Journal of Medicinal Plants Research Vol. 5(14), pp. 3236-3241, 18 July, 2011
Available online at http://www.academicjournals.org/JMPR
ISSN 1996-0875 ©2011 Academic Journals

Full Length Research Paper

Influence of salt-priming on mucilage yield of Isabgol (*Plantago ovata* Forsk) under salinity stress

Kazem Ghassemi-Golezani*, Afsaneh Chadordooz-Jeddi and Parisa Zafarani-Moattar

Department of Agronomy and Plant Breeding, Faculty of Agriculture, University of Tabriz, Tabriz, Iran.

Accepted 11 April, 2011

Seeds of Isabgol (*Plantago ovata* Forsk) were divided into three sub-samples, one of which was kept as control (unprimed), a sub-sample was soaked in 0.8% NaCl solution and another sub-sample was pretreated with 0.8% KNO_3 solution for 4 h in an incubator adjusted to 15°C. In laboratory, the highest germination rate and seedling dry weight were obtained by seeds primed with KNO_3. In the greenhouse, means of plant biomass, grain and mucilage yields per plant decreased with increasing salinity. The highest grain and mucilage yields were produced by the plants from seeds primed with KNO_3, which were not significantly different from those primed with NaCl. Neither salinity nor salt-priming had significant effect on turgidity coefficient and mucilage percentage. No significant interaction of salinity × salt-priming on Isabgol performance suggested that salt-priming can improve grain and mucilage yields of this medicinal plant under both saline and non-saline conditions. Therefore, salt-priming can be used to promote seed germination rate, seedling dry weight and grain yield of Isabgol which ultimately can enhance mucilage production.

Key words: Germination rate, Isabgol, mucilage yield, salt-priming, seedling dry weight.

INTRODUCTION

Salinity adversely reduces the overall productivity of plants by inducing numerous abnormal morphological, physiological and biochemical changes that cause delayed germination, poor stand establishment (Almansouri et al., 2001), high seedling mortality, stunted growth and lower yields (Allakhverdiev et al., 2000; Muhammad and Hussain, 2010). High salt (NaCl) uptake competes with the uptake of other nutrient ions, especially K^+, leading to K^+ deficiency. Increasing NaCl salinity induces Na^+ and Cl^- enhancement and decreases Ca^{2+}, K^+, and Mg^{2+} levels in a number of plants (Khan et al., 1999, 2000; Khan, 2001). The adverse effects of salt stress may be alleviated by seed priming (Ashraf and Foolad, 2005). Seed priming is soaking of seeds in a solution of any priming agent followed by drying of seeds that initiates germination related processes without radicle emergence (McDonald, 1999). Common priming techniques include osmo-priming (soaking seeds in osmotic solutions), halo-priming (soaking seeds in salt solutions) and hydro-priming (soaking seeds in water) (Ghassemi-Golezani et al., 2008a). Seed priming has been reported to improve seed germination and seedling emergence (Abdulrahmani et al., 2007; Ghassemi-Golezani et al., 2008a, b; Ghassemi-Golezani et al., 2010a, b). Seeds with more rapid germination under salt stress may be expected to achieve a high final germination percentage and rapid seedling establishment (Rogers et al., 1995) and hence, ultimate yield.

For the first time, Strogonov (1964) proposed that salt tolerance of plants could be enhanced by treatment of seed with salt solution prior to sowing. Cayuela et al. (1996) have concluded that, the higher salt tolerance of plants from primed seeds seems to be the result of a higher capacity for osmotic adjustment, since plants from primed seeds have more Na and Cl in roots and more sugars and organic acids in leaves than plants from unprimed seeds. Successful results of priming have been obtained for wheat (Mehta et al., 1979), tomato (Cano et al., 1991; Pill et al., 1991; Cayuela et al., 1996), rice (Chang-Zheng et al., 2002), melon (Sivritepe et al., 2003) and cucumber (Esmaielpour et al., 2006) under saline conditions.

However, we did not find any report about the effects of

*Corresponding author. E-mail: golezani@gmail.com Tel: +98411-3392028.

Table 1. Means of germination rate and seedling dry weight of Isabgol affected by salt-priming.

