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Evaluating the Use of Groundwater Salinity/Sodicity on Soil Fertility and Their Impact on Sustainable Salt Tolerance in Wheat and Maize Species

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Abstract: Taxonomic diversity of understorey vegetation (herb species) was studied in two evergreen forests, viz. oak and pine in the Kumaun Himalaya. In terms of taxonomic diversity, Asteraceae and Lamiaceae were the two dominant families in the sampling forest types. Maximum number of species was found at hill base and minimum at hill top in both the forests. The number of families, genera and species ratio observed for pine forest was of course higher with compared to the oak forest showed about the higher taxonomic diversity. Perennials form had higher contribution as compared to annuals forms indicated better ability to store up soil. Very few species (9 species) were found to be common indicates higher dissimilarity in both type of forests. Species richness (per m2) was higher in the pine forest than the oak forest. A high value of beta-diversity in the oak forest point out that the species composition varied from one stand to another. However, low concentration of dominance value in the pine forest with compare to the oak forest point towards the dominance, which is shared by many species.
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Keywords: Species richness; beta-diversity; taxonomic diversity; forest

1. Introduction

The rate of growing global population warrants increase in the area under irrigated agriculture to fulfill the future food and fiber needs, which will need additional amounts of water. Competition for freshwater already exists among the municipal, industrial and agricultural sectors in several regions due to an increase in population. The consequence has been a decreased allocation of freshwater to agriculture (Tilman et al. 2002). This phenomenon is expected to continue and to intensify in less developed, arid region countries such as Pakistan, that already have high population growth rates and suffer from serious environmental problems (Qadir and Oster, 2004). As supplies of good-quality irrigation water are expected to decrease, available water supplies need to be used more efficiently (Oweis et al., 1999; Hatfield et al. 2001**;** Wichelns, 2002), where one of the techniques can be the reuse of saline and or sodic drainage waters (Shalhevet, 1994; Rhoades, 1989; Oster, 2000), or of marginal-quality waters generated by municipalities (Bouwer, 2002). The shortfall in irrigation water requirement is likely to reach 107 MAF by 2013 (Ghafoor et al., 2002b). In Pakistan, to supplement the present canal water availability at farm-gate (43 MAF), more than 531,000 tube wells are pumping 55 MAF water. Estimates show that about 70–80% of pumped water in Pakistan (67,842 million m^3) contains soluble salts and/or sodium ions (Na^+) levels above the permissible limits for irrigation water (Latif and Beg,2004). The use of underground water for irrigation resulted in deterioration of soil physical and chemical properties (Costa et al. 1991; Singh et al. 1992; Sarwar et al. 2002).

There are two major approaches for improving and sustaining productivity in a saline environment: modifying the environment to suit the plant and modifying the plant to suit the environment. Both these approaches have been used, either singly or in combination (Minhas, 1996), but the former has been used more extensively because it facilitates the use of alternative production inputs. 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 moderately salt tolerant crop; the threshold salinity for corn is 1.7 dSm^{-1} (Maas and Grattan, 1999). In another report by (Rhodes et al. 1992) maize can be grown at EC_e 1.5 to 3.0 and 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 varieties and changes in chemical and physical properties of soil under our field conditions by irrigated with brackish tube well water. Wheat is the most important and largest cereal crop in Pakistan. It covers a large proportion of the total area under cultivation. Total wheat area of Pakistan is about 8.5 million hectares and the majority of wheat is grown in Punjab. In Pakistan the most efficient way to increase wheat yield is to improve the salt tolerance of wheat genotypes because increasing the salt tolerance of wheat is much less expensive for poor farmers in developing countries than using other management practices, e.g. leaching salt from the soil surface etc. (Qureshi and Barrett-Lennard, 1998). According to (Rahmatullah et al. 2012), the wheat crop could be grown safely on saline / sodic water irrigation if proper dainage is existing on marginal environmental conditions. The main objective of this work was developed a successful planning of brackish water use for wheat yield and maize fodder production, observed soil deterioration and select best genotypes which can be economically grown by irrigating with brackish tube well water.

2. Material and Methods

2.1 Experimental site and seed source

Field experiments were conducted to study the performance of wheat and maize genotypes under natural field conditions, using available brackish water at farmer field in T. T. Singh District. Wheat genotypes (SARC-1 & V-8670) and Maize (Sahiwal & Akbar) which were already tested in hydroponic and lysimeter study in wire house at University of Agriculture, Faisalabad. Seed of wheat genotypes (8670 & SARC-1) and maize genotypes (Sahiwal-2002 & AKBAR) were collected from the Saline Agriculture Research Centre, Institute of Soil and Environmental Sciences and Plant breeding and genetic Department, University of Agriculture, Faisalabad and Fodder Research Institute, Sahiwal.

2.2 Treatments

T_1 Canal water
T_2 Tubewell water (EC 6.56 dSm^{-1}: SAR 14.8 $(m\ mol\ L^{-1})^{1/2}$: RSC 4.50 meL^{-1})
T_3 Tubewell water + GR*
T_4 Tubewell water + FYM**
* Gypsum requirement on water RSC basis
** FYM @ 25 Mg ha^{-1}

2.3 Soil / Plant sample collection and analysis

Initial soil sampling and analysis were done before start of experiments (Table-1). During the experiments soil sampling was done pre-sowing and post harvesting of each crop. The soil samples were analyzed for chemical (EC_e& SAR) and physical (Infiltration rate). the fully expended next to flag leaf at booting stage in wheat and at tesseling stage in maize was washed, cleaned, detached from plant and stored in separate eppendorf tubes at freezing temperature for leaf sap extraction to determine Na^+, K^+ and Cl^-. Determinations were done by using standard methods described by US Salinity Lab. Staff (1954).

