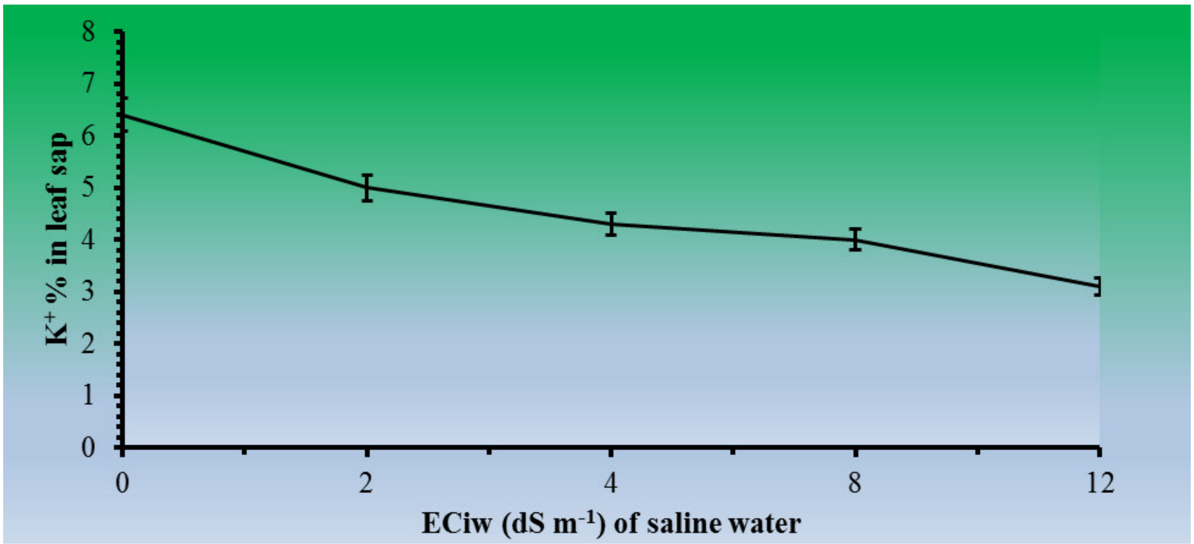

Figure-2:- Effect of saline water on concentration of K^+ determined in the leaf sap of chiku saplings

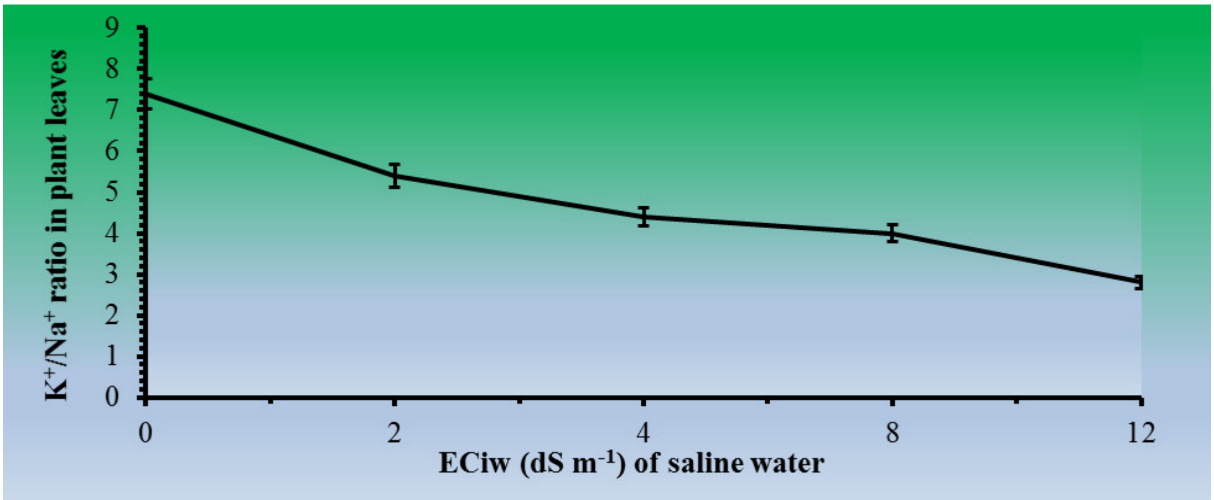

Figure-3:- Effect of saline water on the K^+/Na^+ ratio determined in the leaf sap of chiku saplings

