International Meeting on Soil Fertility Land Management and Agroclimatology. Turkey, 2008. p: 715-735

The Ameliorative Effect of Saline or / Sodic Water on Maize (*Zea Mays* L.)Production

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ABSTRACT

A pot experiment was conducted in green house to evaluate the performance of two maize genotypes using saline or / sodic water with and with out amendments. There were eight treatments T_1 (control with EC 1.07 dS m^{-1}, SAR 1.63, and RSC 0 me L^{-1}), T_2 (EC 2.4 dS m^{-1}, SAR 16 (mmol $L^{-1})^{1/2}$, and RSC 2.25 meL^{-1}), T_3 (EC 3.6 dS m^{-1}, SAR 24 (mmol $L^{-1})^{1/2}$, and RSC 4.5 meL^{-1}), T_4 (T_2+ Gypsum on irrigation water basis), T_5 (T_3+ Gypsum on irrigation water basis),T_6 (T_1+ FYM @ 20 Mg ha^{-1}),T_7 (T_2+FYM @ 20 Mg ha^{-1}),T_8 (T_3+ FYM @ 20 Mg ha^{-1}) . Saline or/ sodic water were prepared with the help of quadratic equation and recommended doses of NPK fertilizers were used. Chlorophyll content was recorded after 40 days of sowing and fully expanded younger leaf were collected and stored in separate polypropylene tubes for sap extraction. The experimental results showed that chlorophyll content, Leaf area $plant^{-1}$, plant height, fresh weight of plant, dry weight of plant of all genotypes decreased significantly with increasing levels of saline or /sodic water but this decrease was minimum when gypsum and FYM was applied. Na^+ concentration of all genotypes increased significantly and decreased with gypsum and FYM application. Potassium and K^+: Na^+ ratio of all genotypes decreased significantly with increasing levels of saline or / sodic water but increased when gypsum and FYM was applied. EC_e, SAR and pH_s in soils after harvesting of crop increased also significantly. The application of FYM and gypsum proved to much helpful in improving soil quality and crop productivity.

Key words: saline or sodic water, maize, gypsum, FYM, soil salinity

INTRODUCTION

Water is a basic necessity for sustainable life in universe. Functions of water are manifold and diversified. Among the versatile functions just a few are; maintenance of turgidity, opening and closing of leaf stomata, uptake and translocation of nutrients and metabolites, synthesis of proteins and other related products, sequestration of excessive salts and toxic material into vacuoles or out of tissue and serving as medium for all biochemical and bio-energy reactions. The Indus River system is the main surface water resource in Pakistan, which is 170 MAF out of which 108 MAF is diverted to canal for irrigation purpose. At present net water available at the farm gate is about 83.37 MAF against the crop irrigation requirement of 134 MAF (Anonymous 2002).

The excessive accumulation of salts in soils of arid and semi arid region is a potential threat to the productivity of irrigated agriculture. It is estimated that over 800 million hectares of land in the world are affected by both salinity and sodicity (Munns, 2005). According to an estimate, 6.67 mha of land in Pakistan has been affected by salinity (Khan, 1998), which is about 1/3rd of the total cultivated land of Pakistan. About 70-75% of pumped ground water is unfit for irrigation due to high EC, SAR, and RSC, therefore adversely affecting the yield of wheat, rice and maize (Ghafoor, *et al* 2001). Therefore a supplemental source of water has to be made to meet this deficit from underground water. For this purpose about 0.53 million tube wells are pumping about 49.91 MAF underground water in Pakistan (Anonymous, 2002).During the recent drought years, the canal supplies further decreased which necessitated the utilization of even poor quality underground water for crops. This strategy although increased the water supplies, yet resulted in deterioration of soil physical and chemical properties (Sarwar *et al*., 2002). Soil solution SAR increased significantly in direct proportional to SAR_{iw} and irrigation with higher SAR water decreased the permeability of soil resulting in accumulation of salts (Ahmad, 2002).

Maize (*Zea mays* L.) is an important crop and provides raw material for agro-based industry. It is not only consumed by human beings in the form of food grains, but also provides feed for livestock and poultry. Maize is highly nutritive and its grains contain starch 72, protein 10, oil 4.8, fiber 8.5, sugar 3.1, and ash 3.1 on percent basis (Chaudhary, 1983). In Pakistan, it is grown on an area of 1022 thousand hectare with an annual production of 3560 thousand tones (Govt. of Pakistan. 2006). Maize is moderately salt tolerant crop; reduction in yield of maize is a common phenomenon because of poor quality irrigation water. Sufficient information is not available about the performance of different maize genotypes and changes in chemical and physical properties of soil under our field conditions by irrigated with brackish tube well water. Many scientists studied changes in physical and chemical properties of soil under control condition by using different EC, SAR and RSC levels, which were not correlated with naturally available brackish water in our local conditions. So that it is now essential to acquire more information about the effect of brackish water on chemical properties of soil and yield of different maize genotypes.

This work will help in successful planning of brackish water for maize production and helpful in selection of best genotype which can be economically grown by irrigating with brackish tube well water. Keeping in view these considerations, the present study was planned with following specific objectives.

1. To evaluate the performance of different maize genotypes irrigated with brackish water and selection of best genotype.
2. To see the effect of brackish water on chemical properties of soil in sandy clay loam texture.
3. To evaluate the technology for economic utilization of brackish water.

MATERIAL and METHODS

Growth Conditions and Experimental Technique

The seed of maize varieties (Sahiwal -2002 and Pak- Fagawi) were taken from Maize Millet Research Institute (MMRI) Yousafwala, Sahiwal. The experiment was conducted in partially green house having glass covered roof, sides with iron wire screen and no control of humidity, temperature and light. Normal soil free from any salinity and sodicity hazards was collected from research area of Institute of Soil and Environmental Sciences, up to 0-15 cm depth. The soil was air dried, ground and passed through a 2 mm sieve and thoroughly mixed and analyzed for pre-requisite physiochemical characters like EC_e, pH_s, SAR and textural class, which are given in Table -1. Soil was filled in Glazed pots (30 cm high and 25 cm diameter) at the rate of 12 kg per pot.