Table-1: Initial physical and chemical characteristics of the soil (0-30 cm)

Irrigation Treatments	EC_e (dSm^{-1})			Increase or decrease in S_3over S_1 (%)
	S_1	S_2	S_3	
Canal water	3.15	3.05	2.71	-14
Tubewell water	3.15	7.34	9.43	+199
Tubewell water+GR*	3.15	5.28	6.10	+94
Tubewell water+FYM**	3.15	6.25	7.48	+137

S_1 Soil analysis before sowing wheat
S_2 Soil analysis after harvesting wheat
S_3 Soil analysis after harvesting maize
* Gypsum requirement on water RSC basis
** FYM @ 25 Mg ha^{-1}

2.4 Experimental procedure

In these experiments wheat-maize (fodder) cropping rotation was practiced. Two genotypes for each crop were selected from solution culture and lysimeter experiments which are SARC-1 and V-8670 for wheat while Akbar and Sahiwal-2002 for maize fodder. The tube well water contains EC 6.5 dSm^{-1}, SAR 10 $(m\ mol\ L^{-1})^{1/2}$ and RSC 4.50 meL^{-1}. The soil was prepared with ploughing and planking. Recommended dose of NPK was applied (120-90-60 kg ha^{-1}) for wheat and (200-150-200 kg ha^{-1}) for maize in each lysimeter. Half of the N and all P and K were applied at the time of sowing while the remaining half N was added in two equal doses at tillering and booting stages in wheat and for maize fodder 2nd dose of N was applied after 30 days of germination. Farm Yard Manure (FYM @ 25 Mg ha^{-1}) and gypsum was applied according to gypsum requirement of water (Eaton, 1954) at sowing time. The five irrigations (2inch) of brackish water were applied for completion of their life cycle.

2.5 Statistical analyses

The average of each sample and attribute for planned experiments were calculated and the standard deviation was tested at α 5% probability by using Stat View 5.0 (SAS Inst., Inc.).

3. Results

The study was carried out to determine the possibility of drainage water for crop production. Impact of different brackish water treatments with and without amendments on ECe, SAR, infiltration rate, Na:K ratio in leaf sap and crop yield and is discussed as under.

3.1 Soil salinity (EC_e dSm^{-1})

Soil analysis at different stages indicated that application of four types irrigation have affect the soil salinity. The data regarding to change in ECe due to application of brackish water with and without amendments is shown in table-2. Maximum increase of 199% of basic salinity level was observed in T_2 in which brackish water was applied without any amendments. However, same brackish tubewell water with gypsum (on RSC basis) minimized the adverse effect and reduced salinity buildup (94% of basic salinity level) as compared to brackish water application. Similarly application of FYM also reduced salinity development (137%).

Table- 2: Impact of irrigation treatments on EC_e of soil

Irrigation Treatments	EC_e (dSm^{-1})			Increase or decrease in S_3 over S_1 (%)
	S_1	S_2	S_3	
Canal water	3.15	3.05	2.71	-14
Tubewell water	3.15	7.34	9.43	+199
Tubewell water+GR*	3.15	5.28	6.10	+94
Tubewell water+FYM**	3.15	6.25	7.48	+137

S_1 Soil analysis before sowing wheat
S_2 Soil analysis after harvesting wheat
S_3 Soil analysis after harvesting maize
* Gypsum requirement on water RSC basis
** FYM @ 25 Mg ha^{-1}