Treatment	Germination rate (per day)	Seedling dry weight (mg)
Control	0.3575ab	7.250b
NaCl	0.3475b	7.500b
KNO_3	0.4500a	9.250a

Different letters in each column indicate significant difference at p≤0.05.

salt-priming on performance of Isabgol (*Plantago ovata* Forsk) under salinity stress. The husk derived from the seeds of Isabgol is used as emollient, demulcent and laxative and in the treatment of dysentery and diarrhea (Chopra et al., 1958).

Thus, this research was aimed to evaluate the influence of salt-priming on seed germination, seedling vigor and grain and mucilage yields of Isabgol under saline and non-saline conditions.

MATERIALS AND METHODS

Seeds of Isabgol (*P. ovata* Forsk) were divided into three sub-samples, one of which was kept as control (unprimed) and two other sub-samples were prepared for priming treatments. Seeds of a sub-sample were soaked in 0.8% NaCl solution with electrical conductivity of 15.3 dSm^{-1} and seeds of another sub-sample were pretreated by 0.8% KNO_3 solution with electrical conductivity of 12.5 dSm^{-1} (Ghassemi-Golezani et al., 2010b) for 4 h in an incubator adjusted to 15°C. After priming, seeds were washed with distilled water for 1 min and then dried back to primary moisture at 20 to 23°C in the laboratory. All the seeds were treated with Benomyl at a rate of 2g kg^{-1}. Laboratory tests were carried out with RCB design at the Seed Technology Laboratory of the University of Tabriz, Iran. Four replicates of 25 seeds were placed between moist filter papers and germinated in an incubator adjusted on 20°C for 21 days. Germination (protrusion time for radicle by 2 mm) was recorded in daily intervals. At the end, seedling dry weight was determined. Rate of seed germination ($\overline{\mathbf{R}}$) was calculated according to Ellis and Roberts (1980):

$$\overline{\mathbf{R}} = \sum n / \sum (D \times n)$$

Where n is the number of seeds germinated on day D and D is the number of days counted from the beginning of the test.

An experiment was conducted in the Greenhouse of the University of Tabriz in 2010. The experiment was arranged as factorial, based on RCB design with three replications. Ten seeds were sown 1 cm deep in each pot filled with 800 g perlite using 36 plastic pots. Salinity treatments (0, 4, 8, 12 $dS.m^{-1}$) were applied immediately after sowing. Tap water and saline solutions were added to the pots in accordance with the treatments to achieve 100% FC. After emergence, seedlings were thinned to keep four plants in each pot. During the growth period, the pots were weighed and the losses were made up with Hoagland solution (EC=2 dS/m).

Perlites within the pots were washed every 20 days and non-saline and salinity treatments were reapplied, in order to prevent further increase in electrical conductivity (EC), due to adding Hoagland solution. At maturity, plants from each pot were harvested and biomass and grain yield per plant was determined. Turgidity coefficient was measured according to Patel et al. (1996). Mucilage percentage of Isabgol was calculated according to Sharma and Koul (1986) and subsequently mucilage yield per plant for each treatment at each replicate was determined. Analysis of variance of the data was carried out using MSTATC software. Duncan test was applied to compare means of each trait at P≤0.05. Excel software was used to draw figures.

RESULTS AND DISCUSSION

Analysis of variance of the laboratory data indicated that, the rate of seed germination and seedling dry weight were significantly affected by salt-priming (P≤0.05). The highest germination rate and seedling dry weight were recorded for seeds primed with KNO_3. However, germination rate and seedling dry weight of unprimed and primed seeds with NaCl were almost similar (Table 1). It might be due to early synthesis of nucleic acids e.g. DNA, RNA and proteins during salt hydration process, which ultimately resulted in improved energy of germination of seeds (Bray et al*.,* 1989; Dell'Aquila and Bewley, 1989). Rapid germination of seeds ultimately could lead to the production of larger seedlings (Abdulrahmani et al., 2007; Ghassemi-Golezani et al., 2008b; Ghassemi-Golezani et al., 2010a, b).

