Pak. J. Bot., 38(3): 613-622, 2006.

EFFECT OF SEED PRIMING ON GROWTH OF BARLEY (*HORDEUM VULGARE*) BY USING BRACKISH WATER IN SALT AFFECTED SOILS

M.A. NAEEM AND S. MUHAMMAD

Department of Soil Science & SWC,
University of Arid Agriculture, Rawalpindi, Pakistan.

Abstract

Impact of different pre-sowing seed treatments on growth of barley by using brackish water for irrigation in different combinations of $CaSO_4$ (10 mM), $CaSO_4$ (30 mM), Gibberellic Acid (20 ppm), Gibberellic Acid (60 ppm) and hydro priming for 12 h were investigated in pot experiment. Artificially prepared brackish water was used for irrigation throughout the crop growth period. Maximum seed germination was observed in treatment with GA_3 (20 ppm followed by $CaSO_4$ (10 mM) while the minimum in farmer practice treatment (control). Similar trend was found in the straw yield. Highest Na^+ concentration was observed in leaves of plants in pre-sowing seed treatment with GA_3 (20 ppm) with a median content of 50.25 ppm while minimum in hydro priming for 12 h. Similar trend was found in the K^+, Ca^{2+} and Mg^{2+}analyzed at the booting stage. Highest Cl^- concentration was observed in plant with median content of 150.03 ppm, while minimum in $CaSO_4$ (10 mM) in the leaf of barley at booting stage with a median content of 125.03 ppm respectively. The maximum Na^+: K^+ ratio in the plant leaf was observed in control (farmer practice) with a median content of 0.280 and lowest in $CaSO_4$ (10 mM) with a median content of 0.226. The Ca^{2+}: Mg^{2+} ratios were observed maximum almost in all the primed treatments than farmer practice (control).

Introduction

In marginal lands and rainfed areas, patchy plant stands often result from the failure of seed to emerge quickly and uniformly. Seed germination is a serious problem in saline and alkaline soils. The yield of most of crops is reduced because enough seeds could not germinate and plants that eventually emerge often grow very slowly that are susceptible to drought, pests and disease infection. Wheat is the most important cereal crop grown in rotation with chickpea in rainfed areas and with cotton or rice in irrigated areas.

Pakistan, despite having the largest contiguous gravity flow canal system for irrigation, is falling short of good quality water due to increased cropping intensity and droughts over the years (Ghafoor, 1999). The rate of water absorption in initial 24 hours of imbibitions could improve the seedling vigor. This was reflected through an increase in shoot weight by allowing the seed to imbibe slowly in 25% polyethylene glycol 6000 (Ehsanullah & Smith, 2002). Priming is a non expensive and value added practice that greatly improve yield. This might be due to some biochemical and physiological changes brought about by seed soaking (Khan *et al.,* 2002*).* The stimulatory effect of hormones on wheat plants suggests that presoaking of seed with auxins may be advantageous for germination and seedling development under saline conditions (Channa *et al.,* 2002*).* The improved germination of primed seeds may therefore, be attributed to counteraction of free radicals and re-synthesis of membrane bound enzymes as in unprimed seeds (Srinivasan & Saxena, 2001). Harmful effects of salt stress on growth and carbohydrate metabolisms in barley seedlings may be alleviated through presoaking of seeds (Roy &

Srivastava, 1999). Amelioration of salinity induced inhibition of growth and development is due to enhanced N-status and Nitrate Reductase activity mediated through plant growth regulators (Angrish *et al.*, 2000). Reduction in growth under salinity could not be related to a single factor but it is the result of various adversely affected physiological and biochemical processes (Khatkar & Kushad, 1999; Raza *et al*., 2006). The different soaking-drying treatments are highly effective in maintaining viability and vigor in most seeds, except leguminous seeds because soaking injury is observed due to rapid up take of water (Som & Chattopadhyay, 1996). Hydration-dehydration in water or solutions of NaCI, benzoic acid and NaH_2P0_4 recorded significantly higher values for total dry matter production than that for the control treatments (Singh & Joythi, 1995). The seed treatment with hormone and salt solution might have increased the metabolic activity of the plant in such a direction as to result in increased uptake of N, P, K^+ and Ca^{2+} (Chippa & Lal, 1988). The objective of the present study was to evaluate the impact of seed soaking on the growth of barley with brackish water irrigation in salt affected soils. Although a lot of work has been done on this aspect the present study will provide latest references.