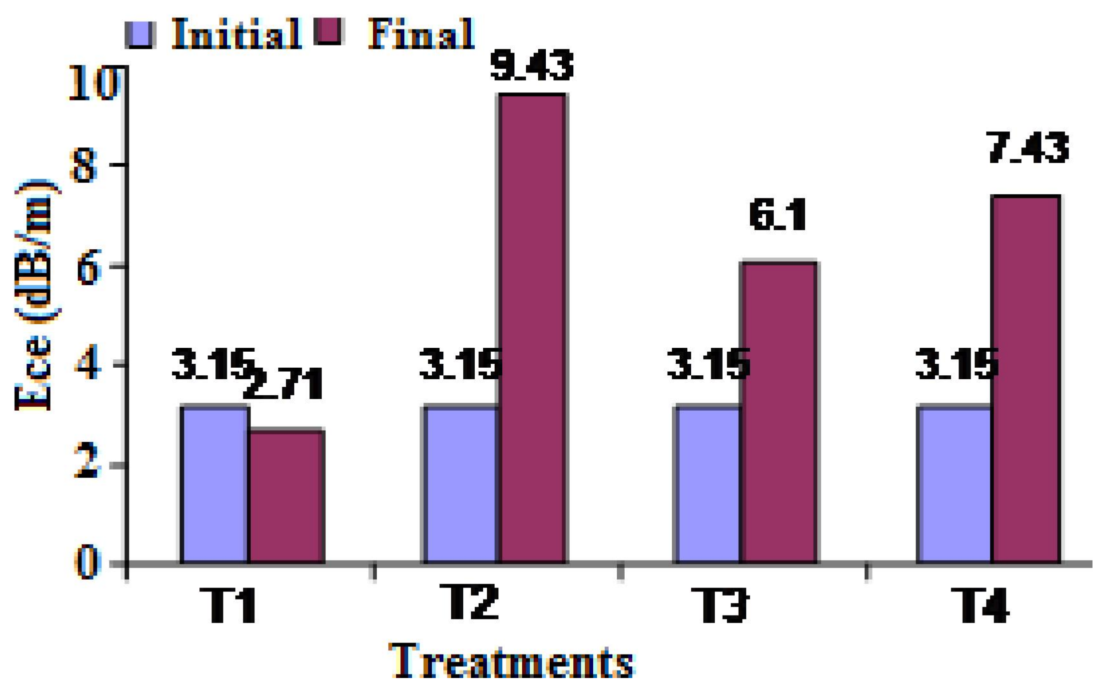

Fig.-1 Impact of irrigation treatments on final EC_e of soil

Soil salinity increased due to accumulation of salts with brackish water application. Cucci et al. (2002) reported that salt build up in soil increased with irrigation water salinity and mean increase in EC_e of soil was 13.9 (dSm^{-1}) in 1st year. An increase in EC_e upto 14.0 dSm^{-1} with application of brackish water (EC 3.6-7.4 dSm^{-1}) was also observed by (Yadav et al., 2004). Similarly, (Sail et al. 2005) observed increase in EC_e from 1.5 to 4.60 (dSm^{-1}) with waste water application. Similar observations were also reported by (Al-Rashed and Al-Senafy 2004) that increases in EC_e was directly proportional to EC_{iw}. Soil salinity almost static with a slight decrease of 14% over the basic salinity level in the case of canal water irrigation. The effect of different treatments on ECe is clearly shown in Fig.-1 indicated that ill effect on brackish water can be minimized with use of gypsum (on RSC basis) and to some extant with application of FYM @ 25 Mg ha^{-1}. Application of EC-SAR-RSC water along with gypsum and FYM minimized the adverse effect of brackish water and lowered the salt accumulation by improving soil aggregation and downward movement of water. (Yadav and Kumar 1995) and (Chaudhry et al., 2003) observed that gypsum application is required for maintaining yield of the crops irrigated with alkali water (RSC > 10 me L^{-1}).

3.2 Soil Sodicity (SAR)

The data regarding SAR of soil as effected by application of brackish tubewater alone and with amendments was represented in table-3.

Table-3:- Impact of irrigation treatments on SAR of soil

Irrigation Treatments	SAR (mmol $L^{-1})^{1/2}$			Increase or decrease over S_1
	S_1	S_2	S_3	
Canal water	3.39	4.00	4.55	+22
Tubewell water	3.39	7.05	9.07	+168
Tubewell water+GR*	3.39	5.58	6.63	+95
Tubewell water+FYM**	3.39	6.48	7.30	+115

S_1 Soil analysis before sowing wheat
S_2 Soil analysis after harvesting wheat
S_3 Soil analysis after harvesting maize
* Gypsum requirement on water RSC basis
** FYM @ 25 Mg ha^{-1}

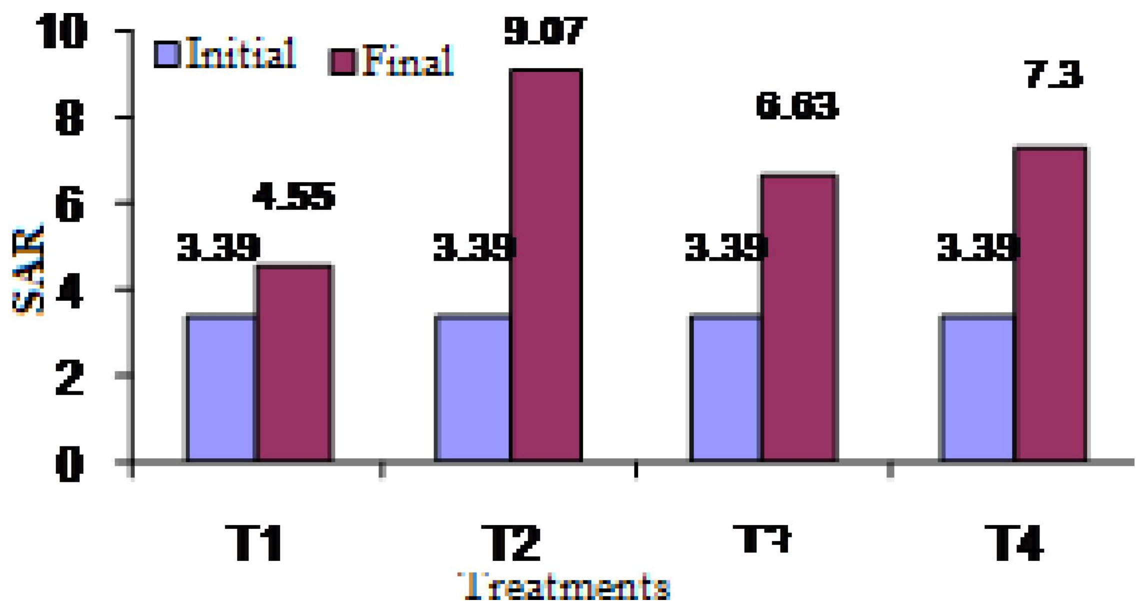

Fig. 2: Impact of irrigation treatments on final SAR of soil

Results indicated that application of canal water caused minimum increase in SAR (22% over baseline salinity), however irrigation with brackish water (T_2) caused maximum soil salinity (168%). Increase in soil SAR with brackish water was due to deterioration of soil structure, low infiltration rate and deficiency of nutrients. It is evident from previous observations by (Ahmad et al. 2002) that increase in soil SAR is directly proportional to SAR_{iw} under average management conditions. Increase in soil salinity in T3 and Y4 was 95% and 115% respectively. This reduction in SAR was due to use of Gypsum (RSC basis) and FYM that eliminated the adverse effect of brackish water. It is easily be deduced that gypsum application has help to reducing the soil SAR. The impact of brackish water treatments on soil Sodicity is fairly visible in Fig.2.Our results correlated with Murtaza et al. (2006) they observed significant increase in EC_e and SAR with the application of saline sodic water in sandy clay loam soil. Use of amendments like gypsum is recommended especially when RSC > 5 me/L, soils are medium textured and annual rainfall of the area is less than 500 mm (Minhas et al., 2004). Previously it was also reported that Use of higher EC and SAR water increased soil EC ranged from 12-100% with in three years along with increase in SAR of soil, but when this water is used with 100% gypsum applied to soil on RSC based of water, it decreased soil SAR (Chaudhry et al. 2003)

