Pak. J. Bot., 50(2): 465-469, 2018.

SALINITY AND DROUGHT STRESS TOLERANCE OF SOME PLANT SPECIES OF THAR DESERT, PAKISTAN: IMPLICATIONS IN BIO-SALINE AGRICULTURE

INAYATULLAH RAJPAR[1], MUHAMMAD SIDDIQUE LASHARI[1], SUNEEL KUMAR BRAHMAN[1], MUHRAM ALI[2], ZIA-UL-HASSAN SHAH[1], BAKHT NISA MANGAN[2] AND ALI HYDER SHAH[1]

[1]*Centre for Bio-saline Agriculture, Department of Soil Science, Sindh Agriculture University, Tandojam, Pakistan*
[2]*Department of Biotechnology and Agronomy, Faculty of Crop Production Sindh Agriculture University, Tandojam, Pakistan*
[3]*Soil Science Division, Nuclear Institute of Agriculture (NIA), Tandojam, Pakistan*
[*]*Corresponding author's email: mslashari@gmail.com*

Abstract

Salinity and drought are twin menaces that have major influence on the sustainability of agriculture, especially in rain-fed areas of Pakistan. Therefore, to evaluate the influence of salinity and drought two pot studies were conducted to compare the salinity (study-1) and drought (study-2) stress tolerance of four common indigenous species of desert plants. The species included in both experiments were *Prosopis cineraria* (Kandi), *Acacia senegal* (Kumbhat), *Salvadora oleoides* (Jar) and *Tecomela undulata* (Rohera). Seeds of all four species were hydro-primed, placed on blotting paper and adjusted in Petri dishes, treated with 0, 0.25, 0.75 and 1.0 % NaCl solution and raised on full strength Hoagland solution. In second study, seeds were placed in plastic trays having 200g acid-washed river bed sand, supplied with Hoagland solution at 5, 8, 12, 16 and 20 % moisture level. Both the experiments were conducted under controlled conditions (25 ± 2°C temperature and 70±04% relative humidity) for six weeks. The results obtained from the study indicated that increasing salinity decreased various growth traits and biomass production of all four species. Both salinity and drought stresses enhanced leaf Na^+ content in all four species, while the drought stress caused reduction in osmotic pressure and chlorophyll content in green leaves. Nonetheless, wide variation existed among species for their tolerance to salinity *S. oleoides* > *P. cineraria*. *A. Senegal* > *T. undulata* and drought stress as *S. oleoides* > *T. undulate* > *P. cineraria* > *A. senegal*. The study concluded that Jar possessed dual potential to tolerate harsh environment caused by salinity and drought, simultaneously and appeared to be the potential plant species for bio-saline agriculture.

Key words: Salinity, Drought, Desert plant species, Stress tolerance and bio-saline agriculture.

Introduction

Soil salinization has been considered a major soil degrading problem in arid and semi-arid regions of the world mainly due to increasing degree of temperature, low precipitation and carbon storage in soil (Lashari *et al.,* 2013). Most of the plant species rarely survive and poses potential to restore their normal functional growth and development process on salt-affected soils, because the toxic level of sodium in soil solution adversely alters the osmotic potential of soil water, which decreases the absorption, and availability of water and nutrients to plants (Ramoliya *et al*., 2004; Panuccio *et al.,* 2014). Salinity induces physiological drought and unavailability of essential nutrients, specific ion toxicity to plants (Marschner, 1995; Taiz & Zeiger, 2006). Considering the major threats of salinity to fertile soils, plant and humans, some out-coming approaches have long been adopted in the past to reclaim salt-affected soils, mainly chemical, mechanical and physical approaches but these all are not easily applicable and economical for farming community. In recent past a simple and reasonable approach has been adopted by the farmers and researchers to screen out salt-tolerant and economically important non-conventional crops cultivation on salt-affected soils with low cost investment (Qureshi, 2004).