The K^+ concentration in the leaf sap of chiku plants was also adversely affected (P <0.05) by water salinity (Figure-2). Raising EC_{iw} of water used for irrigation from 02 to 12 EC (dS m^{-1}) showed reduction in K^+ concentration. As compared to control/freshwater, the saplings receiving water of 02, 04, 08 and 12 EC_{iw} (dS m^{-1}) had 21, 32, 37 and 51% less K^+ in their leaf sap, respectively. The K^+/Na^+ ratio has been reported as one of the criteria for salt-tolerance of plants. Most of plants under saline environment uptake lots of Na^+ (toxic) later on them accumulate that Na^+ in cytoplasm or different cell compartments. Unlike Na^+, plants uptake less K^+ (nutrient). Hence, analyzing K^+/Na^+ ratio under saline water environment is an important tool for increasing screening salt-tolerance in sensitive plants. As increasing water salinity increased Na^+ and decreased K^+, there was significant decrease in K^+/Na^+ ratio (Figure-3). Compared to freshwater irrigated saplings, the chiku plants receiving irrigation water of 02, 04, 08 and 12 EC_{iw} (dS m^{-1}) displayed 27, 41, 46 and 62% lower K^+/Na^+ ratio in their leaf sap.

Discussion

Shortage of canal water is a major issue in lower Sindh, particularly in coastal region, where groundwater is salty, temperature is high and seawater intrusion is common. Continuous application of salty groundwater in irrigation without a proper management may convert the fertile fruit orchards. Productive lands into salt-affected soils and destroy economically important. Among the management practices, growing salt-tolerant plant species with existing water resources has been considered as the major practice for efficient utilization of land, water, plant and other natural and genetic resources in the area. Several researchers have worked out salt-tolerance of selected crop species, including cereals (Witzel *et al*., 2009; Khan *et al*., 2010), oil seeds (Ali *et al*., 2013; Mukhtar *et al*., 2013), fiber crops (Munis *et al*., 2010; Saleh, 2012), vegetables (Jamil *et al*., 2006; Waheed *et al*., 2006), medicinal plants (Misic *et al*., 2009; Taleil *et al*., 2013), sugar crops (Ashraf *et al*., 2007; Jamil *et al*., 2007) and fruit trees, including mango (Daya *et al*., 2014; Kannan *et al*., 2014), date palm, guava, avocado and chiku as well. The list about the salinity limits of irrigation waters also exists (Hebbara *et al*., 2002). According to that list the crops which could be grown with yield reduction of not more than 25% at EC_{iw} of 10, 5 and 3 ds m^{-1} on medium textured soils under average climatic condition have been considered as tolerant, semi-tolerant and sensitive, respectively to salinity. However, the salt-tolerance level of plant of the area may vary with species, climatic condition and stage of the growth. In this study an economically important fruit tree chiku was evaluated for its salinity tolerance under saline irrigation condition. Mainly some important traits were observed during the study using different EC_{iw} levels. The study indicated that irrigating chiku plants with saline water having 02, 04, 08 and 12 EC_{iw} (dS m^{-1}) water decreased shoot height (cm) per plant, number of leaves per plant, number of branches per plant and stem girth (cm) per plant (Table-2). Twenty five percent reduction in majority of the traits was observed with 12 EC_{iw} water.

Usually, the effect of high 12 EC_{iw} dS m^{-1} water was larger on the number of leaves and branches and stem girth. Similar effects of saline water on branches, leaves and stem girth have also been observed by some other workers including, Yaron *et al.* (1996); Qadir *et al.* (1997); Ashraf and Sarwar (2002). It is interesting to note that chiku plant survived in all saline water treatments. This suggests that chiku has ability to survive well under saline irrigation condition, with slight reduction in growth and development parameters. This suggests that care must be taken that the application of saline water should may be continued for longer time. As saline water can ultimately deteorate the soil characteristics. If there are several evidences which indicate that unlike crops, some woody plants are much more tolerant to salt stress. Although, they show sharp decline in growth at lower EC value, they still survive and give response well under salt stress environment. The Na^+ and K^+ concentrations determined in the sap obtained from youngest fully expanded leaves were also adversely affected by saline water. Compared to other treatments, the seedlings irrigated with 12 EC_{iw} (dS m^{-1}) water had much more Na^+ and less K^+. This indicates the toxic effect of Na^+ and deficiency of K^+ created by saline water. There are several evidences (Saqib *et al.,* 2004) which indicate the antagonistic effect of Na^+ to K^+ under saline environment. High concentration of sodium is cytotoxic for growth and development of plants under saline condition (Iqbal and Ashraf, 2007). Reduction in K^+ concentration under saline environment decreases the enzymes activity, as K^+ is largely required for the activation of several enzymes required for plant growth (Netondo *et al*., 2004; Shirazi *et al.,* 2005; Willadino and Camara, 2005). In addition to that excess salts in root zone not only decreases availability of water to plants, but their uptake causes problem of ion toxicity in the cytoplasm. Finally this study suggests that chiku plant has an ability to survive and grow well under saline water irrigation. However, further future studies must be designed and conducted under field conditions just to know the effect of saline water both on plants and soil properties.