The positive effects of osmo-priming on seed germination and seedling growth were also reported for barley (Abdulrahmani et al., 2007), cucumber (Ghassemi-Golezani and Esmaeilpour, 2008), fennel (Neamatollahi et al., 2009) and winter rapeseed (Ghassemi-Golezani et al., 2010b). The effect of salinity on plant biomass, grain yield per plant and mucilage yield was significant, but on turgidity coefficient and mucilage percentage was not. Salt-priming had only significant effect on grain yield per plant. Interaction of salinity × salt-priming for these traits was not significant (Table 2). Mean plant biomass of Isabgol decreased, as salinity increased. This reduction was only significant under 8 nd 12 dS/m NaCl salinity.

Plant biomass under 4 dS/m salinity and non-saline condition was statistically similar (Figure 1). Reduction in plant biomass due to salinity was also reported for maize and sunflower (Katerji et al., 1996) and wheat (Yildirim and Bilge, 2010). Means of grain yield per plant decreased with increasing salinity. However, grain yield per plant under 0 and 4 dS/m salinity were statistically similar (Figure 2). Reduction in grain yield due to salinity

Table 2. Analysis of variance of the effects of salt-priming on grain yield per plant, turgidity coefficient, mucilage percentage and yield of Isabgol under salinity stress.

		MS				
Source of variation	**d.f**	**Plant biomass**	**Grain yield per plant**	**Turgidity coefficient**	**Mucilage percentage**	**Mucilage yield**
Replication	2	0.100	0.006	0.174	8.275	0.002
Salinity (A)	3	2.988**	2.276**	0.137	3.491	0.067**
Priming (B)	2	0.722	0.536*	0.049	0.166	0.012
A*B	6	0.115	0.064	0.012	0.150	0.002
Error	22	0.349	0.148	0.166	4.159	0.005
%CV	-	8.63	18.48	19.69	13.71	23.56

*, **: Statistically significant at $p \leq 0.05$ and $p \leq 0.01$, respectively.

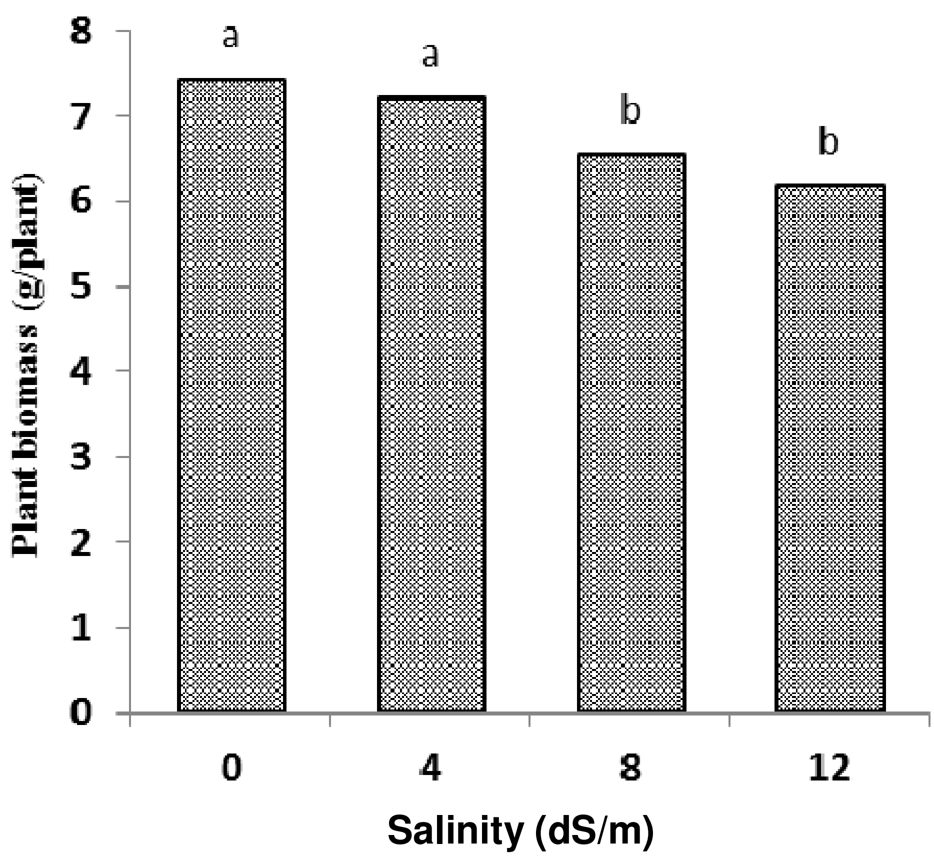

Figure 1. Mean plant biomass of Isabgol affected by salinity stress.