It has been observed by various workers that several tree species have got potential to survive and grow with valuable returns of soil carbon under salt-affected soil conditions (Allen *et al*., 1994). Studies have clearly shown a considerable variation among the tree species and crop varieties in their abilities to tolerate salt-stress. Still there is an equal need for identification and adaptation of soil environment for tree species according to the habitat conditions (Wood & Awang, 1998). Although, afforestation of salt-affected areas requires enough understanding about mechanisms by which forest trees and shrubs become able to survive and particularly avoid the negative impact of salinity (Fuller, 1979). The some morphological and molecular characteristics of tree species show certain level of salt-tolerance such as seed germination, early growth development, physical appearance of plants and salt-tolerance (Fuller, 1979).

It is clearly evident from the reports that almost all desert plants have ability to survive and face extreme drought conditions and grow well during monsoon season of each year. Especially, desert plants survive due to two main mechanisms, technically known as phonological and physiological (Evens *et al.,* 1992; Tasneem *et al.,* 2016). Phonological mechanisms increase the tolerance of water stress and physiological adjustment in plant cells. Tolerance and avoidance mechanisms increase the immunity of plant cells to survive under extreme drought (Otte, 2001). Plants under such types of suppressed conditions regulate their water status using several tactics viz., osmotic adjustment, stomatal aperture, turgor maintenance, root distribution and leaf canopy (Rhizopoulou *et al.,* 1997). It has also been reported that under water and salt stressed condition chlorophyll formation is markedly depressed (William & Sharon, 1981).

In this study we hypothesized that the primary effect of salinity on plants is a physiological drought and the desert plants, which are already drought tolerant in nature hence, they can also tolerate salinity. This study evaluates the salinity tolerance and drought resistance at early growth stages of four common species of Thar flora viz., Kandi (*Prosopis cineraria*), Kumbhat (*Acacia senegal*) Rohira (*Tecomella undulata*) and Jar (*Salvadora oleoides*).

Materials and Methods

Two experiments were conducted at the green house of the Centre for Bio-saline Agriculture, Department of Soil Science, Sindh Agriculture University Tandojam, Pakistan. The four major plant species included in both experiments were: Kandi (*Prosopis cineraria*), Kumbhat (*Acacia senegal*), Jar (*Salyadora oleoides*) and Rohira (*Tecomela undulata*). The seed of all the species was obtained from District Forest Office Mithi, district Tharparkar, Sindh. Seed of all four species was hydro-primed for about 30 minutes in hot water at 60ºC to break the hardness initially.

In experiment-1 the hot water treated seeds were placed on blotting papers adjusted in Petri dishes. The seeds were allowed to germinate for counting and calculating germination raised on full strength Hoagland Solution and stressed with 0, 0.25, 0.50, 0.75 and 1.0 % solution of NaCl. In experiment-II the seeds were placed in plastic containers with a capacity of accommodating 200g acid-washed riverbed sand, supplied with Hoagland Solution and moisture levels at 5, 8, 12, 16 and 20%. The experiments were conducted under controlled environmental conditions. The temperature during experiments was set at 25±2ºC and approximately relative humidity was set at 70±4%. The plants were harvested from Petri dishes after two weeks and from plastic glasses after six weeks of sowing and the data were recorded on germination (%), shoot height (cm), root length (cm), shoot and root weight plant^{-1} and shoot/root ratio. After harvest ion contents in plant leaf dry matter were determined through the adopted methods (Anon., 1954; Rowell, 1994). Mean data recorded from the both experiments were analyzed statistically through software Statistix version 8.1.

Results

Effect of salinity and soil moisture levels on seed germination: Results showed that the salinity have non-significant adverse effects on the seed germination of the studied species in compassion of soil moisture. The maximum decrease up to 70-90% in seed germination was observed at 1.0% salinity levels in all selected plant species. However, the maximum effect of salinity was observed in *T. undulata* and *A. senegal* (Fig. 1A) in compression of other two plant species at 1.00% salinity levels. While the seed germination of all the plant species was significantly increased with the increasing soil moisture levels shown in Fig. 1B. The maximum germination from 70-80% were observed in *S. oleoides* and *T. undulata* plant and 60-70% germination were recorded in *P. cineraria* and *A. senegal* plant species at 16-20% of soil moisture levels.