Soil textural class was determined by Hydrometer methods (Moddie *et al.*, 1959) and textural class was determined by using international soil classification system (ISSS). Electrical conductivity of soil extract was recorded with the help of EC meter (Method 3a and 4a, USDA Hand book No.60, 1954). Calcium and magnesium was determined by titrating the sample with standard versinate solution by using EBT as an indicator (Method 7 USDA Hand book No.60, 1954). Sodium was determined with the help of Sherwood 410 Flame photometer (Method 10a USDA Hand book No.60, 1954).
SAR was calculated by using the following formula (Method 20b USDA Hand book No.60, 1954).

$$SAR = \frac{Na^+}{\sqrt{Ca + Mg/2}}$$

The experiment was laid out in a Completely Randomized Design (CRD) with three repeats with following treatments

Treatments

There were eight treatments viz:
T_1 (control with EC 1.07 dS m^{-1}, SAR 1.63, and RSC 0 me L^{-1}),
T_2 (EC 2.4 dS m^{-1}, SAR 16 $(mmol\ L^{-1})^{1/2}$, and RSC 2.25 meL^{-1}),
T_3 (EC 3.6 dS m^{-1}, SAR 24 $(mmol\ L^{-1})^{1/2}$, and RSC 4.5 meL^{-1}),
T_4 (T_2+ Gypsum on irrigation water basis),
T_5 (T_3+ Gypsum on irrigation water basis),
T_6 (T_1+ FYM @ 20 Mg ha^{-1}),
T_7 (T_2+FYM @ 20 Mg ha^{-1}),
T_8 (T_3+ FYM @ 20 Mg ha^{-1})

The combination of four salts ($NaHCO_3$, Na_2SO_4, $CaCl_2.2H_2O$ and $MgSO_4.7H_2O$) was used to prepare the levels of saline or sodic water with the help of quadratic equation.

$$X = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Brackish water + Tap water were used alternatively for irrigation throughout the growing period. Calculations of salts for developing brackish water (EC along with SAR of water and RSC) made with the help of quadratic equation. Total No. of irrigations were 13, 7 with tap water and 6 with brackish water. The quantity of water per irrigation per pot was one litre and total amount of brackish water applied per pot was 6 litre (Table -2)

Lay out of the Experiment

A basal dose of N, P and K fertilizers was applied at the rate of 200, 150 and 200 kg ha^{-1}, respectively (1.2 g / 10 Kg, 0.9 g / 10 Kg, 1.2 g / 10 Kg, N, P_2O_5 and K_2O, respectively). Urea, DAP and K_2SO_4 were used as the sources of the N, P and K respectively. The amount of Urea, DAP and K_2SO_4 were used 2.607g, 1.956g and 2.4g respectively to fulfill the requirement of NPK. All the P and K were applied at the time of sowing and nitrogen was split into three doses, at sowing, with first irrigation and at flowering stage. FYM was applied at the rate of 20 Mg ha^{-1} at the time of pot filling. Gypsum requirement of irrigation water is calculated by the following formula.

$$\text{GR kg/Acre} = \frac{198 \text{ x } 30 \text{ x } 220 \text{ x } 30 \text{ x } 5 \text{ x RSC x } 86}{1000 \text{ x } 1000 \text{ x } 1000}$$

Initially ten seeds of each cultivar were sown per pot. Thinning was done after 16 days of sowing, keeping three plants per pot. The crop was raised up to 60days and harvested before cob formation. Recommended cultural operations such as weeding, hoeing etc. and plant protection measures like sprays were adopted during the experiment. The crop was harvested before the time of cob formation (after 60days).

Chlorophyll content was measured with a Chlorophyll meter after 40days of sowing with Minolta SPAD-502 DL meter Japan. Plant height was measured with a meter rod at the time of harvesting. Plant fresh weight was taken with the help of electrical weighing balance. Plants were kept in oven for three days at 65^oC and then dry weight was taken with the help of electrical weighing balance. Leaf area of plants was measured at the time of harvesting with the help of ΔT Area meter MK_2.

Fully expanded younger leaves were collected in 1.5 cm^3 polypropylene tubes and stored at freezing temperature (Akhtar *et al*, 1998) for chemical analysis.Frozen leaf samples in polypropylene tubes were thawed and crushed using a stainless steel rod with tapered end and sap was extracted. The sap was collected in the other polypropylene tubes and centrifuged at 6500 rpm for 5 minutes. The supernatant sap was collected and used for ionic analysis (Na^+, K^+). The sap was diluted as required with distilled water. Sodium and Potassium were determined using Sherwood 410 Flame Photometer.

Data of the experiment was subjected to statistical analysis using Completely Randomized Design in factorial arrangement (Fisher *et al*., 1925).

RESULTS and DISCUSSIONS

Effect of Brackish Water on Leaf Area (cm^2) of Maize

Data regarding leaf area of two maize genotypes as affected by different saline/sodic water and the ameliorative effect of gypsum, FYM are presented in Table 3. The comparison of genotypes indicate that the difference in leaf area of S-2000 and Pak-Fagawi genotype, the reduction in leaf area due to different treatments and the interaction of genotypes with treatments were significant at different levels of saline/sodic water.

In control genotype Pak-Fagawi performed well rather than S-2000 and the addition of FYM @ 20 Mg ha^{-1} also resulted to improve the leaf area of Pak-Fagawi.

At, EC 2.4 dS m^{-1}, SAR 16 (mmol $L^{-1})^{1/2}$, and RSC 2.25 meL^{-1}, Sahiwal-2000 gave maximum leaf area (530.1 cm^2) which was 18% less than control and the Pak-Fagawi gave minimum leaf area (520.4 cm^2) which was 29% less than control but when gypsum and FYM were applied in the same treatment the Pak-Fagawi gave maximum leaf area (567.7 cm^2) which was 23% less than control and (628 cm^2) which was 15% less than control while Sahiwal-2000 gave minimum leaf area (559 cm^2) which was 14% less than control and (574.5 cm^2) which was 11% less than control, respectively.

At, EC 3.6 dS m^{-1}, SAR 24 (mmol $L^{-1})^{1/2}$, and RSC 4.5 meL^{-1}, Sahiwal-2000 gave maximum leaf area (415 cm^2) which was 36% less than control and the Pak-Fagawi gave minimum leaf area (351.9 cm^2) which was 52% less than control but when gypsum and FYM were applied in the same treatment the Pak-Fagawi gave maximum leaf area (480.8 cm^2) which was 35% less than control and (471.7 cm^2) which was 36% less than control while Sahiwal-2000 gave minimum leaf area (452.9 cm^2) which was 30% less than control and (448.8 cm^2) which was 31% less than control, respectively.

The genotype Sahiwal-2000 gave the maximum leaf area than the Pak-Fagawi when no amendment was applied while the genotype Pak-Fagawi gave the maximum leaf area than the Sahiwal-2000 when amendments were applied. The addition of gypsum and FYM to the high EC-SAR-RSC water had a positive effect on leaf area. The results are in accordance with the findings of Cicek *et al*. (2002), who reported that leaf area was decreased significantly with increasing levels of saline/sodic water and Ahmad *et al*. (2003), who reported that leaf area was increased when gypsum and FYM were applied along with saline-sodic water.