3.3 Infiltration Rate (IR)

Infiltration rate of soil was monitored before sowing and after harvesting of each crop to evaluate the changes due to application of brackish water application with and without amendments. Canal water application showed some improvement in the soil permeability and it was increased (9%) over initial level at the end of experimental period. Application of brackish tubewell water continuously decreased infiltration rate and it was 26% less than initial rate at the end of experiment. Application of brackish water caused clay dispersion, which decreased infiltration rate and hydraulic conductivity. Swelling and dispersion increase with increasing SAR_{iw} and decreasing EC_{iw} that effect the physical properties of soil (Oster, 1994). Quirk (2001) have confirmed higher HC (hydraulic conductivity) in low Na:Ca ratio, and lower hydraulic conductivity in higher Na:Ca ratio in irrigation water. The application of irrigation water having different Mg:Ca ratios (2, 4, 8 and 16), SAR (10, 25 and 50) and EC (2.0 and 8.0 dS m^{-1}) increased the dispersion from 6.7 to 8.1, 5.8 to 7.25, 3.0 to 5.6, 3.5 to 4.6 respectively, whereas hydraulic conductivity decreased from 6.5 to 5.5, 1.55 to 1.40, 14.3 to 13.1 and 34.0 to 32.0 mm h^{-1} respectively (Yadav, 1982). Similarly decrease in infiltration rate and increase in bulk density also reported by Murtaza et al. (2002) when they used higher SAR (16.43) and RSC (5.57me L^{-1}) water.

Table-4: Impact of irrigation treatments on infiltration rate of soil

Irrigation Treatments	Infiltration rate (cm hr^{-1})			Increase or decrease over S_1
	S_1	S_2	S_3	
Canal water	0.92	0.98	1.00	+9
Tubewell water	0.92	0.73	0.68	-26
Tubewell water+GR*	0.92	0.92	0.98	+7
Tubewell water+FYM**	0.92	0.95	0.96	+4

S_1 Soil analysis before sowing wheat
S_2 Soil analysis after harvesting wheat
S_3 Soil analysis after harvesting maize
* Gypsum requirement on water RSC basis
** FYM @ 25 Mg ha^{-1}

Salts like calcium and magnesium, do not adversely affect infiltration rate because they tend the cluster to clay particles. Calcium and magnesium will generally keep soil flocculated because they compete for the same spaces with sodium to bind to clay particles. Increased amounts of calcium and magnesium can reduce the amount of sodium-induced dispersion. The main concerns related to the relationship between salinity and sodicity of irrigation water are the effects on soil infiltration rate. It was also reported that the application of higher SAR water affect the infiltration rate besides giving rise to specific ion effect and nutrition imbalance in soil plant ecosystem (Azhar et al. 2003). In this study, infiltration rate was observed with brackish water application. The data regarding infiltration rate as effected by brackish water application with and without amendments, for wheat and maize crop production are presented in Table-4. The results revealed that application of gypsum and FYM along with brackish tubewell water improved the infiltration rate that was 34% and 30% as compared to irrigation with brackish water alone. Kahlown and Azam (2003) also recorded that maximum improvement (88.9%) in infiltration rate was recorded with green and farmyard manure application with saline irrigation water (EC 2.25 dS m^{-1}).

3.4 Sodium Potassium Ratio in Cell Sap

In present study brackish water treatments have significant effect on $Na^+$and K^+:Na^+ ratio. The maximum concentration of Na^+ was found in leaf sap of wheat and maize genotypes in the brackish tubewell water treatments that were 176.9 & 210.9 mol m^{-3} in leaf sap of SARC-1 and V-8670 respectively, similarly 186.5 & 210.5 mol m^{-3} in leaf sap of Sahiwal-02 and Akbar followed tubewell water with FYM and tubewell water with gypsum (Table 5 & 6). Our results confirmed the earlier finding of Wang et al. (2005) that irrigation waters differing in salt concentration effect growth and salt ion (Na^+) accumulation in leaf of soybean. Cicek ad Cakirlar (2002) also observed an increase in Na^+ concentration and decrease in K^+:Na^+ under saline condition. Results obtained by Azevedo Neto and Tobasa (2000b) also revealed that Na^+ concentration increased with increase in salinity.

Table- 5: Impact of brackish water application on ionic concentration in leaf sap of wheat genotypes

Irrigation Treatments	Ionic concentration				Decrease over control			
	Na^+ conc. (mol m^{-3})		K^+:Na^+ ratio		Na^+ conc. (%age)		K^+:Na^+ ratio (%age)	
	SARC-1	8670	SARC-1	8670	SARC-1	8670	SARC-1	8670
Canal water	54.2	50.75	2.85	2.5				
Tubewell water	176.9	210.9	0.81	0.64	226	316	-72	-74
Tubewell water+GR*	127.8	135.7	1.17	1.05	136	167	-59	-58
Tubewell water + FYM**	145.4	142.5	0.98	0.98	168	181	-66	-61

Table- 6: Impact of brackish water application on ionic concentration in leaf sap of maize genotypes

Irrigation Treatments	Ionic concentration				Decrease over control			
	Na^+ conc. (mol m^{-3})		K^+:Na^+ ratio		Na^+ conc. (%)		K^+:Na^+ ratio (%)	
	Sahiwal-02	Akbar	Sahiwal-02	Akbar	Sahiwal-02	Akbar	Sahiwal-02	Akbar
Canal water	48.05	40.5	3.72	4.01				
Tubewell water	186.5	210.5	1.08	0.82	288	338	-71	-80
Tubewell water+ GR*	144.5	183.13	1.20	0.91	201	281	-68	-77
Tubewell water+ FYM**	150.25	180.13	1.22	0.9	213	275	-67	-78