Effect of salinity and soil moisture levels on growth and biomass yield of Thar flora: Data represented in Table 1 clearly indicated that salinity suppressed the growth and biomass yield of all four-plant species. The major influences of salinity were observed on *P. cineraria* and *T. undulata* plant species, growth and biomass yield were observed 70-80 low in compression at 1.0% salinity level, however, the growth yield of *S. oleoides* and *A. senegal* grown under same conditions were decline from 40-60% over the control. However, the influence of soil moisture levels was highly effective for increasing the growth and biomass yield of some Thar plant species results shown in Table 3. The maximum biomass yield and growth 80-90% were obtained at 16-20% moisture level from *S. oleoides* and *T. undulate* plant in compression of *P. cineraria* and *A. senegal.*

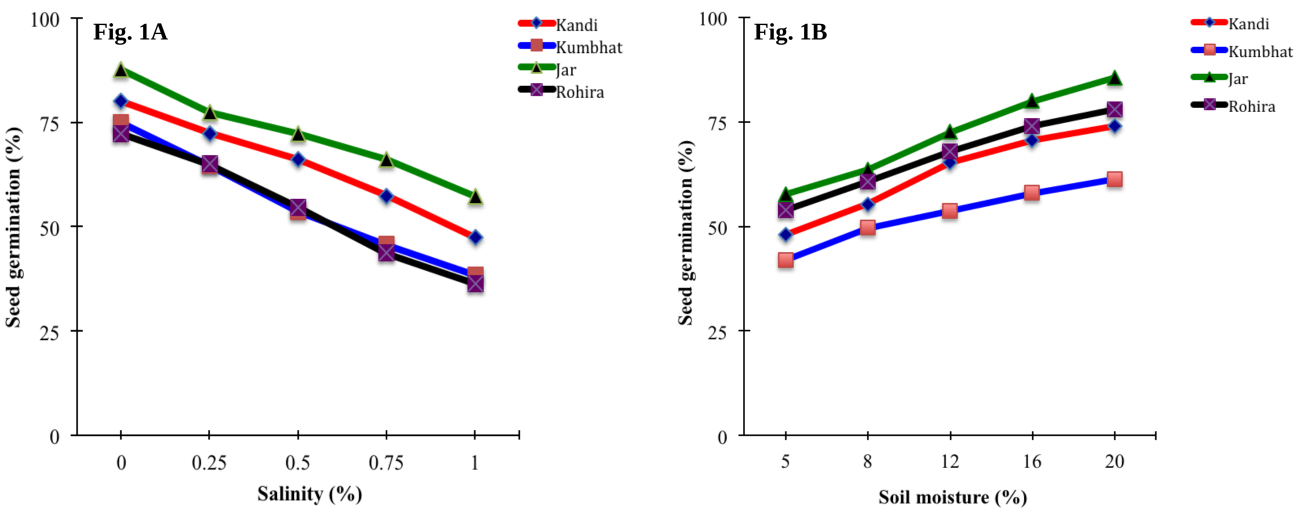

Fig. 1. Effect of salinity (NaCl) and soil moisture levels on seed germination of four desert plant species.

Table 1. Effect of different salinity (NaCl) levels on shoot/root dry weight and shoot root length of four desert plant species.

Salinity (%)	Shoot/ Root dry weight (mg plant^{-1})							
	Kandi		Kumbhat		Jar		Rohira	
00	13.66a	3.13a	61.66a	23.60a	195.33a	68.10a	112.33a	19.03a
0.25	8.00b	1.73b	52.33b	17.56b	133.00b	37.53b	82.67b	16.86b
0.50	6.66b	1.00bc	43.66c	14.60c	102.67c	23.43c	54.67c	12.53c
0.75	4.46c	0.80c	36.00d	10.83d	73.67d	14.63d	27.00d	8.03d
1.00	3.40c	0.63c	31.00e	8.23e	58.00e	10.83e	18.00e	4.73e
± SE	**0.80**	**0.39**	**0.88**	**0.58**	**1.95**	**0.89**	**0.50**	**0.77**
Salinity (%)	**Shoot/Root length (cm)**							
	Kandi		**Kumbhat**		**Jar**		**Rohira**	
00	8.46a	5.33a	7.56a	4.93a	9.33a	6.43a	7.76a	4.60a
0.25	7.43b	4.60b	6.46b	4.33b	8.56b	5.63b	6.70b	3.63b
0.50	6.50c	3.50c	5.90c	3.53c	7.36c	4.90c	5.26c	3.06c
0.75	5.50d	2.70d	4.86d	2.50d	6.53d	4.26d	4.53d	2.70d
1.00	4.90e	2.23e	3.83a	1.80e	5.93e	3.63e	3.83e	2.00e
± SE	**0.22**	**0.17**	**0.14**	**0.15**	**0.05**	**0.13**	**0.15**	**0.07**