Materials and Methods

Experimental procedure: Soil used in the present study was collected from central Punjab, in the region of Hafizabad, Pakistan. Soil properties (Table 1) were determined as described by Muhammad *et al*., (2005). In June 2004-2005, the soil was sampled at 0-15 cm depth, sieved (< 2 mm) and transported to Soil Salinity Research Institute, Pindi Bhattian, Hafizabad.

The experiment was carried out in a greenhouse with three replications and six treatments all with barley crop (*Hordeum valgare*): (1) control, (2) Seed treatment with $CaSO_4$ 10 mM (3) Seed treatment with $CaSO_4$ 30 m M, (4) Seed treatment with GA_3 20 ppm, (5) Seed treatment with GA_3 60 ppm (6) Hydro-priming seed treatment for 12 hours. Soil (12.50 kg) was filled in each experimental pot. The brackish water having EC of 3 ds m^{-1}, SAR15 $(mmol_c\ L^{-1})^{1/2}$ and RSC 1 $mmol_c\ L^{-1}$ was used for irrigation.

Physical and chemical properties: Soil textural analysis was carried out after treatment of 30 g soil with 7% H_2O_2 for two weeks, removal of carbonate with 10% HCl, suspension in [Na $(PO_3)_6$], sieving through a sieve with 63 µm diameter and weighing of the sand fraction. The remaining sample <63 µm was processed further for clay and silt determination by a pipette method. Soil pH was measured using a soil standard paste. Electrical conductivity (EC) was also estimated using a soil paste extract.

Amount and composition of soluble salts were determined after suspending 5 g soil in 50 ml distilled water for 1 h and centrifugation at 2000 g. The concentrations of Na^+, K^+, Mg^{2+}, and Ca^{2+} were determined by atomic absorption spectrometry. The sodium adsorption ratio (SAR) was calculated as:

$$\mathrm{SAR} = \frac{[Na^+]}{\sqrt{0.5([Ca^{2+}]+[Mg^{2+}])}}$$

Table 1. Chemical analysis of the soil before the start of the experiment.

Parameters	Values
pH_s	7.98
EC_e	7.43 dS m^{-1}
TSS	80.80 $mmol_e$ L^{-1}
CO_3^{2-}	Absent
HCO_3^-	3.8 $mmol_e$ L^{-1}
CI^-	38.5 $mmol_e$ L^{-1}
$Ca^{2+} + Mg^{2+}$	17.5 $mmol_e$ L^{-1}
Na^+	63.3 $mmol_e$ L^{-1}
SAR	21.4 ($mmol_e$ L^{-1}) ½

Table 2. Growth response of barley.

Treatments	Germination %	No. of hills per pot	No. of tillers per hill	Plant height (cm)	Straw yield (tons/ha)
Control	80c	7	3	51a	3.31ab
$CaSO_4$ (10 mM)	90b	7	3	50a	3.95b
$CaSO_4$ (30 mM)	99a	7	3	50a	3.58b
GA_3 (20 ppm)	100a	7	3	49a	4.09a
GA_3 (60 ppm)	99a	7	3	50a	3.98b
Hydropriming 12h	100a	7	2	50a	4.53a
LSD	5.27**	-	0.43818*	3.534 NS	0.657*