stress was also reported for broad beans (Katerji et al., 1992), maize and sunflower (Katerji et al., 1996), cotton and wheat (Çullu, 2003), rice (Mahmood et al., 2009) and soybean (Ghassemi-Golezani et al., 2010c). Salinity may delay the onset, reduce the rate, and increase the dispersion of germination events, leading to reductions in plant growth and final crop yield (Ashraf and Foolad, 2005). Disturbed water and nutritional balance of plants may cause reduced crop yield in saline conditions (Muhammad and Hussain, 2010). Mean mucilage yield for 8 and 12 dS/m NaCl salinity was significantly lower than that for 0 and 4 dS/m NaCl salinity (Figure 3). This reduction in mucilage yield directly related with deductions in grain yield per plant under high salinity treatments (Figure 2), since mucilage percentage was not significantly affected by salinity stress (Table 2).

Salt-priming increased grain yield per plant of Isabgol. The highest grain yield was produced by the

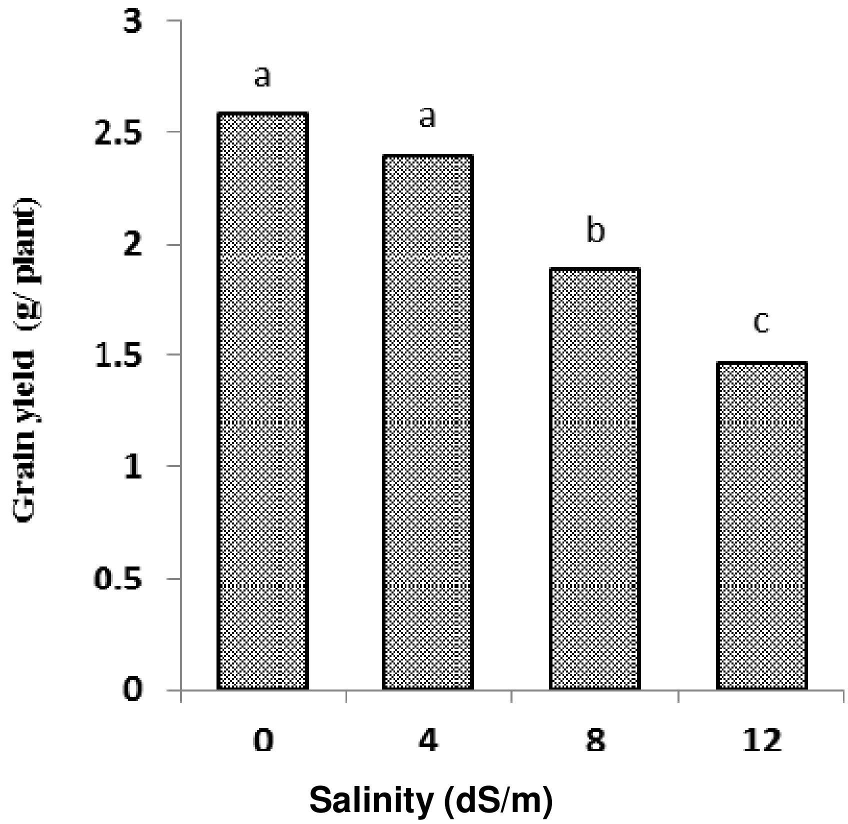

Figure 2. Mean grain yield per plant of Isabgol affected by salinity stress.