Conclusion

It is concluded from this study that chiku (*Achras zapota* L.) is a salt-tolerant plant species particularly at initial growth stage, it can positively be grown with saline water having EC_{iw} up to 08 (dS m^{-1}).

Reference

Alhammadi, S. Mohamed, Shyam and S. Kurup. 2012. Impact of salinity stress on date palm (*Phoenix dactylifera* L.). A review. Crop Production Technologies. In Tech, New York. pp. 169-173.

Ali, A. I. A. Mahmood, M. Salim, M. Arshadullah and A. R. Naseem. 2013. Growth and yield of different brassica genotypes under saline sodic conditions. Pak. J. Agri. Res. V., 26(1): 9-15.

Ashraf, M.Y. and G. Sarwar. 2002. Salt tolerance potential in some members of rassicaceae. Physiological studies on water relations and mineral contents. In: Prospects for Saline Agriculture. (Eds.): R. Ahmad and K. A. Malik. Kluwer Academic Publishers, Netherlands. pp. 237- 245.

Ashraf, M. Rahmatullah , S. Kanwar, M. A. Tahi, A. Sarwar and L. Ali. 2007. Differential salt tolerance of sugarcane genotypes. J. Agri. Sci. Vol., 44(1): 85.

Bandeira, C.T., A. Mesquita and A. Cavalcanti. 2003. O cultivo do sapotizeiro. Fortaleza: Embrapa-CNPAT. Circular Técnica., pp. 13-20.

Cavalcante, I.H.L., L.F. Cavalcante, Y. Hu and M.Z. Beckmann. 2007. Water salinity and initial development of four guava (*Psidium guajava* L.) cultivars in North-eastern Brazil. J. Fruit and Ornamental Plants Res., pp. 15:71.

Craig, G.F., C.A. Atkins and D.T. Bell. 1991. Effect of salinity on growth of four strains of *rhizobium* and their infectivity and effectiveness on two species of acacia. Plant and Soil. 133(2): 253-262.

Daya, V. A. K. Dubey, O. P. Awashti, R. Pandey and A. Dahuja. 2014. Growth, lipid peroxidation, antioxidant enzymes and nutrient accumulation in Amrapali mango (*Mangifera indica* L.) grafted on different rootstocks under NaCl stress. J. Plant Knowl., 3(1): 15-22.

Duran, Z.V.H., A.M. Raya, J.A. Ruiz and D.F. Tarifa. 2004. Impact of salinity on macro- and micronutrient uptake in mango (*Mangifera indica* L. cv. Osteen) with different rootstocks. Spanish J. Agric., Res., 2(1): 121-133.

Gupta, R.K. and I.P. Abrol. 1990. Reclamation and management of salt-affected soils. Adv. Soil Sci., 1(1): 233-290.

Heaton, H.J., R. Whitkus and A. Gîmez-Pompa. 1999. Extreme ecological and phenotypic differences in the tropical tree chicozapote (*Manilkara zapota*) are not matched by genetic divergence: a random amplified polymorphic DNA (RAPD) analysis. Mol. Ecol., 8: 627-632.

Hebbara, M., M.V. Manjunatha, S.G. Patil and D.R. Patil. 2002. Performance of fruit pieces in saline-waterlogged soils. Karnataka J. Agric. Sci., 15 (1): 94-98.

Iqbal, M. and M. Ashraf. 2007. Seed preconditioning modulates growth, ionic relations, and photosynthetic capacity in adult plants of hexaploid wheat under salt stress. J. Plant Nutr. 30:381-396. Jones, M.M and N.C. Turner. 1978. Osmotic adjustment in leaves of Sorghum in response to water deficits. Plant Physiol., 6: 122-126.

Jackson, M.L. 1962. Soil chemical analysis. Constable and co.Ltd. London. p. 244.

Jamil, M. S. Rehman, and E.S. Rha. 2007. Salinity effect on plant growth, psii photochemistry and chlorophyll content in Sugar beet (B*eta vulgaris* L.) and cabbage (B*rassica oleracea capitata* L.). Pak. J. Bot., 39(3): 753-760.

Jamil, M. D. B. Lee, K. Y. Jung, M. Ashraf, S. C. Lee and E. S. Rha. 2006. Effect of salt (NaCl) stress on germination and early seedling growth of four vegetables species. J. centr. Europ. Agri. V., 7(2): 273-282.