Results

Growth parameters of the barley crop including germination % age, number of hills per pot, number of tillers per hill, plant height and straw yield as affected by seed priming are seriated in Table 2. Barley seed primed with GA_3 (20 ppm) showed significant increase in germination followed by $CaSO_4$ (10 mM), $CaSO_4$ (30 mM), GA_3 (60 ppm) and hydro-priming for 12 hours respectively while, minimum germination percentage was observed in control treatment. Similarly, significant increase in straw yield was observed in seed primed with Gibrellic Acid (20 ppm), and hydro priming seed treatment for 12 hours, with a median of 4.53 tons ha^{-1} and 4.1 tons ha^{-1} while minimum in control followed by pre-sowing seed treatment with $CaSO_4$ (10 mM), $CaSO_4$ (30 mM), and GA_3 (60 ppm) with median of 3.31 tons ha^{-1}, 3.9 tons ha^{-1}, 3.9 tons ha^{-1} and 3.9 tons ha^{-1} respectively. Highest Na^+ concentration was observed in control treatment followed by pre-sowing seed with GA_3 (20 ppm) with a median of 50.3 ppm and 50.1 ppm while lowest Na^+ concentration was observed in hydro priming for 12 hours in the leaf of barley at booting stage with a median of 44.32 ppm (Table 3). Maximum Potassium concentration was observed at booting stage in pre-sowing seed treatment with GA_3 (20 ppm), with a median of 221.6 ppm while lowest in pre-sowing seed treatment with pre-sowing seed treatment for 12 hours and GA_3 (60 ppm) with median of 177.57 ppm. Maximum calcium concentration was observed in the pre-sowing seed treatment with GA_3 (20 ppm), with a median of 9.88 ppm (Table 2), while minimum in seed treatments for 12 hours, with a median of 7.40 ppm. Maximum magnesium concentration was observed in the pre-sowing seed treatment with GA_3 (20 ppm), with a median of 28.12 ppm of the treatment sum (Table 3), while minimum in farmer practice, pre-sowing seed treatment for 12 hours with a median of 20.29 ppm. Maximum concentration of chloride was observed in the pre-sowing seed in control, with a median content of 150.0 ppm, while lowest in GA_3 (20 ppm) with a median of 125.03 ppm (Table 2).

Table 3. Chemical analysis of leaf of barley at booting stage.

Treatments	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	Na^+: K^+	Ca^{2+}: Mg^{2+}
	ppm						
Control	50.25a	183.2b	7.40c	27.52ab	150.03	0.280	0268
$CaSO_4$ (10 mM)	48.33a	188.9b	8.57bc	21.78b	133.38	0.267	0408
$CaSO_4$ (30 mM)	49.42a	187.9b	8.77bc	21.93b	125.03	0.263	0399
GA_3 (20ppm)	50 .13a	221.6a	9.88a	28.12a	137.89	0.226	0.35I
GA_3 (60ppm)	44.59a	177.Sb	7.79bc	20.29b	125.50	0.25I	0384
Hydro priming 12h	44.32a	180.8b	8.87ab	22.78b	125.61	0.245	0389
LSD	12.49NS	28.46*	1.29*	2.90**	34.01NS		

Table 4. Chemical analysis of straw after harvesting.

Treatments	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^{-1}	Na^+: K^+	Ca^{2+}: Mg^{2+}
	ppm						
Control	944.68b	365.75a	79.68a	162.55b	13.76a	2.583	0.491
$CaSO_4$ (10 mM)	1058.33a	390.53a	55.4b	178.89a	8.76c	2.710	0.309
$CaSO_4$ (30 mM)	856.04c	372.61a	46.39c	151.70c	10.64bc	2.345	0.306
GA_3 (20ppm)	921.03b	384.33a	43.96c	169.57b	5.78d	2.396	0.260
GA_3 (60ppm)	860.34c	368.51a	50.69c	166.04b	6.75d	2.334	0.305
Hydro-priming 12h	943.35b	401.32a	57.58b	154.87c	10.79b	2.36	0.371
LSD	51.02^{**}	34.42^{Ns}	8.31**	7.60**	1.99**		

The highest Na^+: K^+ ratio was observed in the plant leaf cell cap in control treament with a median content of 0.280, while lowest in Seed treatment with $CaSO_4$ (30 mM) with a median of 0.226 ppm. The highest Ca^{2+}: Mg^{2+} ratio was observed in the plant leaf with a median content of 0.408 while lowest in Seed treatment with $CaSO_4$ (30 mM).

Highest concentration of Na^+ in plant straw was observed in the seed primed with $CaSO_4$ (10 mM) with a median content of 1058 ppm, while lowest Na^+ concentration was observed in $CaSO_4$ (3 gm M) and 60 ppm GA_3 (Table 4). Maximum concentration of K^+ was observed in plants by hydro-priming seed treatment for 12 hours with a median content of 401.32 ppm, while lowest K^+ concentration was observed in control, in the straw of Barley with a median content of 365.75 ppm (Table 4). Highest Ca^{2+} concentration was observed in the control, with a median content of 79.68 ppm, while lowest in GA_3 (20 ppm) with a meadian of 43.96 ppm (Table 4).

Magnesium concentration was highest in the seed primed with $CaSO_4$ (10 mM) with a median content of 178.9 ppm, while lowest in control with a median of 151.70 ppm (Table 4).