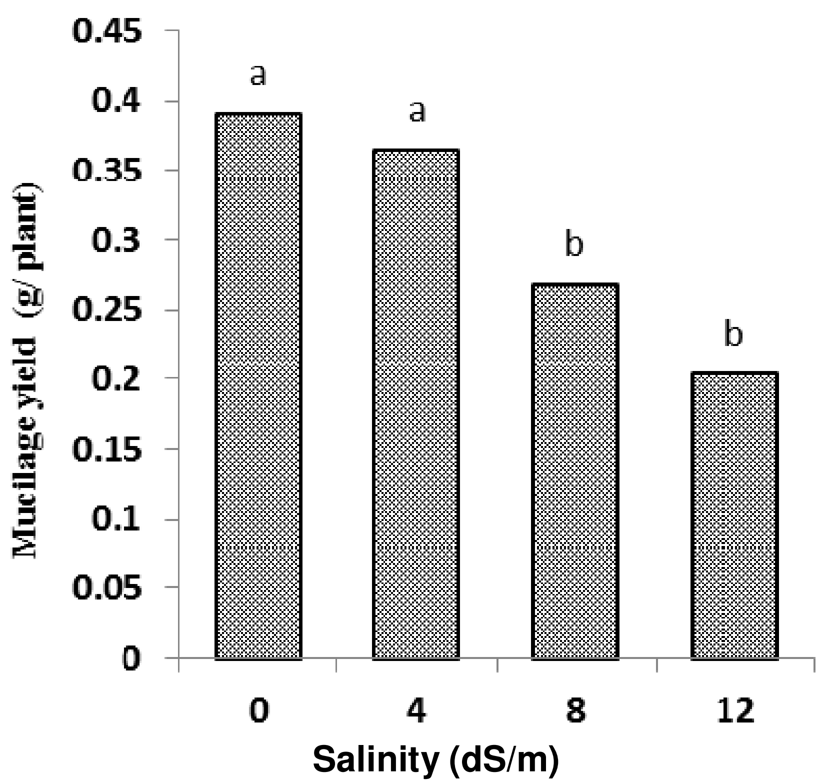

Figure 3. Mean mucilage yield of Isabgol under saline and non-saline conditions.

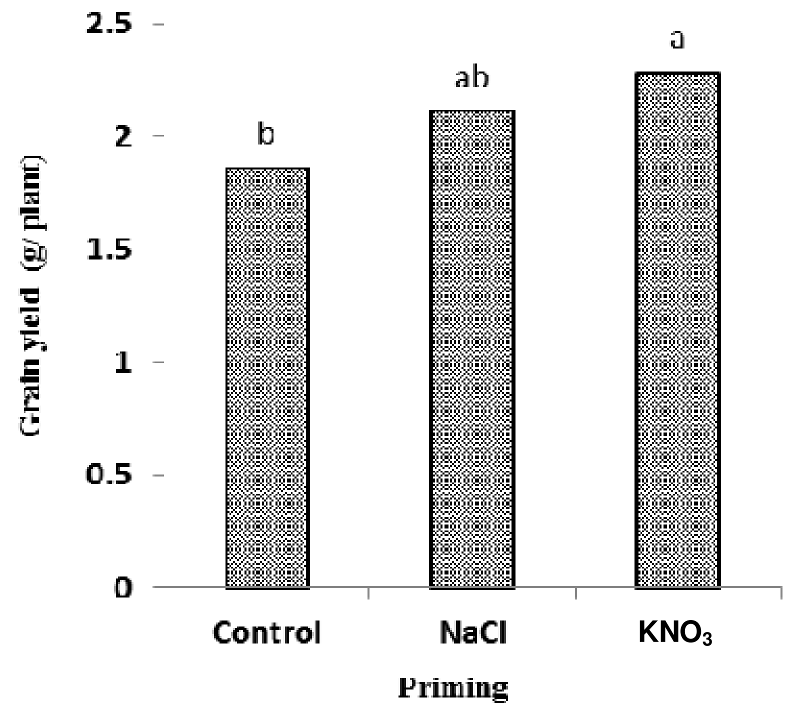

Figure 4. Mean grain yield per plant of Isabgol affected by salt-priming.

plants from seeds primed with KNO_3, which was not significantly different from those primed with NaCl (Figure 4). Seed priming has been used to improve germination, seedling emergence and yield (Khan, 1992). No significant interaction of salinity × salt-priming on Isabgol performance (Table 2) suggest that, salt-priming can improve grain yield of this medicinal plant under both saline and non-saline conditions. Priming with KNO_3 and NaCl quantitatively (but not significantly) increased mucilage yield by 22% and 14%, respectively. Therefore, salt-priming can be used to promote seed germination rate, seedling dry weight and grain yield of Isabgol which ultimately can enhance mucilage production.