Effect of Brackish Water on Chlorophyll Content (mg g^{-1}) of Maize

Data regarding chlorophyll content of two maize genotypes as affected by different saline/sodic water and the ameliorative effect of gypsum, FYM are presented in Table 4. The comparison of genotypes indicate that the difference in chlorophyll content of S-2000 and Pak-Fagawi genotype was non significant at different levels of saline/sodic water and the interaction of genotypes with treatments was also non-significant. On an overall average basis, the reduction in chlorophyll content due to saline/sodic water irrigation was significant in different treatments. Maximum chlorophyll content (24.3) was found when FYM at 20 Mg ha^{-1} applied with control, followed by control (23.5). While the minimum chlorophyll content (16.5) was found where brackish water of EC 3.6 dS m^{-1}, SAR 24 (mmol $L^{-1})^{1/2}$, and RSC 4.5 meL^{-1} with out any amendment was applied. On percent basis application of brackish water (EC 2.4 dS m^{-1}, SAR 16 (mmol $L^{-1})^{1/2}$, and RSC 2.25 meL^{-1}) reduced the chlorophyll content of maize by 13% over control(23.5) while application of gypsum and FYM in the same treatment reduced the leaf area by 8% and 4%, respectively over control. Similarly there was 30% reduction in chlorophyll content over control when brackish water of EC 3.6 dS m^{-1}, SAR 24 (mmol $L^{-1})^{1/2}$, and RSC 4.5 meL^{-1} was applied while 20% and 15% reduction was observed in the same treatment when gypsum and FYM was applied, respectively.

The addition of gypsum and FYM to the high EC-SAR-RSC water had a positive effect on chlorophyll content The results are in confirmation with those of Cicek *et al*. (2002), who reported that chlorophyll content was decreased significantly with increasing levels of brackish water and Ahmad *et* a*l*. (2003), Chaudhary *et* a*l*. (2004) who reported that chlorophyll content was increased when gypsum and FYM were applied along with saline-sodic water.

Effect of Brackish Water on Plant Height (cm) of Maize

Data regarding plant height of two maize genotypes as affected by different saline/sodic water and the ameliorative effect of gypsum, FYM are presented in Table 5. The comparison of genotypes indicates that the difference in plant height of S-2000 and Pak-Fagawi genotype was significant at different levels of saline/sodic water and the interaction of genotypes with treatments was non-significant. On an overall average basis, the genotype Pak-Fagawi showed 6% (30.6cm) more plant height as compared to Sahiwal-2000 (28.8cm). While the reduction in plant height due to saline/sodic water irrigation was also significant in different treatments. Maximum plant height (34.5cm) was found when FYM at 20 Mg ha^{-1} applied with control, followed by control (34.4cm), without any amendment, while the minimum plant height (24.9cm) was found where we applied brackish water of EC 3.6 dS m^{-1}, SAR 24 (mmol $L^{-1})^{1/2}$, and RSC 4.5 meL^{-1} with out any amendment. On percent basis application of brackish water (EC 2.4 dS m^{-1}, SAR 16 (mmol $L^{-1})^{1/2}$, and RSC 2.25 meL^{-1}) reduced the plant height of maize by 19% (34.4cm) over control while application of gypsum and FYM in the same treatment reduced the plant height by 13% over control. Similarly there is 28% reduction in plant height with respect to control when brackish water of EC 3.6 dS m^{-1}, SAR 24 (mmol $L^{-1})^{1/2}$, and RSC 4.5 meL^{-1} was applied while 18% and 20% reduction was observed in the same treatment when gypsum and FYM were applied, respectively.

The addition of gypsum and FYM to the high EC-SAR-RSC water had a positive effect on plant height and the reduction in plant height was 30-35% less as compared to high EC-SAR-RSC irrigation water. The results are in confirmation with those of Cicek *et al.* (2002), who reported that plant height was decreased significantly with increasing levels of saline/sodic water while maximum height in gypsum and FYM treated plots was also reported by Murtaza *et al*. (2006), Chaudhary *et al*. (2004) in sugarcane and Sharma *et al*. (2001) in rice-wheat system.

Effect of Brackish Water on Fresh Weight (g) of Maize

Data regarding fresh weight of two maize genotypes as affected by different saline/sodic water and the ameliorative effect of gypsum, FYM are presented in Table 6. The comparison of genotypes indicate that the difference in fresh weight of S-2000 and Pak-Fagawi genotype was non significant at different levels of saline/sodic water and the interaction of genotypes with treatments was also non-significant. On an overall average basis, the reduction in fresh weight due to saline/sodic water irrigation was significant in different treatments. Maximum fresh weight (46.8g) was found when FYM at 20 Mg ha^{-1} applied with control, followed by control (46.3g). While the minimum fresh weight (30.2g) was found where brackish water of EC 3.6 dS m^{-1}, SAR 24 (mmol $L^{-1})^{1/2}$, and RSC 4.5 meL^{-1} was applied with out any amendment. On percent basis application of brackish water (EC 2.4 dS m^{-1}, SAR 16 (mmol $L^{-1})^{1/2}$, and RSC 2.25 meL^{-1}) reduced the fresh weight of maize by 27% over control (46.3g) while application of gypsum and FYM in the same treatment reduced the fresh weight by 20% and 19%, respectively over control. Similarly there is 35% reduction in fresh weight over control when brackish water of EC 3.6 dS m^{-1}, SAR 24 (mmol $L^{-1})^{1/2}$, and RSC 4.5 meL^{-1} was applied while 29% and 30% reduction was observed in the same treatment when gypsum and FYM were applied, respectively.

The addition of gypsum and FYM to the high EC-SAR-RSC water had a positive effect on fresh weight and the reduction in fresh weight was 10-20% less as compared to high EC-SAR-RSC irrigation water. The results are in accordance with Cicek *et al*. (2002), who reported that fresh weight of plant was decreased significantly with increasing levels of saline/sodic water and the usefulness of gypsum and FYM in ameliorating the adverse effects of poor quality irrigation water and improving fresh weight of crop has been reported by Chaudhary *et al*. (2004) and Sharma and Minhas (2004).

Effect of Brackish Water on Dry Weight (g) of Maize

Data regarding dry weight of two maize genotypes as affected by different saline/sodic water and the ameliorative effect of gypsum, FYM are presented in Table 7. The comparison of genotypes indicate that the difference in dry weight of S-2000 and Pak-Fagawi genotype was non significant at different levels of saline/sodic water and the interaction of genotypes with treatments was also non-significant. On an overall average basis, the reduction in dry weight due to saline/sodic water irrigation was significant in different treatments. Maximum dry weight (18.3g) was found in control, followed by control + FYM at 20 Mg ha^{-1} (17.2g). While the minimum dry weight (11.6g) was found where we apply brackish water of EC 3.6 dS m^{-1}, SAR 24 $(mmol\ L^{-1})^{1/2}$, and RSC 4.5 meL^{-1} with out any amendment. On percent basis application of brackish water (EC 2.4 dS m^{-1}, SAR 16 $(mmol\ L^{-1})^{1/2}$, and RSC 2.25 meL^{-1}) reduced the dry weight of maize by 30% over control (18.3g) while application of gypsum and FYM in the same treatment reduced the dry weight by 24% and 23%, respectively over control. Similarly there is 37% reduction in dry weight with respect to control when brackish water of EC 3.6 dS m^{-1}, SAR 24 $(mmol\ L^{-1})^{1/2}$, and RSC 4.5 meL^{-1} was applied while 30% reduction was observed in the same treatment when gypsum and FYM was applied.