A significant increase in Cl^{-1} concentration was observed in the control with a highest median 13.8 ppm, while lowest in hydro-priming seed treatment for 12 hours with a median content of 5.78 ppm (Table 4).

Highest Na^+: K^+ ratio in the wheat straw was observed in treatment 2 with a median content of 2.71 while lowest in treatment 4. The highest Ca^{2+}: Mg^{2+} ratio was observed in control treatment with median of 0.491 while lowest in treatment 3 with median of 0.260. Soil pHs, EC_e (dS m^{-1}) and SAR of soil were analyzed after the harvest of barley crop. Maximum EC_e was measured under the control soil, with a median content of 19.81 dS m^{-1}, while minimum EC_e was measured in $CaSO_4$ (30 mM 16.1 dS m^{-1} (Table 5). Maximum pH_s was measured in, GA_3 (60 ppm) and hydro-priming seed treatment in control, $CaSO_4$ (10 mM) with no significant difference with a median of 7.96 while minimum pH_s was measured in $CaSO_4$ (30 mM), control and GA_3 (20 ppm), in the soil after the harvest of barley crop, with a median content of 7.9, 7.9 and 7.9 respectively

(Table 5). Maximum Sodium Adsorption Ratio (SAR) was calculated in $CaSO_4$ (30 mM), with a median content of 17.5 (mM), while minimum SAR was observed in GA_3 (60 ppm) with median of 15.81 (Table 5).

Table 5. Chemical analysis of soil after harvest of barley crop.

Treatments	pHs	ECe (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$
Control	7.92ab	19.81a	16.09a
$CaSO_4$ (10 mM)	7.96a	17.80a	16.05a
$CaSO_4$ (30 mM)	7.94a	19.73a	17.49a
GA_3 (20ppm)	7.89b	18.05a	16.42a
GA_3 (60ppm)	7.96a	17.60a	16.44a
Hydro-priming 12h	7.96a	16.05a	15.81a
LSD	0.057*	3.51^{NS}	1.628^{NS}

Discussion

Brackish irrigation water adversely affects the germination of seed that ultimately causes reduction in crop yields. Brackish irrigation water also adversely affects the physico-chemical characteristics of soils that in turn results in low crop productivity. These effects can, however, be minimized by soaking seeds before sowing. In this study, impacts of seed soaking on growth of barley under brackish irrigation water in salt affected soil are being discussed. Increasing the agricultural growth rate, crop sustainability and soil productivity are the major challenges to the present day agriculture. Crop growth is limited by many soil and climatic factors, yields and production can however, be increased or sustained by adopting seed soaking techniques under the salinity stress conditions. Germination percentage was highest in seeds primed with GA_3 (20 ppm) and lowest in control treatment (farmer practice). The effect of treatments on germination was significant that might be due to some biochemical and physiological changes brought about the seed soaking by $CaSO_4.7H_20$, GA_3 and hydro-priming. Similar results were obtained by Khan *et al*., (2002). They reported that $CaSO_4$ creates conducive environment for the germination under saline conditions. GA_3 initiate germination while hydro-priming broke down dormancy in the seed by the activation of hydrolytic enzyme (alpha amylase). These results are in line with Qureshi *et al.*, (1990), Qureshi *et al*., (1991), Maas *et al*., (1996), Steppuhn & Wall (1997) and Greenway & Munns, (1980). Decrease in number of tillers with salinity has also been reported by Qureshi *et al*., (1990, 1991), Maas *et al*., (1996) and Steppuhn & Wall (1997). Reduction in the number of tillers with salinity could be attributed to toxicity of Na^+ and Cl^- in cytoplasm (Greenway & Munns, 1980). The treatments have no significant effect on the plant height. Maximum plant height was observed in the farmer practice while, minimum in seed priming with $CaSO_4$ (30 mM). Plant height was reduced almost in all the treatments due to higher concentration of salts in the experimental soil. The decrease in plant height could be attributed to less availability of water. Excess salts under saline conditions modify plant cell wall metabolic activities causing deposition of various materials thus limiting cell elasticity and thus turgor pressure which resulted in decrease in plant height. Similar results were obtained by Qureshi *et al*., (1990), Nadeem *el al*., (1995), Steppuhn & Wall (1997) and Aceves *et al.*, (1975). Reduction in the plant height due to salinity was also reported by Qureshi *et al*., (1990), Nadeem *et al*., (1995), Steppuhn & Wall (1997) in barley. The treatments have significant effect on straw yield. The highest straw yield was found in the treatment primed with GA_3 (60 ppm) and $CaSO_4$ (30 mM). The high straw yields in the seed primed with GA_3 (60 ppm) and $CaSO_4$ (30 mM) was attributed to GA_3 and $CaSO_4$ priming, which enhances germination and ultimately increases straw yield. The decrease in straw yield at salinity could be attributed to poor water absorption due to increased solutes in the soil solution. Also the increase in ion concentration in the leaf cell sap might be the cause of retardation of enzymatic processes. The direct toxic effect of sodium and chloride could be another reason. These results were found similar by Fitter & Hay (1981). Increase in the straw yield due to increasing cell size and activating the enzymatic process was reported by Fitter and Hay (1981).