The results of this study shows that K^+:Na^+ ratio in leaf sap varies among the genotypes as well as treatments. Highest K^+:Na^+ ratio was observed in cell sap of SARC-1 (wheat genotype) and Sahiwal-02 (maize genotype) as compared to other genotypes sown in same growth conditions. Lowest ratio was observed in wheat and maize genotypes with brackish water irrigation. However, use of Gypsum and FYM along with brackish water minimized the adverse effect of high salt concentration in irrigation water. It has been suggested by Vetterien et al. (2004) that tolerant species have ability to maintain higher K^+ and lower Na^+ uptake as compared to salt sensitive species, while the most sensitive variety contained a 4-fold greater Na^+ concentration in shoots than the most tolerant variety. Our results confirmed the finding of Azevedo Neto and Tabosa (2000 b) that Na^+ concentration increased in leaf of salt stressed maize plant. Increase in Na^+ concentration under salt stress become toxic and adversely effect plant growth (Hasegawa et al., 2000). It was inferred that the genotypes possess high K^+:Na^+ ratio can be used as selectivity characteristic of salt tolerance. Therefore, SARC-1 and Sahiwal-02 maintained high K^+:Na^+ ratio even at high salt concentration in irrigation water and it tolerated these adverse conditions. It was due to K^+ versus Na^+ selectivity that was an affective strategy for identifying salt tolerance in plant species (Al-Karaki, 2000).

4.0 Crop Yield

The plant height of randomly selected plants of wheat and maize genotypes were measured at maturity stage. However, wheat grain yield and maize fodder weight were evaluated on whole plot basis to avoid any variation in experimental area and explained as under:

4.1 Wheat grain yield (kg/ha) and plant height (cm)

The data regarding the grain yield and plant height of wheat genotypes are presented in Fig. 3 and 4 showing reduction in plant height and grain yield with brackish water application. Lowest plant height was observed in tubewell water application which was 62 cm and 49cm as compared to canal water treatment which was 83 cm and 82 cm in SARC-1 and V-8670 respectively. Similar effect was observed on grain yield of wheat genotypes that was decreased 30% and 42% over canal water treatment in SARC-1 and V-8670, with application of brackish tubewell water. These findings are correlated with ealier studies of Singh (2004) that wheat grain yield reduced up to 47% in saline water treatments. Similarly Hamdy et al. (2005) observed that saline water (9 dSm^{-1}) decreased wheat grain yield upto

25% when compared with canal water treatment. A reduction in wheat grain yield (7, 5 &13 %) with application of water having EC of 1.5, 2.0 & 2.85 (dS m^{-1}) was also reported by Chaudhary et al. (1986). Our results also support the earlier finding of Oad et al. (2001) in which lower wheat grain yield (1333 kg ha^{-1}) was observed with saline water treatment as compared to canal water application (4733 kg ha^{-1}). Similarly, Holloway and Alstan (1992) observed a reduction in wheat yield due to reduced tillering, plant height, root length and water use efficiency. The results also confirmed the finding of El-Hendawy et al. (2005) that salinity (upto 150 m M NaCl) reduced number of tillers and yield upto 41 and 221% respectively. The variation in the behavior of wheat genotypes indicated that SARC-1 produced better yield as compared to V-8670 under all treatments. Overall results show that application of brackish water along with FYM was comparatively more effective than other brackish water treatments in overcoming the adverse effect of poor quality water due to addition of organic matter which improved the soil physical conditions and improved infiltration rate. Use of gypsum minimized the deleterious effect of brackish water and improved soil conditions and crop yields (Chaudhry et al., 2004). Previously it was reported by Eneji et al. (2001) that the better biomass and yield of rice after amending soil with different sources of manures.

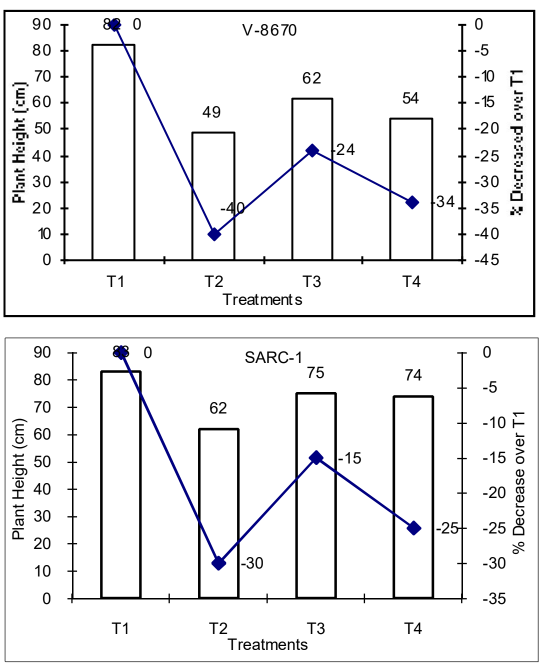

Fig 3: Impact of brackish water application on plant height of wheat genotypes

- The means having different letters are significantly different from each other at 5% level of probability

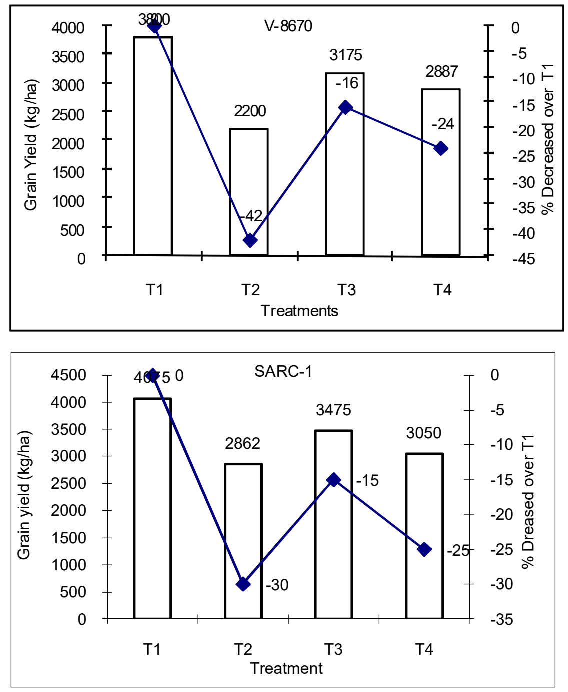

Fig 4: Impact of brackish water application on grain yield of wheat genotypes

- The means having different letters are significantly different from each other at 5% level of probability