The addition of gypsum and FYM to the high EC-SAR-RSC water had a positive effect on dry weight and the reduction in dry weight was 10-18% less as compared to high EC-SAR-RSC irrigation water. The results are in accordance with Cicek *et al*. (2002), who reported that dry weight of plant was decreased significantly with increasing levels of saline/sodic water and Chaudhary *et al.* (2004) in sugarcane and Sharma *et al*. (2001) in rice-wheat system who reported the usefulness of gypsum and FYM in ameliorating the adverse effects of poor quality irrigation water and improving dry weight of crop.

Ionic Concentration in Leaf Sap

Na^+ Concentration in Leaf Sap of Maize

Data regarding Na^+ concentration in leaf sap of two maize genotypes as affected by different saline/sodic water and the ameliorative effect of gypsum, FYM are presented in Table 8. The comparison of genotypes indicate that the difference in Na^+ concentration in leaf sap of S-2000 and Pak-Fagawi genotype, the reduction in Na^+ concentration in leaf sap due to different treatments and the interaction of genotypes with treatments were significant at different levels of saline/sodic water.

At control Pak-Fagawi gave minimum Na^+ concentration (215.7) as compared to Sahiwal-2000 which gave maximum Na^+ concentration (287.3). But when FYM @ 20 Mg ha^{-1} was applied in control Pak-Fagawi showed 7% decrease in Na^+ concentration over control while Sahiwal-2000 showed 4% decrease in Na^+ concentration over control.

At, EC 2.4 dS m^{-1}, SAR 16 (mmol $L^{-1})^{1/2}$, and RSC 2.25 meL^{-1}, Sahiwal-2000 gave maximum Na^+ concentration (412.6) which was 44% more than control (287.3) while the Pak-Fagawi gave Na^+ concentration (403.7) which was 87% more than control but when gypsum and FYM were applied in the same treatment the Pak-Fagawi gave Na^+ concentration (367) and (382.7) which was 70% and 77% more than control, respectively while Sahiwal-2000 gave Na^+ concentration (394.6) and (378) which was 37% and 32% more than control, respectively.

At, EC 3.6 dS m^{-1}, SAR 24 (mmol $L^{-1})^{1/2}$, and RSC 4.5 meL^{-1}, Sahiwal-2000 gave maximum Na^+ concentration (455) which was 58% more than control (287.3) while the Pak-Fagawi gave Na^+ concentration (439.3) which was 104% more than control but when gypsum and FYM were applied in the same treatment the Pak-Fagawi gave Na^+ concentration (388.3) and (399) which was 80% and 85% more than control, respectively while Sahiwal-2000 gave Na^+ concentration (416.3) and (408.7) which was 45% and 42% more than control, respectively.

The Na^+ concentration in leaf sap of maize genotypes was less when gypsum was added to the brackish water and further decrease in Na^+ concentration in leaf sap was observed in treatment having FYM. On an overall basis Pak-Fagawi had less Na^+ concentration in leaf sap compared to Sahiwal-2000.The results are in accordance with the findings of Ahmad *et a*l. (2003), Yaduvanshi *et al*. (2005) and Murtaza *et al*. (2006) who reported that Na^+ concentration in leaf sap increases with increasing levels of saline-sodic water and decreases when gypsum and farm yard manure was applied.

K^+ Concentration in Leaf Sap of Maize

Data regarding K^+ concentration in leaf sap of two maize genotypes as affected by different saline/sodic water and the ameliorative effect of gypsum, FYM are presented in Table 9. The interaction of genotypes with treatments was non-significant but the comparison of genotypes indicate that the difference in K^+ concentration in leaf sap of S-2000 and Pak-Fagawi genotype was significant at different levels of saline/sodic water. The genotype Pak-Fagawi showed less K^+ concentration in leaf sap in all treatments as compared to Sahiwal-2000. On an overall average basis, the genotype Pak-Fagawi showed 19% (258) less K^+ concentration in leaf sap as compared to Sahiwal-2000 (308.9). While the reduction in K^+ concentration in leaf sap due to saline/sodic water irrigation was also significant in different treatments. Maximum K^+ concentration in leaf sap was found when FYM at 20 Mg ha^{-1} applied with control, followed by treatment having EC 2.4 dS m^{-1}, SAR 16 (mmol $L^{-1})^{1/2}$, and RSC 2.25 meL^{-1}+FYM

(291.7) which was 1% more than control (289.2). While the minimum K^+ concentration (252.5) was found in treatment having EC 3.6 dS m^{-1}, SAR 24 (mmol $L^{-1})^{1/2}$, and RSC 4.5 meL^{-1} without any amendment which was 13% less than control. On percent basis application of brackish water (EC 2.4 dS m^{-1}, SAR 16 (mmol $L^{-1})^{1/2}$, and RSC 2.25 meL^{-1}) reduced the K^+ concentration of leaf sap of maize by 6% (271.2) over control while application of gypsum and FYM in the same treatment decreased the K^+ concentration by 4% and increased the K^+ concentration by 1%, respectively over control. Similarly there was 13% reduction in K^+ concentration with respect to control when brackish water of EC 3.6 dS m^{-1}, SAR 24 (mmol $L^{-1})^{1/2}$, and RSC 4.5 meL^{-1} was applied while 8% and 3% reduction was observed in the same treatment when gypsum and FYM was applied, respectively.

The K^+ concentration in leaf sap of maize genotypes was more when gypsum was added to the brackish water and further increase in K^+ concentration in leaf sap was observed in treatment having FYM. On an overall basis Pak-Fagawi had less K^+ concentration in leaf sap compared to Sahiwal-2000.The results are in accordance with the findings of Ahmad *et al*. (2003), Yaduvanshi *et al*. (2005) and Murtaza *et al*. (2006) who reported that K^+ concentration in leaf sap decreases with increasing levels of saline-sodic water and increases when gypsum and farm yard manure was applied.

Effect of Brackish Water on K^+/Na^+ Ratio of Maize

Data regarding K^+/Na^+ ratio of two maize genotypes as affected by different saline/sodic water and the ameliorative effect of gypsum, FYM are presented in Table 10. The comparison of genotypes indicate that the difference in K^+/Na^+ ratio of S-2000 and Pak-Fagawi genotype, the reduction in K^+/Na^+ ratio due to different treatments and the interaction of genotypes with treatments were significant at different levels of saline/sodic water.