The treatments differed non-significantly regarding the uptake of Na^+ in the cell sap of leaf at the booting stage. Maximum uptake of Na^+ in plant leaf was in control while, minimum in $CaSO_4$ (10 mM) and $CaSO_4$ (30 mM) treatments. Hence, higher Na^+ in leaf hampered the growth and development of leaf due to antagonistic effect with K^+ and vice versa. The reason for lower uptake of sodium is that GA_3 and hydro priming which exceeded the growth and development of the meristimatic tissue. This showed no significant effect on the uptake of Na^+ in plant leaf. Similar results were also reported by (Sinha & Haque, 2003 and Khan *et al*., 2002).

Maximum Potassium uptake in plant leaf at the booting stage was in pre-sowing seed with GA_3 (20 ppm) while, lowest in GA_3 (60 ppm). The treatments having non significant effect to each other. Accumulation of K^+ in the leaves activates the enzymatic activity, which involves in the opening and closing of stomata. So, the gypsum and GA_3 showed better growth of leaves by inhibiting the uptake of Na^+ ion. Similar results were reported by (Angrish *et al*., 2001 and Mass *et al*., 1996). Maximum uptake of Ca^{2+} in plant leaf at the booting stage was in pre-sowing seed with GA_3 (20 ppm) while, lowest in control treatment. The treatments differed significantly with each other. Calcium creates the suitable condition in the rhizosphere and also involves in the vigor of the plant. Similar findings were reported by (Mass *et al.*, 1996 and Bose & Mishra, 2001). Maximum uptake of Mg^{2+} in plant leaf at the booting stage was in pre-sowing seed treatment with GA_3 (20 ppm) and minimum in GA_3 (60 ppm). The treatments differed significantly with each other. Magnesium involves in the process of photosynthesis in the plant growth. So, GA_3 involves in the growth and development of leaf. Similar findings were reported by (Mass *et al*., 1996) and (Bose & Mishra, 2001).

The data regarding the uptake of chloride differed significantly. Maximum uptake of chloride in plant leaf at the booting stage was in control and minimum in $CaSO_4$ (30 mM) treatment. This may be due to specific ion toxicity to the plant leaves if exceeds from the safe limit (50 ppm). This is mostly consented with cation (Na^+) to create salinity/sodicity hazardous effect for plant. These results are also supported by the results of Amador & Dieguez, (2000). Na^+: K^+ ratio showed great variability among all the treatments. Maximum Na^+: K^+ ratio was in control while, minimum in the GA_3 treatment. This is due to the effect of GA_3 that enhances germination in seed, growth and development in leaves and straw, reduces the early senescence in leaf. These results were in line with Mass *et al*., 1994, Ashraf & Rauf 2001; Ashraf & Iram, 2001.