Table 2. Effect of different salinity (NaCl) levels on ion concentrations determined in shoot dry matter of desert plant species.

Salinity (%)	Kandi		Kumbhat		Jar		Rohira	
	Na^+ %	K^+ %	Na^+ %	K^+ %	Na^+ %	K^+ %	Na^+ %	K^+ %
0.00	0.80e	1.89a	0.77d	1.39a	1.70e	1.63a	0.96d	0.89a
0.25	0.91d	1.63b	0.97c	1.17b	1.88d	1.53b	1.18c	0.83a
0.50	1.01c	1.51c	1.09ab	1.01c	2.04c	1.37c	1.34b	0.73b
0.75	1.13b	0.13d	1.06b	0.87d	2.18b	1.23d	1.43ab	0.63c
1.00	1.20a	0.10e	1.16a	0.75e	2.32a	1.07e	1.50a	0.59c
± SE	**0.02**	**0.04**	**0.03**	**0.02**	**0.03**	**0.03**	**0.03**	**0.03**

Table 3. Effect of soil moisture stress on shoot/root dry weight and shoot root length of four desert plant species.

Soil moisture (%)	Shoot dry weight (mg plant^{-1})				Shoot length (cm)			
	Kandi	Kumbhat	Jar	Rohira	Kandi	Kumbhat	Jar	Rohira
5.00	134.00e	153.00e	204.00e	169.67e	6.70e	7.10e	7.93e	7.56e
8.00	165.00d	174.00d	233.67d	185.33d	7.16d	7.93d	8.70d	8.23d
12.00	208.00c	223.67c	264.33c	215.67c	7.76c	8.70c	9.60c	9.26c
16.00	245.00b	263.33b	299.33b	268.67b	8.40b	9.30b	10.56b	9.93b
20.00	273.00a	293.33a	320.67a	299.67a	9.16a	9.70a	11.56a	10.60a
SE ±	**2.03**	**2.66**	**3.66**	**6.44**	**0.13**	**0.10**	**0.12**	**0.13**

Table 4. Effect of moisture levels on ion concentrations determined in shoot dry matter of desert plant species.

Soil moisture (%)	Kandi		Kumbhat		Jar		Rohira	
	Na^+ %	K^+ %	Na^+ %	K^+ %	Na^+ %	K^+ %	Na^+ %	K^+ %
5.00	0.87a	2.05e	0.86a	1.67e	1.66a	1.69e	0.81a	0.39c
8.00	0.80b	2.21d	0.79b	1.83d	1.56b	1.85d	0.72b	0.43c
12.00	0.72c	2.39c	0.72c	1.99c	1.45c	2.01c	0.61c	0.53b
16.00	0.62d	2.55b	0.66d	2.13b	1.32b	2.25b	0.52d	0.63a
20.00	0.51e	2.69a	0.54e	2.31a	1.19e	2.35a	0.35e	0.69a
SE ±	**0.01**	**0.02**	**0.01**	**0.02**	**0.02**	**0.04**	**0.02**	**0.03**

Effect of salinity and soil moisture levels on ion content of Thar flora: Data presented in Table 2, showed negative impact of salinity on potassium concentration in plant tissue and over concentration sodium ion in dry plant tissues. The significantly higher concentrations of sodium ion (Na^+) were observed in dry tissues of *S. oleoides* and *T. undulate* at 1.0% salinity level over the control. While the lower concentration of sodium ion (Na^+) were observed in *P. cineraria* and *A. senegal* in compression of *S. oleoides* and *T. undulate*. However, the potassium ion (K^+) concentration in all plant species was decreased with the increasing level of salinity verses control treatment. Meanwhile, increasing soil moisture shown positive effects on selected species of Thar Desert (Table 4). The maximum concentration of K^+ ion was observed in *S. oleoides* and *P. cineraria* at 16 and 20% soil moisture with significantly lower concentration of Na^+ ion in compression of *A. senegal* and *T. undulata*.