T_1 Canal water3.15
T_2 Tubewell water
T_3 Tubewell water+GR
T_4 Tubewell water+FYM

4.2 Maize fodder yield (kg/ha) and plant height (cm)

On an overall average basis, maize plant height and fodder yield reduced in brackish water treatments. The maximum plant height was obtained by Sahiwal-02 with canal water treatment (315, 195, 260 and 245 cm in T_1, T_2, T_3 and T_4 respectively) and similarly, maximum fresh biomass also gain by Sahiwal-02 (96250kg ha^{-1}) with canal water application. Application of brackish tubewell water reduced growth parameters of both maize genotypes, maximum reduction in plant height (49%) and fresh biomass (75%) was observed in Akbar as compared to Sahiwal-02. Salinity inhibits maize growth and reduction in plant height and biomass (Irshad et al. 2002). Relative yield decrease with increasing irrigation water salinity and time interval between irrigations (Feng et al. 2003).

Irrigation with brackish water reduces plant growth and biomass. As shown in Fig. 5 & 6, the reduction in plant height and fodder yield was maximum in brackish tubewell water application treatment as compared to control and other treatment. The reduction in fresh biomass was more with tubewell brackish water application due to more accumulation of salts which deteriorate the soil physical condition. Previously, Hussain et al. (2002) also reported same effect of brackish water application. Application of tubewell brackish water along with gypsum and FYM reduced the adverse effect of brackish water. The management practices to be followed for optimal crop production with brackish water must aim at preventing the buildup of salinity, sodicity and toxic ions in the root zone to levels that limit the productivity of soils. Previously Chaudhary *et al.* (2004) also reported an improvement in crop yield in brackish water along with gypsum treatment as compared to brackish water irrigation. In another study maximum barley fodder yield (40t ha^{-1}) was obtained when brackish water (EC 6.5 and $11 dSm^{-1}$) applied along with 30 t ha^{-1} poultry manures (Gilani et al. 2006).

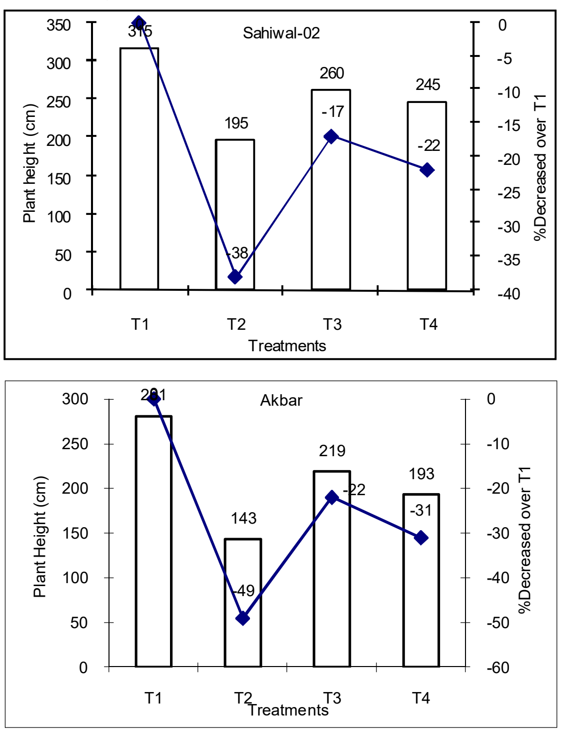

Fig 5: Impact of brackish water application on plant height of maize genotypes

- The means having different letters are significantly different from each other at 5% level of probability

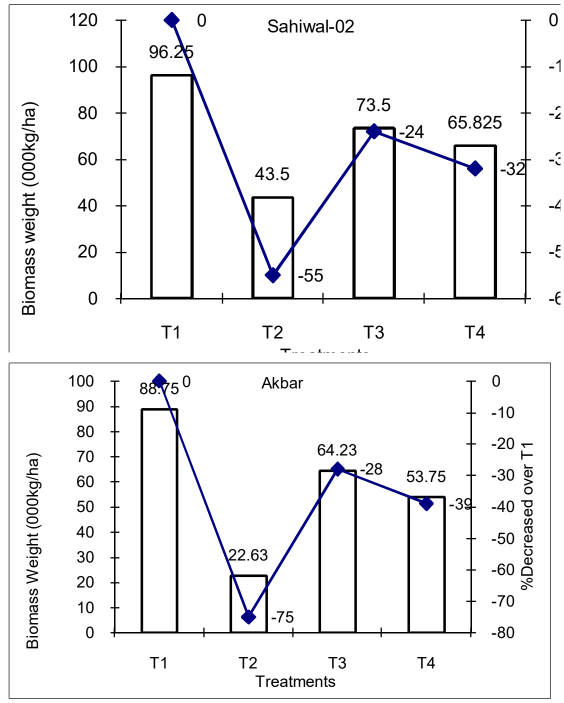

Fig 6: Impact of brackish water application on biomass weight of maize genotypes

- The means having different letters are significantly different from each other at 5% level of probability

T_1	Canal water
T_2	Tubewell water
T_3	Tubewell water+GR
T_4	Tubewell water+FYM

4. Conclusions

On the basis of all experiments, following recommendations have been suggested for the beneficence of the end users for the adoption in existing cropping scheme.