Maximum Ca^{2+}: Mg^{2+} ratios in plant leaf at booting stage were observed by $CaSO_4$ primed treatments. This was due to $CaSO_4$ that created the suitable condition for germination and antagonize with Na^+ to reduce the salinity effect and improved vegetative growth of leaf. These results were found similar to Mass *et al.*, 1994. Maximum uptake of Na^+ in plant leaf was in the $CaSO_4$ (10 mM) while, minimum in seed primed with Gibberellic acid 60 ppm. The concentration of Na^+ in straw increased linearly with the increase in its concentration in all the treatments. However, analysis of variance revealed that treatments differed significantly with regard to Na^+ accumulation in straw. Na^+ in the straw was increased due to continuous application of brackish water EC_e (3 dS m^{-1}), SAR (15 mmol $L^{-1})^{1/2}$, and RSC ($mmol_c$ L^{-1}) on saline-sodic soil to each treatment having no leaching fraction. The safe limit of Na^+ in straw is 250 ppm (Plank *et al*., 1988). If Na^+ increased beyond the safe limit, it caused early senescence, chlorophyll destruction, and nutritional disorder, inhibition of enzymatic activity and disturbed opening and closing of stomata due to antagonism with K^+. Increased Na^+ concentration in straw with increased salinity was also reported by (Angrish *et al*., 2001), Qureshi *et al*., (1991, Akhtar *et al*., (1994) and Nawaz *et al*., (1998) in barley. High Na^+ concentration in straw under salinity could be due to high NaCl concentration in the saline environment. Salt tolerant barley plants maintain low leaf Na^+ concentration mainly by the mechanism of exclusion of Na^+ from the leaves (Gorham *et al*., 1986). There is a positive correlation between relative salt tolerance and Na^+ exclusion in many crops including wheat (Qureshi *et al*., 1991), rice (Aslam *et al*., 1993) and barley (Storey & Wyn Jones, 1978).

Maximum uptake of K^+ in plant leaf was in the hydro priming seed treatments for 12 hours and was lowest in control. Potassium concentration in straw in all the treatments decreased with an increase in soil salinity. Decreased in potassium concentration in leaf cell sap and straw with increased salinity was in accordance with the finding of Qureshi *et al*., (1998), Akhtar *et al*., (1998), Nawaz *et al*., (1998) in wheat. High external Na^+ concentration interfered with K^+ absorption resulting in low leaf potassium concentration. Maximum uptake of Ca^{2+} in plant leaf was in control and was lowest in the seed primed with Gibberelic acid (20 ppm). During subsequent growth stages salinity did not induce further decrease in Ca^{2+} content of leaves of any treatment. Calcium concentration remained low in straw and in leaves than the sufficiency range, suggesting that Ca^{2+} deficiencies in plant continued at all growth stages. Hence, Ca^{2+} deficiencies in all treatments were surely influenced by the soil salinity at all growth stages. Safe limit for Ca^{2+} in straw and plant is 3-5 g/kg (Plank *et al*., 1988).Calcium displacement from the plasma lemma due to high Na^+ concentration results in loss of membrane integrity and ultimately K^+, hence reduction in K^+ concentration in leaves. Similar results were also found by Crammer *et al*., 1985; Kent and Lauchli, 1985.The maximum uptake of Mg^{2+} in the plant straw was in the seed primed with $CaSO_4$ (10 ppm) and lowest in seed primed with $CaSO_4$ (30 ppm). The treatments differed significantly among each other. Safe limit for Mg^{2+} in plant is 2-6 g/kg (Plank *et al*., 1988). The reduction of Mg^{2+} content in straw was due to the application of brackish water to the wheat crop which ultimately leads to low photosynthetic activity. These results were similarly reported by Sinha and Haque, 2003.

The maximum uptake of Chloride was observed in the control while, minimum in GA_3 20 ppm. The treatments differed significantly among each other. More Na^+ and Cl^- were absorbed in control as compared to other treatments. High Cl^- concentration with increased salinity has also reported by Shah and Wyn Jones (1988), Akhtar *et al*., (1994), Nawaz *et al*., (1998).

Na^+: K^+ ratio of straw was relatively found with a tiny variation among all the treatments. Ca^{2+} and Mg^{2+} ratio of straw were also found with a similar trend of Na^+: K^+

ratio. These results matched the findings of other scientists, where salinity significantly reduced Na^+: K^+ ratio of wheat (Qureshi *et al.,* 1991; Akhtar *et al*., 1998; Nawaz *et al*., 1998). Decreased Na^+: K^+ ratio with increased salinity was due to displacement of Ca^{2+} from plasma lemma at high external Na^+ concentration resulting in loss of membrane integrity and efflux of cytosolic potassium (Cramer *et al*., 1985). This K^+ leakage from the cell lowers the Na^+: K^+ ratio in the tissue (Kent & Lauchli, 1985).