Khan, M. A. E. Islam, M.U. Shirazi, S. Mumtaz, S.M. Mujtaba, M. Ali khan, A. Shereen, M.Y. Ashraf and G.M.

Kaleri. 2010. Physiological responses of various wheat genotypes to salinity. Pak. J. Bot., 42(5): 3497-3505.

Kannan, R. T. Damodaran, , B. K. Pandey, S. Umamaheswari, R. B. Rai, S. K. Jha, V. K. Mishra, , D. K. Sharma and V. Sah. Isolation and characterization of endophytic plant growth-promoting bacteria (PGPB) associated to the sodicity tolerant polyembryonic mango (Mangifera *indica* L.) root stock and growth vigour in rice under saline sodic environment. J. Microbio. Res. V., 8(7): 628-636.

Mickelbart, M.V. and T.E. Marler. 1996. Photosynthesis, water relations, and mineral content of sapodilla foliage as influenced by root zone salinity. J. Hort, Sci., 31: 230-233.

Misic, D. B. Siler, B. Filipovic and Z. Popovic. 2009. Rapid in vitro selection of salt-tolerant genotypes of the potentially medicinal plant *Centaurium maritimum* (L.) Fritsch. Arch. Bio. Sci. Belgrade., 61 (1): 57-69.

Munis, M. F. H. L. Tu, K. Ziaf, J. Tan, F. Deng and X. Zhang. 2010. Critical osmotic, ionic and physiological indicators of salinity tolerance in cotton (*Gossypium hirsutum* L.) For cultivar selection. Pak. J. Bot., 42(3): 1685-1694.

Netondo, G.W., J.C. Onyango and E. Beck. 2004. *Jatropha curcas* L. and salinity. Gas exchange and chlorophyll fluorescence of *Jatropha curcas* L. under salt stress. Crop Sci., 44: 806-811.

Qadir, M., R. H. Qureshi and N. Ahmad. 1997. Nutrient availability in a calcareous saline-sodic soil during vegetative bioremediation. Arid Soil Res. Rehabil., 11: 343-352.

Ryan, J., G. Estefan and A. Rashid. 2001. Soil and Plant Analysis Laboratory Manual. 2nd ed. pp. 1-172.

Rowell, D. L. 1994. The preparations of saturation extracts and the analysis of soil salinity and sodicity. Soil Science Methods and Applications. Rowell, D.L. (Ed.), Longman Group., UK.

Saleh, B. 2012. Salt stress alters physiological indicators in cotton (*Gossypium hirsutum* L.). Soil Environ. 31(2): 113-118.

Saqib, M., J. Akhtar and R.H. Qureshi. 2004. Pot study on wheat growth in saline and waterlogged compacted soil II. Root growth and leaf ionic relations. Soil Till. Res., 77: 179-187.

Shirazi, M.U., M.A. Khan, A. Mukhtiar, S.M. Mujtaba, S. Mumtaz, M. Ali, B. Khanzada, M.A. Halo, M. Rafique, J.A. Shah, K.A. Jafri and N. Depar. 2006. Growth performance and nutrient contents of some salt-tolerant multipurpose tree species growing under saline environment. Pak. J. Bot., 38(5): 1381-1388.

Sohail, M., A. S. Saied, J. Gebauer and A. Buerkert. 2009. Effect of NaCl salinity on growth and mineral composition of wild (*Ziziphus spina-christi* L.). J. Agric., 110(2): 107-114.

Talei, D. M. A. Kadir, M. K. Yusop, A. Valdiani and M. P. Abdullah. 2013. Growth indices and salinity tolerance threshold in a medicinal plant Andrographis paniculata Nees. J. Med. Plants. Res. V., 7(3): 104-110.

Waheed, A. I. A. Hafiz, G. Qadir, G. Murtaza, T. Mahmood and M. Ashraf. 2006. Effect of salinity on germination, growth, yield, ionic balance and solute composition of pigeonpea (*Cajanus cajan* (L.) Millsp). Pak. J. Bot., 38(4): 1103-1117.

Walkley, A. 1947. A critical examination of rapid method for determining organic carbon in soil: Effect of variations in digestion conditions and of organic soil constituents. Soil Sci., 63: 251-263.

Willadino, L.G. and C.T.R. Camara. 2005. Stresses ambient: dense benefices in plants. In press Uni. Recife., pp. 118-126.

Witzel, K. A. Weidner, S. Giridara-Kumar, A. Borner and H.P. Moc. 2009. Salt stress-induced alterations in the root proteome of barley genotypes with contrasting response towards salinity. J. Bot. V., 60(12): 3545–3557.

Yaron, B., N. Zeilson and A. H. Halvey. 1996. Response of Bacara roses to saline irrigation. J. Hort. Sci., 99: 481-484.