At control Pak-Fagawi gave maximum K^+/Na^+ ratio (1.2) as compared to Sahiwal-2000 which was (1.1). But when FYM @ 20 Mg ha^{-1} was applied in control Pak-Fagawi showed 6% increase in K^+/Na^+ ratio over control while Sahiwal-2000 showed 17% increase in K^+/Na^+ ratio over control.

At, EC 2.4 dS m^{-1}, SAR 16 (mmol $L^{-1})^{1/2}$, and RSC 2.25 meL^{-1}, Sahiwal-2000 gave maximum K^+/Na^+ ratio (0.7) which was 36% less than control (1.1) while the Pak-Fagawi gave K^+/Na^+ ratio (0.6) which was 49% less than control but when gypsum and FYM were applied in the same treatment the Pak-Fagawi gave K^+/Na^+ ratio (1) and (0.7) which was 22% and 43% less than control, respectively while Sahiwal-2000 gave K^+/Na^+ ratio (1) and (0.9) which was 31% and 23% less than control, respectively.

At, EC 3.6 dS m^{-1}, SAR 24 (mmol $L^{-1})^{1/2}$, and RSC 4.5 meL^{-1}, Sahiwal-2000 gave maximum K^+/Na^+ ratio (0.6) which was 44% less than control (1.1) while the Pak-Fagawi gave K^+/Na^+ ratio (0.5) which was 57% less than control but when gypsum and FYM were applied in the same treatment the Pak-Fagawi gave

K^+/Na^+ ratio (0.6) and (0.6) which was 48% and 48% more than control, respectively while Sahiwal-2000 gave K^+/Na^+ ratio (0.7) and (0.8) which was 39% and 32% less than control, respectively.

The K^+/Na^+ ratio of maize genotypes was more when gypsum was added to the brackish water and further increase in K^+/Na^+ ratio was observed in treatment having FYM. On an overall basis Pak-Fagawi had less K^+/Na^+ ratio as compared to Sahiwal-2000.The results are in accordance with the findings of Ahmad *et al*. (2003), Yaduvanshi *et al*. (2005) and Sharma and Minhas (2004) who reported that K^+/Na concentration in leaf sap decreases with increasing levels of saline-sodic water and increases when gypsum and farm yard manure was applied.

Soil Analysis

After harvesting of crop the soil is tested for chemical analysis (EC_e, pH_s, SAR).

Effect of Brackish Water on EC_e (dS m^{-1}) of Soil

Data regarding EC_e of soil of two maize genotypes as affected by different saline/sodic water and the ameliorative effect of gypsum, FYM are presented in Table 11. The comparison of genotypes indicate that the difference in EC_e of soil of S-2000 and Pak-Fagawi genotype was non significant at different levels of saline/sodic water and the interaction of genotypes with treatments was also non-significant. On an overall average basis, the increase in EC_e of soil due to saline/sodic water irrigation was significant in different treatments. Maximum EC_e (16) was found when water of EC 3.6 dS m^{-1}, SAR 24 (mmol $L^{-1})^{1/2}$, and RSC 4.5 meL^{-1} was applied followed by T_2 (15.3) where water of EC 2.4 dS m^{-1}, SAR 16 (mmol $L^{-1})^{1/2}$, and RSC 2.25 meL^{-1} was applied. While the minimum EC_e (12.2) was found where FYM was applied with control. On percent basis application of brackish water (EC 2.4 dS m^{-1}, SAR 16 (mmol $L^{-1})^{1/2}$, and RSC 2.25 meL^{-1}) increased the EC_e by 13% over control(13.5) while application of gypsum and FYM in the same treatment increased the EC_e by 4.6% and 1.2%, respectively over control. Similarly there was 19% increase in EC_e of soil with respect to control when brackish water of EC 3.6 dS m^{-1}, SAR 24 (mmol $L^{-1})^{1/2}$, and RSC 4.5 meL^{-1} was applied while 7.5% and 2.5% increase in EC_e of soil was observed in the same treatment when gypsum and FYM was applied, respectively.

The addition of gypsum and FYM to the high EC-SAR-RSC water had a positive decrease in EC_e of soil as compared to high EC-SAR-RSC irrigation water. Similar trend of increase in EC_e was observed by Murtaza *et al*. (1996), Niazi *et al*. (2000) and Chaudhary *et al*. (1990) who reported a significant increase in EC_e at different soil depths with the application of different levels of saline-sodic water and a significant decrease in EC_e at different soil depths with the application of different doses of gypsum and farm yard manure.

Effect of Brackish Water on pH_s of Soil

Data regarding pH_s of soil of two maize genotypes as affected by different saline/sodic water and the ameliorative effect of gypsum, FYM are presented in Table 12. The comparison of genotypes indicate that the difference in pH_s of soil of S-2000 and Pak-Fagawi genotype was non significant at different levels of saline/sodic water and the interaction of genotypes with treatments was also non-significant. On an overall average basis, the increase in pH_s of soil due to saline/sodic water irrigation was significant in different treatments. Maximum pH_s (8.9) was observed when water of EC 3.6 dS m^{-1}, SAR 24 (mmol L^{-1})$^{1/2}$, and RSC 4.5 meL^{-1} was applied followed by T_5 (8.8) where water of EC 3.6 dS m^{-1}, SAR 24 (mmol L^{-1})$^{1/2}$, and RSC 4.5 meL^{-1} was applied along with gypsum. While the minimum pH_s (7.3) was found where FYM was applied in control. On percent basis application of brackish water (EC 2.4 dS m^{-1}, SAR 16 (mmol L^{-1})$^{1/2}$, and RSC 2.25 meL^{-1}) increased the pH_s by 12% over control while application of gypsum and FYM in the same treatment increased the pH_s by 10% and 9% respectively, over control. Similarly there was 17% increase in pH_s of soil with respect to control when brackish water of EC 3.6 dS m^{-1}, SAR 24 (mmol L^{-1})$^{1/2}$, and RSC 4.5 meL^{-1} was applied while 14% and 15% increase in pH_s of soil was observed in the same treatment when gypsum and FYM was applied, respectively.

The addition of gypsum and FYM to the high EC-SAR-RSC water had a positive decrease in pH_s of soil as compared to high EC-SAR-RSC irrigation water. A reduction in pH_s was observed by Zaka *et al.* (2003) with the application of organic amendments and gypsum. It reflects that gypsum along with FYM caused maximum leaching of Na^+ to affect a decrease in SAR of soil which in turn decreased pH_s (Hussain *et al.*, 1993). Similar results were reported by Murtaza *et al.* (1999) and Niazi *et al.* (2000) who found a significant decrease in pH_s with the application of gypsum and farm yard manure.