Discussion

Impact of salinity and soil moisture content on seed germination: Four desert plant species used in this study were: *P. cineraria*, *A. senegal*, *S. oleoides* and *T. undulata*. These species were selected on the basis of natural habitat, environmental conditions, drought tolerance and economical value in desert área. Mainly the all species of Thar flora are considered as true xerophytes and can grow under extremly arid conditions. It is evidence from the general practices of farming community of desert área that only drought tolerance crops and trees species can grow under such type of extreme hard conditions, survive and provide some reliable source and basic needs of life. The experiments were organized to assess either drought resistance plant species have some potential to survive under saline conditions. However, to evaluate the limits of drought and salinity tolerance the two experiments were organized under different salinity levels and soil moisture contents. Soil salinity induce toxic effects of plant, reduce rate of seedling emergence, growth and biomass yield of several crop species (Loutfy *et al.,* 2008; Wang *et al.,* 2013). In this study the seed germination of all four species were effected at high salinity level 1.0%. However, the major influes of salinity was observed on *P. cineraria* and *T. undulata* species of Thar flora as compare to *S. oleoides* and *A. senegal*, it indicates that all flora are have their on value to survival under saline condition. Simalarly, drought induce effect on plant during dry seasons, majority of Thar flora loose their leaves and functional growth during dry seasons (Anon., 2005). Meanwhile, in this study plants show positive response in case of seedling emergence due to incresing moisture content in soil. While the almost species of Thar flora possess hard coted seeds so need sufficiant quantity of soil moisture for seedling emergence, even under moonsoon conditions of desert most of the hard coted seeds takes lot of time for emergence (Anon., 2002), even in this study similar results were found and hard coated seeds takes more time during the process of germination.

Impact of salinity and soil moisture content on vegetative growth: Salinity and extreme conditions of drought oftenly depress the vegatitive growth of flora (Porcelli *et al.,* 1995), nutriente uptake and water movement in plant tissues (Jaleel *et al*., 2007 and 2009). Accumulations of sodium salts in root médium causes ion toxicity and nutritional embalance (Lashari *et al.,* 2015). The severe impact of salinity causes >90% losses of plant life after germination and 10-20% un-productive plants harvest (Boem & Lavado, 1996). Extreme conditions of drought and salnity also causes some negative effects on the growth and metabolic system of several plant species (Munns, 2002; Siddiqi *et al.,* 2011; Varol *et al*., 2017), in such conditions plant losses their green leaves, vegetative growth and productivity. In concerned with this study the growth and biomass yield of all four species of Thar flora were badly affected at 1.0% level of salinity, the maximum adverse impacts of salinity were observed on *P. cineraria* and *T. undulata* plant species in compression of *S. oleoides* and *A. senegal* plants. In relations of soil moisture content, *S. oleoides* and *T. undulata* plant species respond positively at 16-20% of soil moisture content. These findings indicates that Thar flora have ability to survive under drought condition and respond positively when applied suficiente quantity of soil moisture.