In all the treatments, where brackish water was applied increased the total salt contents (EC_e) in the soil solution after harvest of barley. The EC_e of soil before the start of experiment was 7.43 dS m^{-1} and after the harvest of barley increased to18 dS m^{-1}. The maximum EC_e was measured in control treatment and lowest in hydro priming seed treatments for 12 hours. The increase in EC_e was due to brackish water application to the soil having no leaching fraction. Similar results were reported by Sen and Bandyopadhya (1979) and Rhoades (1983). The pH_s of the original soil was 7.98 which was significantly affected after harvest of the crop. Soil reaction was maximum in hydro priming seed treatments for 12 hours and GA_3 20 ppm. It may be due to brackish irrigation water application to crop having no leaching fraction. In general low pHs values were measured after harvesting the crop. This might be due to the production of organic acids during decomposition of organic matter (in case of organic amendment). Rhoades *et al*., (1988) and Hussain *et al*., (1993) also provided the similar conclusions.

Sodium adsorption ratio of the original soil was 21.4 which decreased to 18 $(mmol_c\ L^{-1})^{1/2}$ by the application of brackish irrigation water. There was non-significant effect on SAR after harvest of barley. Maximum SAR was calculated in seed primed with $CaSO_4$ (30 m M) while lowest in hydro priming seed treatments for 12 hours. There was no leaching fraction having more salinity and sodicity in the soil due to applied brackish irrigation water. Results are in agreement with those of Rhoades *et al*., (1988). The use of gypsum and FYM also reduced the SAR due to their reclamation effects, which is obvious from the above treatments, and it was confirmed by Kausar and Muhammad (1972).

Conclusion

On the basis of results, it is concluded that seed priming had beneficial effects on seed germination particularly under the salt stress provided that the soil is drained. It has no beneficial effect on crop at later growth stages under very high salt stress (EC_e 19.86 d S m^{-1} PH_S 7.69, SAR 17.49) in soil, especially due to sodium. Under the drained condition, the application of brackish water of crop causes considerable loss to soil health and reduces crop productively.

However, farmers may adopt this strategy for those crops, which are very sensitive to salt stress at the initial stages for which further studies for different crops are needed.

References

Aceves, N.E., Stolzy and G.R. Mehyus. 1675. Effect of soil osmotic potential produced with two salt species on plant water potential, growth and grain yield of wheat. *Plant Soil*, 42: 619-627.

Amador, B.M and E.T. Dieguez. 2000. Effects of salinity on the germination and seedingcharacter tics of cowpea (*Vigna unguiculata* L.). *Aust. J. Exp. Agric*. 40: 433-438.

Angrish, R., B. Kumar and K.S. Datta. 2001. Effect of gibberelic acid and kinetin onnitrogen content and nitrate reductase activity in wheat under saline conditions. *Indian J. Plant Physiol.,* 6: 172-177.

Ashraf, M. and A. Iram. 2002. Optimization and influence of seed priming with salts of potassium or calcium in two spring wheat cultivars differing in salt tolerance, at the initial growth stages. *Agrochimica*, 46: 47-55.

Ashraf, M. and H. Rauf. 2001. Inducing salt tolerance in maize (*Zea mays* L.) through seed priming with chloride salts: growth and ion transport at early growth stages. *Acta Physiol. Plant.*, 23: 407-414.

Bose, B. and T. Mishra. 2002. Effect of seed treatment with magnesium salts on growth and chemical attributes of mustard. *Indian J. Plant Physiol*., 6: 431-434.

Channa, A.N., A.S. Larik and K.A. Larik. 2002. Effect of salinity and phytohormones on the germination and growth of wheat. *Pakistan J. Seed Sci. Technol*., 1: 31-40.

Chippa, B.R and P. Lal. 1998. Effect of pre-soaking seed treatment in wheat grown on sodic soils. *Indian J. Plant. Physiol*., 11: 183-185.

Ehsanullah, K. and M.I. Smith. 2002. Soaking injuiry in relation to the rate of imbibitions in soybean (*Glycin max* L. Merrill). *Pakistan J. Seed Sci. Technol*., 1(1): 27-33.

Fitter, A.H. and R.K.H. Hay. 1981. Ionic toxicity. PP. 200-229. In: *Environment physiology of Plant*. (Eds.): A.H. Fitter and R.K.M. Hay. Acid. Pres Inc., London.

Ghafoor, A. 1999. Historcial perspectives of land use and land cover changes in Pakistan. Paper presented in International Workshop on Land Use, Land Cover Changes in South Asia. April, 11-13, 1999, Pusa, New Delhi, India.

Harang, B. 1976. A "delay relay" for the auto-200 sampling system. Atomic absorption. *News Letter*, 5: 106-107.