Effect of Brackish Water on SAR (mmol L^{-1})$^{1/2}$ of Soil

Data regarding SAR of soil of two maize genotypes as affected by different saline/sodic water and the ameliorative effect of gypsum, FYM are presented in Table 13. The comparison of genotypes indicate that the difference in SAR of soil of S-2000 and Pak-Fagawi genotype was non significant at different levels of saline/sodic water and the interaction of genotypes with treatments was also non-significant. On an overall average basis, the increase in SAR of soil due to saline/sodic water irrigation was significant in different treatments. Maximum SAR (52.5) was observed when water of EC 3.6 dS m^{-1}, SAR 24 (mmol L^{-1})$^{1/2}$, and RSC 4.5 meL^{-1} was applied followed by T_5 (43) where water of EC 3.6 dS m^{-1}, SAR 24 (mmol L^{-1})$^{1/2}$, and RSC 4.5 meL^{-1} was applied along with gypsum. While the minimum SAR (13.3) was found where FYM was applied in control. On percent basis application of brackish water (EC 2.4 dS m^{-1}, SAR 16 (mmol L^{-1})$^{1/2}$, and RSC 2.25 meL^{-1}) increased the SAR by 148% over control while application of gypsum and FYM in the same treatment increased the SAR by 64% and 98% respectively, over control. Similarly there was 258% increase in SAR of soil with respect to control when brackish water of EC 3.6 dS m^{-1}, SAR 24 (mmol $L^{-1})^{1/2}$, and RSC 4.5 meL^{-1} was applied while 193% and 190% increase in SAR of soil was observed in the same treatment when gypsum and FYM was applied, respectively.

The addition of gypsum and FYM to the high EC-SAR-RSC water had a positive decrease in SAR of soil as compared to high EC-SAR-RSC irrigation water. A reduction in SAR was observed by Zaka *et al*. (2003) with the application of organic amendments and gypsum. It reflects that gypsum along with FYM caused maximum leaching of Na^+ to affect a decrease in SAR of soil (Hussain *et al*., 1993). Similar results were reported by Murtaza *et al*. (1999) and Niazi *et al*. (2000) who found a significant decrease in SAR with the application of gypsum and farm yard manure.

CONCLUSIONS

Chlorophyll content, Leaf area $plant^{-1}$, Plant height, fresh weight of plant, dry weight of plant of all genotypes decreased significantly with increasing levels of brackish water but this decrease was minimum when gypsum and FYM was applied. Na^+ concentration of all genotypes increased significantly with increasing levels of brackish water but this increase was reduced when gypsum and FYM was applied. K^+ concentration of all genotypes decreased significantly with increasing levels of brackish water, but was increased when gypsum and FYM applied. K^+: Na^+ ratio of all genotypes decreased significantly with increasing levels of brackish water but increased when gypsum and FYM was applied. EC_e, SAR and pH_s in soils after harvesting of crop increased significantly with increasing levels of brackish water but decreased when gypsum and FYM were applied. It was concluded that maize crop could successfully be grown with brackish water using gypsum and FYM amendments.

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Table 1. Physical and chemical Characteristics of the Soil.

Determination	**Value**	**Unit**
pH_s	7.24	_
EC_e	2.08	dS m^{-1}
SAR	8.65	$(mmol\ L^{-1})^{1/2}$
Textural Class	Sandy Clay Loam	(Sand 67.75%,Silt 16.25% Clay 16%)

Table 2. Salts added per litter of irrigation water to irrigate one pot per irrigation

Treatments	Na_2SO_4 (g/L)	$NaHCO_3$ (g/L)	$MgSO_4.7H_2O$ (g/L)	$CaCl_2.2H_2O$ (g/L)
T1	-	-	-	-
T2	1.070	0.47	0.330	0.050
T3	1.720	0.6835	0.3578	0.0534
T4	1.070 + *Gyp	0.47 + Gyp	0.330 + Gyp	0.050 + Gyp
T5	1.720 + Gyp	0.6835 + Gyp	0.3578 + Gyp	0.0534+Gyp
T6	Control+**FYM	Control + FYM	Control + FYM	Control+ FYM
T7	1.070 + FYM	0.47 + FYM	0.330 + FYM	0.050 + FYM
T8	1.720 + FYM	0.6835 + FYM	0.3578 + FYM	0.0534 + FYM

* Gyp is applied on irrigation water basis** FYM was added in pots @ 20 $Mgha^{-}$

Table 3. Effect of brackish water on leaf area (cm^2) of maize

Treatments	**Pak- Fagwai**	**Sahiwal -2002**	**Mean**
T_1 (Control)	*737.8±6.20	646.6±7.58	691.9
T_2 (EC 2.4, SAR 16 and RSC 2.25)	520.4±0.87 (-29)	530.1±4.22 (-18)	525.3 (-24)
T_3 (EC 3.6, SAR 24 and RSC 4.5)	351.9±10.42 (-52)	415.0±1.26 (-36)	383.5 (-45)
T_4 (T_2+ Gypsum $_{iw}$)	567.7±10.38 (-23)	559.0±3.78 (-14)	563.4 (-19)
T_5 (T_3+ Gypsum $_{iw}$)	480.8±13.56 (-35)	452.9±10.82 (-30)	466.8 (-33)
T6(T1+ FYM @ 20 Mg ha^{-1})	878.9±12.87 (19)	691.9±10.51 (7)	785.4 (14)
T_7 (T_2 + FYM @ 20 Mg ha^{-1})	628.0±2.13 (-15)	574.5±2.45 (-11)	601.3 (-13)
T_8 (T_3 + FYM @ 20 Mg ha^{-1})	471.7±2.06 (-36)	448.8±4.61 (-31)	460.2 (-34)
Mean	579.6	539.8	

Values in parentheses show % increase/decrease over control.
*Average of three replications ± S.E

Table 4. Effect of brackish water on chlorophyll content (mg g^{-1}) of maize

Treatments	**Pak- Fagwai**	**Sahiwal -2002**	**Mean**
T_1 (Control)	*23.0±2.32	23.9±0.53	23.5
T_2 (EC 2.4, SAR 16 and RSC 2.25)	20.1±0.21 (-13)	20.7±1.11 (-14)	20.4 (-13)
T_3 (EC 3.6, SAR 24 and RSC 4.5)	15.6±2.27 (-32)	17.4±3.12 (-27)	16.5 (-30)
T_4 (T_2+ Gypsum $_{iw}$)	22.2±3.08 (-4)	21.2±0.32 (-11)	21.7 (-8)
T_5 (T_3+ Gypsum $_{iw}$)	19.6±0.55 (-15)	18.2±0.62 (-24)	18.9 (-20)
T6(T1+ FYM @ 20 Mg ha^{-1})	24.6±0.81 (7)	24.1±0.63 (1)	24.3 (4)
T_7 (T_2 + FYM @ 20 Mg ha^{-1})	23.4±0.23 (-3)	22.6±1.14 (-6)	23.0 (-4)
T_8 (T_3 + FYM @ 20 Mg ha^{-1})	20.6±0.83 (-11)	19.6±0.85 (-18)	20.1 (-15)
Mean	21.1	21.0	