Ion accumulation salinity v/s soil moisture content: Salinity induce harmful effects on specific ions and stimulate the concentration of toxic ions such as sodium and chloride in plant tissues and inhabits plant growth mechanisam, functionality and quality (Seema & Pandey, 2008). Similarly, under drought conditions plant may not able to excess essencial ion for functional metabolisams (Munns & Tester, 2008; Shahid *et al.,* 2015), in such type of stressed conditions forced to be complete life cycle with out quality and quantity of food and foder (Adolf *et al.,* 2012). Morever, the findings of the experimental results indicates that salinity has promising effects on the accumulation of toxic ion of sodium and reduction of key ion potassium in dry plant tissues. While the all Thar flora species were suffered due to toxicity of sodium ions and very low uptake of essential ions such as potassium and phosphorus at the 1.0% salinity in *S. oleoides* and *T. undulata* plants in compression of *P. cineraria* and *A. senegal* plants. Similarly, the influences of soil moisture were observed highly positive in accumulation of major nutriente in plant dry tissues. The maximum influence of soil moisture content were found in *S. oleoides* and *P. cineraria* plant species in compression of *A. senegal* and *T. undulata* plant species at the 16 to 20% moisture level.

Conclusion

It is concluded from the experimental study and physiological mechanisms of salt content in Thar flora leaf tissue and growth that *S. oleoides* and *P. cineraria* plant species (60-40%) respond well under saline conditions in compression of *A. senegal* and *T. undulata* plant. These finding indicates that all Thar flora species are not salt tolerance in compression of drought resistance. While in case of drought and salinity resistance *S. oleoides* showed a potential to tolerate both stresses and survive effectively in compression of all other three-plant species. Therefore, these findings suggest that further research may be planned to investigate salt-tolerance of other economically important desert plant species. This can be considered for future cultivation on salt-affected areas of Sindh province.

References

Adolf, V., S. Shabala, M. Andersen, F. Razzaghi and S.E. Jacob-Sen. 2012: Varietal differences of quinoa's tolerance to saline conditions. *Plant Soil*, 357: 117-129.

Allen, J.A., J.L. Chambers and M. Stine. 1994. Prospects for increasing the salt tolerance of forest trees: a review. *Tree Physiol.*, 14: 843-853.

Anonymous. 1954. Diagnosis and Improvement of Saline and Alkaline Soils. USDA Hand book 60, Washington, D. C. pp. 69-75, 136.

Anonymous. 2002. An Assessment: Drought in Tharparkar. Arid Zone Report. pp. 13.

Anonymous. 2005. An Assessment: Drought in Tharparkar. Arid Zone Report. pp. 26-31.

Boem, G.F.H. and R.S. Lavado. 1996. The effects of soil sodicity on emergence, growth, development and yield of oilseed rape (*Brassica napus*). *J. Agric. Sci*., 126: 169-173.

Evans, R.D., R.A. Black, W.H. Loescher and R.J. Fellows. 1992. Osmotic relations of the drought tolerant shrub *Artemesia tridentata* in response to water stress. *Plant Cell and Environ*., 15: 49-59.

Fuller, W.H. 1979. Management of saline soils. *Outlook on Agriculture*, 10: 5-12.

Jaleel, C.A., B. Sankar, P.V. Murali, M. Gomathinayagam, G.M.A. Lakshmanan and R. Panneerselvam. 2009. Drought stress in plants: A review on morphological characteristics and pigments composition. *Int. J. Agric. Biol*., 11: 101-105.

Jaleel, C.A., P. Manivannan, B. Sankar, A. Kishorekumar, R. Gopi, R. Somasundaram and R. Panneerselvam. 2007. Water deficit stress mitigation by calcium chloride in *Catharanthus roseus*; effects on oxidative stress, proline metabolism and indole alkaloid accumulation. Colloids Surf. B: *Bio Interfaces*, 60: 110-116.

Lashari, M.S., Y. Liu, L. Li, W. Pan, J. Fu, G. Pan, J. Zheng, J. Zheng, X. Zhang and X. Yu. 2013. Effects of amendment of biochar-manure compost in conjunction with pyroligneous solution on soil quality and wheat yield of a salt-stressed cropland from Central China Great Plain. *Field Crops Research*, 144: 113-118.

Lashari, M.S., Y. Ye, G. Pan, H. Ji, L. Li, W.K. Grace, H. Lu and J. Zheng. 2015. Biochar-manure compost in conjunction with pyroligneous solution alleviated maize salt stress and improved growth in a salt-affected soil from Central China: A two-year field experiment. *J. Sci. Food Agric*., 95: 1321-1327.