REFERENCES

Abdulrahmani B, Ghassemi-Golezani K, Valizadeh M, Feizi-Asl V (2007). Seed priming and seedling establishment of barly (*Hordeum vulgare* L.). J. Food Agric. Environ., 5: 179-184.

Allakhverdiev SI, Sakamoto A, Nishiyama Y, Inaba M, Murata N (2000). Ionic and osmotic effects of NaCl-induced inactivation of photosystems I and II in *Synechococcus* sp. Plant Physiol., 123: 1047-1056.

Almansouri M, Kinet JM, Lutts S (2001). Effect of salt and osmotic stresses on germination in durum wheat (*Triticum durum* Desf.). Plant Soil, 231: 243-254.

Ashraf M, Foolad MR (2005). Pre-sowing seed treatment: A shotgun approach to improve germination, plant growth and crop yield under saline and non-saline conditions. Adv. Agron., 88: 223-271.

Bray CM, Davison PA, Ashraf M, Taylor RM (1989). Biochemical changes during priming of leek seeds. Ann. Bot., 63: 185-193.

Cano EA, Bolarin MC, Perez AF, Caro M (1991). Effect of NaCl priming on increased salt tolerance in tomato. J. Hortic. Sci., 66: 621-628.

Cayuela E, Perez AF, Caro M, Bolarin MC (1996). Priming of seeds with NaCl induces physiological changes in tomato plants grown under salt stress. Physiol. Plant, 96: 231-236.

Chang-Zheng H, Jin H, Zhi-Yu Z, Song-Lin R, Wen-Jian S (2002). Effect of seed priming with mixed-salt solution on germination and physiological characteristics of seedling in rice (*Oryza sativa* L.) under stress conditions. J. Zhejiang Univ. Agric. Life Sci., 28: 175-178.

Chopra RN, Chopra IC, Handa KL, Kapur LD (1958). Chopra's indigenous drugs of India. UN Dhur and Sons Pvt, Calcutta.

Çullu MA (2003). Estimation of the effect of soil salinity on crop yield using remote sensing and geographic information system. Turk. J. Agric For., 27: 23-28.

Dell'Aquila A, Bewley JD (1989). Protein synthesis in the axes of polyethylene glycol treated pea seeds and during subsequent germination. J. Exp. Bot., 40: 1001-1007.

Ellis RH, Roberts EH (1980). Towards a Rational Basis for Testing Seed Quality. In: Hebblethwaite PD. (ed) Seed Production. Butterworths, London, pp. 605-635.

Esmaielpour B, Ghassemi-Golezani K, Rahimzadeh K F, Gregoorian V, Toorchi M (2006). The effect of NaCl priming on cucumber seedling growth under salinity stress. J. Food. Agric. Environ., 4: 347-349.

Ghassemi-Golezani K, Aliloo AA, Valizadeh M, Moghaddam M (2008a). Effects of different priming techniques on seed invigoration and seedling establishment of lentil (*Lens culinaris* Medik). J. Food Agric. Environ., 6: 222-226.

Ghassemi-Golezani K, Chadordooz-Jeddi A, Nasrollahzadeh S, Moghaddam M (2010a). Effects of hydro-priming duration on seedling vigour and grain yield of pinto bean (*Phaseolus Vulgaris* L.) cultivars. Not. Bot. Hortic. Agrobot. Cluj., 38: 109-113.

Ghassemi-Golezani K, Esmaeilpour B (2008). The effect of salt priming on the performance of differentially matured cucumber (*Cucumis sativus*) seeds. Not. Bot. Hortic. Agrobot. Cluj., 36: 67-70.

Ghassemi-Golezani K, Jabbarpour S, Zehtab-Salmasi S, Mohammadi A (2010b). Response of winter rapeseed (*Brassica napus* L.) cultivars to salt priming of seeds. Afr. J. Agric. Res., 5: 1089-1094.