Values in parentheses show % increase/decrease over control.
*Average of three replications ± S.E

Table 5. Effect of brackish water on plant height (cm) of maize

Treatments	Pak- Fagwai	Sahiwal -2002	Mean
T_1 (Control)	*36.6±0.74	32.1±0.91	34.4
T_2 (EC 2.4, SAR 16 and RSC 2.25)	27.5±1.25 (-25)	28.2±0.49 (-12)	27.8 (-19)
T_3 (EC 3.6, SAR 24 and RSC 4.5)	24.4±0.60 (-33)	25.3±0.51 (-21)	24.9 (-28)
T_4 (T_2+ Gypsum $_{iw}$)	30.5±0.58 (-17)	29.6±0.73 (-8)	30.0 (-13)
T_5 (T_3+ Gypsum $_{iw}$)	29.4±0.67 (-20)	27.0±0.84 (-16)	28.2 (-18)
T6(T1+ FYM @ 20 Mg ha^{-1})	36.7±0.74 (0.3)	32.3±0.49 (0.7)	34.5 (0.5)
T_7 (T_2 + FYM @ 20 Mg ha^{-1})	30.8±2.56 (-16)	29.3±1.08 (-9)	30.0 (-13)
T_8 (T_3 + FYM @ 20 Mg ha^{-1})	28.8±2.18 (-21)	26.3±0.69 (-18)	27.6 (-20)
Mean	30.6	28.8	

Values in parentheses show % increase/decrease over control.
*Average of three replications ± S.E

Table-6: Effect of brackish water on fresh weight (g) of maize

Treatments	Pak- Fagwai	Sahiwal-2002	Mean
T_1 (Control)	*48.9±1.28	43.6±3.11	46.3
T_2 (EC 2.4, SAR 16 and RSC 2.25)	32.9±2.81 (-23)	34.9±3.14 (-25)	33.9 (-27)
T_3 (EC 3.6, SAR 24 and RSC 4.5)	29.4±0.85 (-40)	30.9±3.92 (-36)	30.2 (-35)
T_4 (T_2+ Gypsum $_{iw}$)	37.8±2.41 (-23)	36.4±2.15 (-21)	37.1 (-20)
T_5 (T_3+ Gypsum $_{iw}$)	33.6±2.65 (-31)	31.8±1.88 (-34)	32.7 (-29)
T6(T1+ FYM @ 20 Mg ha^{-1})	49.2±1.75 (0.5)	44.5±2.15 (2.6)	46.8 (1.3)
T_7 (T_2 + FYM @ 20 Mg ha^{-1})	38.4±0.88 (-22)	36.3±1.21 (-21)	37.3 (-19)
T_8 (T_3 + FYM @ 20 Mg ha^{-1})	32.7±2.70 (-33)	31.8±2.20 (-34)	32.3 (-30)
Mean	37.9	36.3	

Values in parentheses show % increase/decrease over control.
*Average of three replications ± S.E

Table 7. Effect of brackish water on dry weight (g) of maize

Treatments	Pak- Fagwai	Sahiwal -2002	Mean
T_1 (Control)	*19.6±1.39	17.0±1.05	
T_2 (EC 2.4, SAR 16 and RSC 2.25)	12.3±1.65 (-37)	13.1±0.81 (-23)	
T_3 (EC 3.6, SAR 24 and RSC 4.5)	11.1±0.92 (-43)	12.1±0.05 (-29)	
T_4 (T_2+ Gypsum $_{iw}$)	14.0±0.68 (-29)	14.0±1.49 (-18)	
T_5 (T_3+ Gypsum $_{iw}$)	13.2±1.05 (-33)	12.4±0.47 (-27)	
T6(T1+ FYM @ 20 Mg ha^{-1})	20.0±0.78 (2)	17.1±0.27 (0.7)	
T_7 (T_2 + FYM @ 20 Mg ha^{-1})	14.5±0.47 (-26)	13.8±1.19 (-19)	
T_8 (T_3 + FYM @ 20 Mg ha^{-1})	13.1±0.93 (-33)	12.8±0.47 (-25)	
Mean	14.5	13.9	

Values in parentheses show % increase/decrease over control.
*Average of three replications ± S.E

Table 8. Effect of brackish water on Na^+ content (m mol/m^3) of maize

Treatments	Pak- Fagwai	Sahiwal -2002	Mean
T_1 (Control)	*215.7±3.84	287.3±11.26	
T_2 (EC 2.4, SAR 16 and RSC 2.25)	403.7±7.54 (87)	412.6±6.01 (44)	
T_3 (EC 3.6, SAR 24 and RSC 4.5)	439.3±2.73 (104)	455.0±7.37 (58)	
T_4 (T_2+ Gypsum $_{iw}$)	367.0±10.41 (70)	394.6±5.13 (37)	
T_5 (T_3+ Gypsum $_{iw}$)	388.3±11.14 (80)	416.3±2.33 (45)	
T6(T1+ FYM @ 20 Mg ha^{-1})	201.0±6.93 (-7)	276.7±1.45 (-4)	
T_7 (T_2 + FYM @ 20 Mg ha^{-1})	382.7±12.57 (77)	378.0±8.89 (32)	
T_8 (T_3 + FYM @ 20 Mg ha^{-1})	399.0±10.41 (85)	408.7±9.33 (42)	
Mean	355.8	378.6	

Values in parentheses show % increase/decrease over control.
*Average of three replications ± S.E

Table 9. Effect of brackish water on K^+ content (m mol/m^3) of maize

Treatments	Pak- Fagwai	Sahiwal -2002	Mean
T_1 (Control)	*260.3±2.73	318.0±4.36	
T_2 (EC 2.4, SAR 16 and RSC 2.25)	247.0±5.51 (-5)	295.3±5.78 (-7)	
T_3 (EC 3.6, SAR 24 and RSC 4.5)	227.2±9.24 (-13)	277.7±8.19 (-13)	
T_4 (T_2+ Gypsum $_{iw}$)	253.3±5.21 (-3)	304.3±4.04 (-4)	
T_5 (T_3+ Gypsum $_{iw}$)	243.3±3.76 (-7)	287.4±8.09 (-10)	
T6(T1+ FYM @ 20 Mg ha^{-1})	320.7±6.57 (23)	358.3±5.78 (13)	
T_7 (T_2 + FYM @ 20 Mg ha^{-1})	262.0±4.73 (1)	321.3±4.33 (1.0)	
T_8 (T_3 + FYM @ 20 Mg ha^{-1})	250.3±3.71 (-4)	309.0±5.77 (-3)	
Mean	258.0	308.9	

Values in parentheses show % increase/decrease over control.