Loutfy, I., I.M. Aref and A.I.M. Ahmed. 2008. Response of *Eucalyptus camaldulensis*, *Eucalyptus microtheca* and *Eucalyptus intertexta* seedlings to irrigation with saline water. *World J. Agric. Sci*., 4: 825-834.

Marschner, H. 1995. Mineral nutrition of higher plants. London: Academic Press.

Munns, R and M. Tester. 2008. Mechanisms of salinity tolerance. *Ann. Rev. Plant Biol.*, 59: 651-681.

Munns, R. 2002. Comparative physiology of salt and water stress. *Plant, Cell & Environ.*, 25: 239-250.

Otte, M.L. 2001. What is stress to a wetland plants? *Environ. Exp. Bot*., 46: 195-202.

Panuccio, M.R., S.E. Jacobsen, S.S. Akhtar and A. Muscolo. 2014. Effect of saline water irrigation on seed germination and early seedling growth of the halophyte quinoa. *AoB Plants*, 6: plu047.

Porcelli, C.A., F.H.G. Boem and R.S. Lavado. 1995. The K/Na and Ca/Na ratios and rapeseed yield, under soil salinity or sodicity. *Plant Soil*, 175: 251-255.

Qureshi, R. 2004. Floristic and Ethno botany Study of Desert-Nara Region, PhD. Thesis HEC Islamabad.

Ramoliya, P.J., H.M. Patel and A.N. Pandey. 2004. Effect of salinization of soil on growth and macro- and micronutrient accumulation in seedlings of *Salvadora persica* (Salvadoraceae). *Forest Ecology and Management*, 202: 181-193.

Rhizopoulou, S., K. Heberlein and A. Kassianou. 1997. Field water relations of *Capparis spinosa* L. *J. Arid Environ*., 36: 237-248.

Rowell, D.L. 1994. Soil Science methods and applications. Addison Wesley Longman Ltd, Edinbourgh Gate, Harlow, Essex, Cm2 O.J.E, England.

Seema, A.H. and A.N. Pandey. 2008. Growth, water status and nutrient accumulation of seedlings of *Acacia senegal* (L.) Willd. in response to soil salinity. *Anales de Biología*, 30: 17-21.

Shahid, M, R. Tassadduq, I. Muhammad, I. Mazhar, Ihtisham-ul-Haq and S. Muhammad. 2015. Effect of plastic mulch and different irrigation practices on soil properties, nutrient contents and their availablity in maize. *J. Envorn. Agric. Sci*., 3: 35-41.

Siddiqi, E.H., M. Ashraf, F. Al-Qurainy and N.A. Akram. 2011. Salt-induced modu- lation in inorganic nutrients, antioxidant enzymes, proline content and seed oil composition in safflower (*Carthamus tinctorius* L.). *J. Sci. Food Agric*., 91: 2785-2793.

Taiz, L. and E. Zeiger. 2006. Plant physiology, 4th ed. Sunderland, Massachusetts: Sinauer Associates, Inc.

Tasneem, K., H. Naveed, A. Amjad, U. Asmat, A. Muhammad and A. Ashfaq. 2016. Quantification of root-shoot development and water use efficiency in autumn maize (*Zea mays* L) under different irrigation strategies. *J. Envorn. Agric. Sci*., 6: 16-22.

Varol, T., H.B. Ozel and N. Bilir. 2017. Drought effects on productivr and growth characteristics in seed orchards. *Pak. J. Bot.*, 49(4): 1225-1229.

Wang, J.L., X.J. Huang, T.Y. Zhong and Z.G. Chen. 2013. Climate change impacts and adaptation for saline agriculture in north Jiangsu Province, China. *Environ. Sci. Pol*., 25: 83-93.

William, V.D. and S.E. Sharon. 1981. Isolation, assay, biosynthesis, metabolism; uptake and translocation and function of proline in plant cells and tissue. *The Bot. Rev*., 47: 350-361.

Wood, H. and K. Awang. 1998. Acacias for Amenity Planting and Environmental Conservation. Proc. of the 3rd Meeting of the Consultative Group for Research and Development of Acacias, Kuala Lumpur, Malaysia.

(Received for publication 15 February 2017)