Ghassemi-Golezani K, Sheikhzadeh-Mosaddegh P, Valizadeh M (2008b). Effects of hydro-priming duration and limited irrigation on field performance of chickpea. Res. J. Seed Sci., 1: 34-40.

Ghassemi-Golezani K, Taifeh NM, Oustan S, Moghaddam M, Seyyed RS (2010c). Oil and protein accumulation in soybean grains under salinity stress. Not. Sci. Biol., 2: 64-67.

Katerji N, Van Hoorn JW, Hamdy A, Bouzid N, El-Sayed Mahrous S, Mastrorilli M (1992). Effect of salinity on water stress, growth and yield of broadbeans. Agric. Water Manage., 21: 107-117.

Katerji N, Van Hoorn JW, Hamdy A, Karam F, Mastrorilli A (1996). Effect of salinity on water stress, growth and yield of maize and sunflower. Agric. Water Manage, 30: 237-249.

Khan AA (1992). Preplant physiological seed conditioning. Hortic. Rev., 14: 131-181.

Khan MA (2001). Experimental assessment of salinity tolerance of Ceriops tagal seedlings and saplings from the Indus delta, Pak. Aquat. Bot., 70: 259-268.

Khan MA, Ungar IA, Showalter AM (1999). Effects of salinity on growth, ion content and osmotic relations in *Halopyrum mocoronatum* (L.) Stapf. J. Plant Nutr., 22: 191-204.

Khan MA, Ungar IA, Showalter AM (2000). Effects of sodium chloride treatments on growth and ion accumulation of the halophyte *Haloxylon recurvum*. Commun. Soil Sci. Plant Anal., 31: 2763-2774.

Mahmood A, Latif T, Khan MA (2009). Effect of salinity on growth, yield and yield components in basmati rice germplasm. Pak. J. Bot., 41: 3035-3045.

McDonald MB (1999). Seed deterioration: Physiology, repair and assessment. Seed Sci. Technol., 27: 177-237.

Mehta PC, Puntamkar SS, Seth SP (1979). Effect of pre-soaking of seeds in different salts with varying concentration on the germination and yield of wheat grown on salinized soil. New Agric., 6: 73-76.

Muhammad Z, Hussain F (2010). Vegetative growth performance of five medicinal plants under NaCl salt stress. Pak. J. Bot., 42: 303-316.

Neamatollahi E, Bannayan M, Ghanbari A, Haydari M, Ahmadian A (2009). Does hydro and osmo-priming improve fennel (*Foeniculum vulgare*) seeds germination and seedlings growth? Not. Bot. Hortic. Agrobot. Cluj., 37: 190-194.

Patel BS, Patel JC, Sadaria SG (1996). Response of blond psyllium (*Plantago ovata*) to irrigation and phosphorus. Indian J. Agron., 41: 311-314.

Pill WG, Frett JJ, Morneau DC (1991). Germination and seedling emergence of primed tomato and asparagus seeds under adverse conditions. Hortic. Sci., 26: 1160-1162.

Rogers ME, Noble CL, Halloran GM, Nicolas ME (1995). The effect of NaCl on the germination and early seedling growth of white clover (*Trifolium repens* L.) populations selected for high and low salinity tolerance. Seed Sci. Technol., 23: 277-278.

Sharma PK, Koul A (1986). Mucilage in seeds of *Plantago ovata* and its wild allies. J. Ethnopharmacol., 17: 289-295.

Sivritepe N, Sivritepe HO, Eris A (2003). The effect of NaCl priming on salt tolerance in melon seedling grown under saline conditions. Sci. Hortic., 97: 229-237.

Strogonov BP (1964). Practical means for increasing salt tolerance of plants as related to type of salinity in the soil. In: PoljakoVMayber A, Meyer AA (eds) Physiological basis of salt tolerance of plants. Israel program for scientific translations Ltd, Jerusalem, pp. 218-244.

Yildirim M, Bilge B (2010). Responses of some wheat genotypes and their F2 progenies to salinity and heat stress. Sci. Res. Essays, 5: 1734-1741.