1. Application of brackish tubewell water for crop production results in build up of soil salinity and cause in reduction in yield.
2. Results presented here reveal that wheat and maize fodder yield are enhanced if brackish tubewell water applied with gypsum requirement. It has observed that FYM also have important role to minimized adverse effect of brackish tubewell water on crop production.
3. Wheat genotype SARC-1 and maize variety Sahiwal-2002 can be grown profitably when apply brackish tubewell water alone and/or with amendments

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References

[1] Ahmad N.Evaluation of effectiveness of sulphurous acid generator in treating the sodic under different scenarios for wheat crop. M. Phil. Thesis, Water Resources Management, Center of Excellence in Water Resources Engineering, Univ. of Engg. & Tech., Lahore, Pakistan.2002; 1:335-336.
[2] Al- RashedM,& Al- Senafy M. Assessment of ground water salinization and soil degradation in Abdally Farm, Kuwait. Agriculture and Marine Sciences2004;9: 17-19.
[3] Al-Karaki GN. Growth, water use efficiency, and sodium and potassium acquisition by tomato cultivars grown under salt stress.Journal of Plant Nutrition2002; 33:1-8.
[4] Azhar M, Yamin J & Ali CK. Ground water exploitation and application: the major issues. Paper prepared for 3rd International civil Engineering Congress,21st- 22nd Feb., 2003, Karachi.
[5] AzevedoNeto AD &TabosaJN.. Salt stress in maize seedling: II. Distribution of cation macronutrients and its relation with sodium. Revista Brasilia Agriculture Ambient2000; 4: 165-171.
[6] AzevedoNeto AD, Prisco JT, Eneas-Filho J, de Lacenda CF, Silva JV, Costa PHA, &Filho EG. Effect of salt stress on plant growth, stomatal response and solute accumulation of different maize genotypes. Brasilian Journal of Plant Physiology2004; 16 (1): 31-38.
[7] Bajawa MS, &Josan AS. Prediction of sustained sodic irrigation effects on soil sodium saturation and crop yield. Agriculture Water Management1989; 16: 217-228.
[8] Bouwer H. Integrated water management for the 21st century: problems and solutions. Journal of Irrigation and Drainage Engineering2002; 28:193 – 202.
[9] Chaudhary MR, Rafique MS, Ali H &Shahid LA. Soil properties and crop yield as affected by different water salinity levels. Pakistan Journal of Soil Science1986;42-50.
[10] Chaudhary MR,Iqbal M &Subhani KM.Use of brackish drainage water effluent for crop production. 9th International Drainage Workshop, September 10– 13, 2003, Utrecht (The Netherlands).
[11] Chaudhary MR, Iqbal M &Subhani KM.. Use of Poor Quality Drainage Water for Crop Production and Its Impact on Soil. *Pakistan.* Journal of Water Resources 2004;Vol.8 (1) January-June.
[12] Cicek N &Cakirlar H. The effect of salinity on some physiological parameters in two maize cultivars. Bulgarian Journal of Plant Physiology2002;28(1-2): 66-74.
[13] Costa JL, Prunty L, Montgomery BR, Richardson JL &Alessi RS. Water quality effect on the soils and alfalfa. Soil Science Society of America Journal1991;55: 203-209.
[14] Cucci G, Rubino P & Caliandro A. Effects of Irrigation Water with Different Salt Concentrations and SAR Values on Soil Salinisation and Sodification. Italian Journal of Agronomy2000;7(1):41-48.
[15] Eaton RP. Significance of carbonates in irrigation waters. Soil Science1950; 69: 123-133.
[16] El- Hendawy SE, Hu Y, Yakout GM, Awad AM, Hafiz SE &Schmidhalter. Evaluating salt tolerance of wheat genotypes using multiple parameters. European Journal of Agronomy 2005. 22: 243-253.
[17] Eneji AE, Yamamoto S &Honna T. Rice growth and nutrient uptake as affected by livestock manure in four Japanese soils. Journal of Plant Nutrition2001;24 (2): 1-11.
[18] Feng YY & Cong CZ. Equilibrium of organic matter in heavy fraction for three long term experimental field soils in China. Pedosphere2003;16(2):177-184.
[19] Ghafoor A, Qadir M &Murtaza G. Agriculture in the Indus Plains: Sustainability of Land and Water resources: A Review. InternationalJournl of Agriculture and Biology2002;4(3): 428-437.
[20] Gilani MA, Hachicha M, Soiuci J &Elgassier H. Utilization of Brackish Saline Water in North Africa. The 18th World Congress of Soil Science (July 9-15, 2006)2006;Philadelphia, Pennsylvania, USA.
[21] Hasegawa PM, Bressan RA, Zhu JK & Bohnert HJ. Plant cellular and molecular responses to high salinity. Annaul Rev. Plant Physiology and Plant Molecular Biology2000;51:463-499.
[22] Hatfield JL, Sauer TJ and Prueger JH. Managing soils to achieve greater water use