*Average of three replications ± S.E

Table 10. Effect of brackish water on K^+/Na^+ ratio of maize

Treatments	Pak- Fagwai	Sahiwal -2002	Mean
T_1 (Control)	*1.2±0.01	1.1±0.04	1.2
T_2 (EC 2.4, SAR 16 and RSC 2.25)	0.6±0.02 (-49)	0.7±0.02 (-36)	0.7 (-43)
T_3 (EC 3.6, SAR 24 and RSC 4.5)	0.5±0.02 (-57)	0.6±0.01 (-44)	0.6 (-51)
T_4 (T_2+ Gypsum $_{iw}$)	1.0±0.03 (-22)	1.0±0.01 (-31)	1.0 (-26)
T_5 (T_3+ Gypsum $_{iw}$)	0.6±0.02 (-48)	0.7±0.02 (-39)	0.7 (-44)
T6(T1+ FYM @ 20 Mg ha^{-1})	1.3±0.04 (6)	1.3±0.02 (17)	1.3 (11)
T_7 (T_2 + FYM @ 20 Mg ha^{-1})	0.7±0.03 (-43)	0.9±0.03 (-23)	0.8 (-34)
T_8 (T_3 + FYM @ 20 Mg ha^{-1})	0.6±0.02 (-48)	0.8±0.02 (-32)	0.7 (-40)
Mean	0.8	0.9	

Values in parentheses show % increase/decrease over control.

*Average of three replications ± S.E

Table 11. Effect of brackish water on K^+/Na^+ ratio of maize

Treatments	**Pak- Fagwai**	**Sahiwal -2002**	**Mean**
T_1 (Control)	*1.2±0.01	1.1±0.04	1.2
T_2 (EC 2.4, SAR 16 and RSC 2.25)	0.6±0.02 (-49)	0.7±0.02 (-36)	0.7 (-43)
T_3 (EC 3.6, SAR 24 and RSC 4.5)	0.5±0.02 (-57)	0.6±0.01 (-44)	0.6 (-51)
T_4 (T_2+ Gypsum $_{iw}$)	1.0±0.03 (-22)	1.0±0.01 (-31)	1.0 (-26)
T_5 (T_3+ Gypsum $_{iw}$)	0.6±0.02 (-48)	0.7±0.02 (-39)	0.7 (-44)
T6(T1+ FYM @ 20 Mg ha^{-1})	1.3±0.04 (6)	1.3±0.02 (17)	1.3 (11)
T_7 (T_2 + FYM @ 20 Mg ha^{-1})	0.7±0.03 (-43)	0.9±0.03 (-23)	0.8 (-34)
T_8 (T_3 + FYM @ 20 Mg ha^{-1})	0.6±0.02 (-48)	0.8±0.02 (-32)	0.7 (-40)
Mean	0.8	0.9	

Values in parentheses show % increase/decrease over control.
*Average of three replications ± S.E

Table 12. Effect of brackish water on EC_e (dS m^{-1}) of soil

Treatments	**Pak- Fagwai**	**Sahiwal -2002**	**Mean**
T_1 (Control)	*13.1±0.81	13.9±0.53	13.5
T_2 (EC 2.4, SAR 16 and RSC 2.25)	15.7±0.61 (20)	14.9±0.99 (7)	15.3 (13)
T_3 (EC 3.6, SAR 24 and RSC 4.5)	16.0±0.68 (22)	16±0.50 (15)	16.0 (19)
T_4 (T_2+ Gypsum $_{iw}$)	14.3±0.17 (9)	14.0±0.26 (0.7)	14.1 (4.6)
T_5 (T_3+ Gypsum $_{iw}$)	14.0±0.96 (7)	15.0±0.28 (8)	14.5 (7.5)
T6(T1+ FYM @ 20 Mg ha^{-1})	12.2±0.66 (-7)	12.3±0.42 (-11)	12.2 (-9)
T_7 (T_2 + FYM @ 20 Mg ha^{-1})	13.6±0.08 (5)	13.6±0.20 (-2)	13.7 (1.2)
T_8 (T_3 + FYM @ 20 Mg ha^{-1})	13.5±0.26 (3)	14.2±0.63 (2)	13.9 (2.5)
Mean	13.9	14.0	

Values in parentheses show % increase/decrease over control.
*Average of three replications ± S.E

Table 13. Effect of brackish water on pH_s of soil

Treatments	**Pak- Fagwai**	**Sahiwal -2002**	**Mean**
T_1 (Control)	*7.7±0.07	7.6±0.06	7.7
T_2 (EC 2.4, SAR 16 and RSC 2.25)	8.5±0.04 (11)	8.6±0.06 (14)	8.6 (12)
T_3 (EC 3.6, SAR 24 and RSC 4.5)	8.9±0.12 (15)	8.9±0.25 (18)	8.9 (17)
T_4 (T_2+ Gypsum $_{iw}$)	8.6±0.08 (12)	8.4±0.14 (10)	8.5 (10)
T_5 (T_3+ Gypsum $_{iw}$)	8.8±0.17 (14)	8.7±0.20 (15)	8.8 (14)
T6(T1+ FYM @ 20 Mg ha^{-1})	7.2±0.11 (-6)	7.4±0.05 (-3)	7.3 (-5)
T_7 (T_2 + FYM @ 20 Mg ha^{-1})	8.3±0.12 (8)	8.5±0.19 (12)	8.4 (9)
T_8 (T_3 + FYM @ 20 Mg ha^{-1})	8.6±0.07 (11)	9.0±0.15 (19)	8.8 (15)
Mean	8.3	8.4	

Values in parentheses show % increase/decrease over control.
*Average of three replications ± S.E

Table 14. Effect of brackish water on SAR $(mmol\ L^{-1})^{1/2}$ of soil

Treatments	**Pak- Fagwai**	**Sahiwal -2002**	**Mean**
T_1 (Control)	*15.0±0.90	14.3±0.75	14.7
T_2 (EC 2.4, SAR 16 and RSC 2.25)	36.7±1.94 (145)	36.1±3.06 (152)	36.4 (148)
T_3 (EC 3.6, SAR 24 and RSC 4.5)	52.9±1.69 (253)	52.0±1.69 (264)	52.5 (258)
T_4 (T_2+ Gypsum $_{iw}$)	24.2±1.04 (61)	23.8±0.84 (67)	24.0 (64)
T_5 (T_3+ Gypsum $_{iw}$)	43.3±1.44 (189)	42.6±1.86 (198)	43.0 (193)
T6(T1+ FYM @ 20 Mg ha^{-1})	13.3±0.45 (-11)	13.3±1.52 (-7)	13.3 (-9)
T_7 (T_2 + FYM @ 20 Mg ha^{-1})	29.5±0.77 (97)	28.5±0.70 (99)	29 (98)
T_8 (T_3 + FYM @ 20 Mg ha^{-1})	43.9±1.17 (193)	41.2±0.80 (188)	42.5 (190)
Mean	32.3	31.5	

Values in parentheses show % increase/decrease over control.
*Average of three replications ± S.E