Hussain. T., M.A. Abbas., S.N. Akhtar and G. Jilani. 1993. Efficient use of brackish ground water through cultureal approach. *Pakistan J. Soil. Sci*., 8: 37-40.

Kausar, M.A and S. Muhammad. 1972. Comparisons of biological and chemical methods for reclaiming sodic soils. *Pakistan J.Sci. Res*., 24: 252-261.

Khan, M., N. Akhtar, H. Hassan, A. Wadud and A. Khan. 2002. Seed priming and its influence on wheat productivity. *Pakistan J. Seed. Sci. Technol*., 1: 41-43.

Khatkar, D. and M.S. Kushad. 1999. Stage sensitivity of wheat cultivars to short term salinity stress. *Indian J. Plant Physiol*., 5: 26-31.

Mass, E.V., S.M. Lesch, L.E. Francios and C.M. Grieve. 1996. Contribution of individual culms to yield of salt stressed wheat. *Crop Sci*., 36: 142-149.

Muhammad, M.T. Mueller and R.G. Joregensen. 2006. Relationships between soil biological and other soil properties in saline and alkaline arable soils from the Pakistani Punjab. *Soil Arid Environment* (Accepted).

Nadeem, M.Y., R.H. Qurshi, M. Aslam and N. Ahmed. 1995. Interactive effect of salinityand niotrogen on the yield of wheat. *Pak. J. Agri. Sci*., 32: 160-167.

Page, A.L., R.H. Miller and D.R. Deeney. 1982. Methods of soil analysis. Part 2,Chemical and Micro Biological Properties. ASA. Mongr. No. 9, Madison, WI, USA.

Qureshi, R.H., A. Rashid and N.J Ahmad. 1990. A procedure for quick screening of wheat cultivars for salt tolerance. P. 315-324. In: *Genetic aspect of plant mineral nutrition*, (Eds.): N.M. Elbasam, Damborth and B.C. Laughman. Kluwer Acad. Pub., The Netherlands.

Raza,S. H., Athar, H.R. and Ashraf, M. 2006. Influence of exogenously applied glycinebetaine on the photosynthetic capacity of two differently adapted wheat cultivars under salt stress. *Pak. J. Bot*., 38(2): 341-351.

Rhoades, J.D., F.T. Binghan, J. Letey, A.R. Dedrick, M. Bean, G.J. Hoffman, W.J. Aleves, R.V. Swain, P.G. Pacheco and R.D. Lemert. 1988. Reuse of drainage water for irrigation. Results of Imperial Valley Study. *Hilgardia*., 56: 1-6.

Roy, N.K. and A. Srivastava. 1999. Adverse effect of salt stress condition on chlorophyll content in wheat (*Triticum aestivum* L.) leaves and its amelioration through presoaking treatments. *Indian J. Agri. Sci*., 70: 777-778.

Sen, H.S. and A.K. Bandyopadhya. 1979. Movement of water and salt in soil with reference to static water tables maintained at different depths. A lysimeter study. *J. Indian Soc. Soil Sci*., 27: 70-72.

Singh, B.G. and T. Joythi. 1995. Effect of chemical soaking of safflower (*Carthamus tincatorius* L.) on dry matter production and yield. *Indian J. Plant Physiol*., 1: 60-62.

Sinha, T.S. and A. Haque. 2003. Effect of soil salinity on ionb concentration in the leaves of Indian mustard (*Brassica juncea* L.). *A hand book of plant physiol. for sustainable agriculture*, 57: 370-379.

Som, S. and B.K. Chattopadhyay. 1996. Effect of different hydration-dehydration treatments on cowpea (*Vigna unguiculata*) seeds. *Indian J. Plant Physiol*., 1: 273-276.

Srinivasan, K. and S. Saxena. 2001. Priming seeds for improved viability and storability in *Raphanus sativus* cv. Chinese Pink. *Indian J. Plant Physio*l., 6: 271-274.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and Procedures of Statistical Analysis. 2nd Ed. McGraw Hill Book Co. Inc., New York, USA.

Steppuhn, H. and K.G. Wall. 1997. Grain yield from spring sown Canadian wheat grass grown in saline rooting media. *Can. J. Plant Sci*., 77: 63-68.

US. Salinity lab. Staff. 1954. Diagnosis and improvement of saline and alkali soils. USDA. Hand Book No. 60, USDA, Washington DC, USA.

(Received for publication 9 June 2006)