efficiency: A review. Agronomy Journal 2001;93:271 –280.
[23] Hamdy A, Sardo V &FarragGhanem KA. Saline water in supplemental irrigation of wheat and barley under rain fed agriculture. AgricultureWater Manage 2005;78, 122-127.
[24] Holloway RE & Alston AM. The effects of salt and boron on growth of wheat. Australian Journal of Agriculture Research1992;43:987-1001.
[25] Hussain N, Jakhar RA, Tahir M, Noreen R, Hassan NM &Mujeeb F. Impact of Ca/Mg Ratios of Irrigation Water on Soil Properties and Crop Yields. Asian Journal of Plant Sciences2002;1: 51-52.
[26] Irshad M, Yamamoto S, Eneji AE &Honna T. Influence of composed manure and salinity on growth and nutrient contents of maize tissue. Sympo. No. 58, Paper No. 96. 17th WCSS, 14-21 August, 20002;Thailand.
[27] Kahlown MH&Azam M. Effect of saline drainage effluent in soil healthand crop yield. Agriculture Water Management2003; 62: 127-138.
[28] Latif M & Beg A. Hydrosalinity issues, challenges and options in OIC member states. In: Latif M, Mahmood S and Saeed MM, Editors, Proceedings of the International Training Workshop on Hydrosalinity Abatement and Advance Techniques for Sustainable Irrigated Agriculture, 20–25 September Lahore, Pakistan (2004), pp. 1–14.
[29] Maas EV & Grattan SR. Crop yield as affected by salinity. In. R.W. Skaggs and J. van Schilfgaarde, eds., agricultural Drainage. Agronomy Monograph 38. ASA, CSSA, SSSA, Madison, WI.
[30] Minhas PS. Saline water management for irrigation in India. Agriculture Water Management 1996; 30: 1–24.
[31] Minhas PS, Sharma DR &Chauhan CPS. Management of saline and alkali waters for irrigation. In: Advances in Sodic Land Reclamation, International conference on ‘‘Sustainable Management of Sodic management. Pakistan Journal of Agricultural Sciences2004;35:16-23.
[32] Murtaza G, Shah SH, Ghafoor A, Akhtar S &Mahmood N. Management of brackish water for crop production under arid and semi-arid conditions. Pakistan Journal of AgriculturalSciencrs2002; 39:166-170.
[33] MurtazaG, Ghafoor A &Qadir M. Irrigation and soil management strategies for using saline-sodic water in a cotton–wheat rotation. Agriculture Water Management2006;81: 98-114.
[34] Oad NL, Oad FC, Mangio HR, Abro ZA &Soomro A. Irrigation management strategies in corn production under various water qualities. Journal of Biological Sciences2001;1(4):251-252.
[35] OsterJD. Irrigation with poor quality water. Agriculture Water Management1994;25 (1994): 271–297.
[36] Oster JD. Irrigation sustainability. In: Proceedings of the Sixth International Micro-irrigation Congress, 22–27 October 2000. Cape Town. ICID-CIID. Plenary Session, P6. CD Rom. Document Transformation Technologies, POB 560, Lirene, 0062, South Africa
[37] Oster JD & Grattan SR. Drainage water reuse. Irrigation and Drainage System2002;16 (2002): 297–310.
[38] Oweis T, Hachum A & Kijne J. Water harvesting and supplemental irrigation for improvedwater use efficiency in dry areas. SWIM Paper 7, Colombo: International Water Management Institute. 1999; 41
[39] Poustini K &Siosemardeh A. Ion distribution in wheat cultivars in response to salinity stress. Field Crops Research2004;85: 125–133
[40] Quirk JP. The significance of the threshold to turbidity concentrations in relation to sodicity and microstructure. Australian Journal of Soil Research2001;39: 1185-1217.
[41] Qadir M & Oster JD. Crop and irrigation management strategies for saline-sodic soils and water aimed at environmentally sustainable agriculture. Science Total Environment. 2004;323:1–19.
[42] Qureshi RH & Barrett-Lennar EG. Three approaches for managing saline, sodic and waterlogged soils. P: 19-24 In: Saline Agriculture for irrigated land in Pakistan. A Hand book, ACIAR, Canberra, Australia.1998.
[43] Rahmatullah, Murtaza G, Ghafoor A, Saifullah. Improving the performance of wheat (Triticumaestivum) by seed priming in salt affected soils irrigated withsaline sodic water. The Journal of Animal and Plant Sciences 2012;22(4):1055-1059.
[44] Rhoades JD. Intercepting, isolating and reusing drainage water for irrigation to conserve water and protect water quality. Agriculture Water Management1989;16: 37–52.

[45] Rhoades JD, Kandiah A &Mashali AM. The use of saline waters for crop production. FAO Irrigation and Drainage Paper 48, Rome.1992.
[46] Sail JK, Bibi S &Qurashi AS. Environmental impact of sewage water irrigation on ground water quality. Pakistan Journal of Water Resources2005;9: 49-53.
[47] Sarwar G, Hussain N, Iqbal J, Aslam M & Hassan A. Correlation of brackish water and physical properties of silty clay loam soil. Pakistan Journal of Agricultural Science2002;39: 250-257.
[48] Shalhevet J. Using water of marginal quality for crop production: major issues, Agricultural Water Management1994;25: 233–269.
[49] Singh RB, Minhas PS, Chauhan CPS& Gupta RK. Effect of high salinity and SAR waters on salinization, sodication and yields of pearl-millet and wheat. Agricultural Water Management1992;21. 93-105.
[50] Singh RK, Singh KN, Misra B, Sharma SK &Tyagi NK. Harnessing plant salt tolerance for overcoming sodicity constraints. In: Advances in Sodic Land Reclamation, International Conference on Sustainable Management of Sodic Lands, 9–14 Febraury 2004, Lucknow, India, 2004;pp. 81–120.
[51] Tilman D, Cassman KG, Matson PA, Naylor R, Polasky S. Agricultural sustainability and intensive production practices. Nature2002;418: 671–677.
[52] U. S. Salinity Laboratory Staff. 1954. Diagnosis and improvement of saline and alkali soils.USDA Handbook, vol. 60. US Government Printing Office, Washington, DC, USA.
[53] Vetterlein D, Kuhn K, Schubert S &Jahn R. Consequences of sodium exclusion for the osmotic potential in the rhizosphere-Comparison of two maize cultivars differing in Na^+ uptake. Journal of Plant Nutrition and Soil Science2004;167: 337-344.
[54] Wang D, Grieve CM &Suarez DL.Composition of irrigation water salinity affects growth characteristics and uptake of selenium and salt ions by soybean. Journal of plant nutrition 2005;28: 1073-1088.
[55] Wichelns D. An economic perspective on the potential gains from improvements in irrigation water management. Agricultural Water Management2002;52: 233–248.
[56] Yadav JSP. Use of saline ground water for irrigation. In Proceeding of the international symposium on salt-affected soils, 1982;p. 281-290. Karnal, India, CSSRI.
[57] Yadav RK, Kumar A, Lal D&Batra L. Yield responses of winter (rabi) forage crops to irrigation with saline drainage water. Experimental Agriculture2004;40: 65–75.
[58] Yadav HD & Kumar V. Use of sodic waters. In: Reclamation and Management of Waterlogged Saline Soils, Rao, K.V.G.K., Agarwal, M.C., Singh, O.P. and Osterbaan, R.J (Eds).1995; 226-241, CCSRI, Karnal and CCS HAU, Hisar.

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