AGRONOMIC APPROACH FOR ABATING DELETERIOUS EFFECTS OF BRACKISH WATER ON RICE AND WHEAT

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ABSTRACT

Most of the agricultural land in Pakistan falls in arid and semi-arid regions where both surface and ground water contains high concentrations of salts. As a result of the continuous use of brackish water for irrigation, secondary Stalinization / sodification is increasing in agricultural land. Therefore, the present study was designed to find out the effective agronomic and engineering practices to minimize the deleterious effect of brackish water on crops (Wheat and Rice) and soil at Soil Salinity Research Institute, Pindi Bhattian Research Farm, during 2007 to 2011. Six treatments i.e T_1 = Conventional seed bed preparation (cultivator only), T_2=Use of Rotavator (once) + T_1, T_3=Use of Disc plough (once) + T_1, T_4=Use of Chisel plough (once) + T_1 , T_5= T_3 + Chisel plough (once) and T_6= T_2 + Chisel plough (once) were compared. The source of irrigation was tube well water having EC_e=1.54 (dS m^{-1}), SAR=7.60 (mmol $L^{-1})^{1/2}$ and RSC=4.80 (meq L^{-1}). A normal field {pH_s=8.22, EC_e=1.50 (dS m^{-1}) and SAR=13.11 (mmol $L^{-1})^{1/2}$} was selected for this study. Rice (Shaheen Basmati) and Wheat (Inqulab-91) were grown as test crops. The results showed that maximum paddy (3.593 $t.ha^{-1}$) and wheat grain yield (3.883 $t.ha^{-1}$) were obtained with T_5 {(T_3+ chisel plough (once) used. It was concluded that bad effect of brackish water could be minimized in soil by using Disc plough (once) + Chisel plough (once).

Key words: Agronomic practices, Wheat-rice, brackish water
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INTRODUCTION

Pakistan is an agricultural country with total geographical area of 79.61 million hectares, out of which cultivated area is 22.16 million hectares, about 22.04 million hectares of the cultivated area is used for crop production and nearly 17.13 million hectares of the cropped area is irrigated [20]. Pakistan has the largest irrigation system in the world but the availability of canal water dose not commensurate to grow crops on all the culturable land. Agriculture in arid and semiarid region is threatened with acute shortage of irrigation water [3]. To overcome / meet the shortage and to make up the gap, canal water resources can be supplemented by ground water of which 70-75% is brackish [5].

According to an estimate there are 565000 tube wells pumping ground water in the Indus Basin. In Punjab alone, the number of private tube wells has increased from about ten thousand in 1960 to about five hundred thousand in 2000. The ground water abstraction from the public and private tube wells is about 6.05 MAF, of which 1.23 MAF is from public tube wells and 4.8 MAF is contributed by the private sector. The situation of ground water quality is deteriorating due to rapid growth of tube wells in the private sector. These ground waters have different types of salts, which deteriorate the soil accordingly [12]. The deterioration of soil was due to high SAR and RSC of irrigation water [7] and indiscriminate use of such water has made large irrigated areas unproductive [6]. Rice wheat rotation has been followed on a large area of the country because of high water requirements of the system, sodication rates of the soil are being irrigated and their steady state pH and sodicity value are much more (about1.8 times) than that of the low water requiring rotations like millet/maize-wheat [11].

The use of such water can lead to rapid increase in salt content of plant root zone in arid and semiarid conditions where evaporation rates are high. This root zone salt build up can be deleterious for crop growing [14]. Similarly, it was further reported that

continuous use of such ground water without appropriate management practices or any amendment could make the soils saline / sodic [13]. However low quality waters can be used for irrigation if proper management practices are followed [16 &21]. These results do show that subject to the following of specific soil-water-crop management systems, it is possible to control the buildup of sodicity in soils and sustain crop yield. There are two major approaches to improve soil health and sustaining crop production in a saline environment modifying the environment to suit the plant and modify the plant to suit the environment [23]. Both these practices have been used either singly or in combination [24] but the first approach has been used extensively [23]. In view of the above discussion, agronomic / engineering techniques can prove helpful to modify the saline environment. In this regard the role of tillage implements in seed bed preparation to minimize the deleterious effects of brackish (saline sodic) water cannot be neglected.

Ahmad et al. [2] concluded that tillage implements had significant effect on soil properties and ultimately on crop yield. They further added that Rotavator though produced fine soil tilth at top layer but did not affect the soil at depth thus causing low yield but with cultivator produced good results. Chisel plough on the other hand may be good for breaking any hard layer developed by implements used for many years for the same depth. Moreover it was further concluded that cultivation increases the mulch ability, infiltration rate, helps in leaching the salts and reclaiming saline sodic soils [15] and prolong the salts build up period with poor quality (brackish) water. Similarly Sadiq et al. [17] has reported that the disc plow not only ensured favorable yields but also helped in improving soil properties as compared with cultivator and Rotavator used for land preparation. It was further concluded that the increase in yield recorded with the use of disc plow could be attributed to the disc plow cutting the soil deeper, which in turn could have increased the mulching ability and the infiltration rate as well as helped more in leaching of salts in the soils. Mari et al. [9] reported the similar type of findings that infiltration rate was found 17% more by disc plough as compared with disc harrow, cultivator, mould board plough and Sat-Hari. The present study was conducted to find out the best agronomic/engineering techniques for combating the adverse effects of brackish (saline sodic) water on the yield of crops and soil health.

MATERIAL AND METHODS

The experiment was conducted at Agricultural Research Farm, Soil Salinity Research Institute, Pindi Bhattian, Hafizabad for four years (2007-2011) on wheat & Rice crops. A normal field {(pH_s=8.00, EC_e=1.50 dS m^{-1} and SAR=10.31 (mmol $L^{-1})^{1/2}$} was selected. The trial was laid out using randomized complete block design with three replications. Plot size was kept 5m x 10m. The field was well prepared according to the treatment plan. Following treatments were tested.

T_1- cultivator only in seed bed preparation
T_2- T_1 + Rotavator (once) in seed bed preparation
T_3- T_1 + Disc plough (once) in seed bed preparation
T_4- T_1 + Chisel plough (once) in seed bed preparation
T_5- T_3 + Chisel plough (once) in seed bed preparation
T_6- T_2 + Chisel plough (once) in seed bed preparation

After preparation the field according to the treatment plan, wheat crop (Inqlab-91) was sown with Rabi drill during Rabi season and Rice nursery (Shaheen Basmati) was transplanted manually in lines keeping plant to plant and row to row distance of 22.5 cm during Kharif. Tubewell water {(EC_e-1.5 d Sm^{-1}, SAR-7.60 (mmol $L^{-1})^{1/2}$ and RSC-4.80 $meqL^{-1}$)} was used for irrigation. Recommended dose of fertilizer for wheat (120-110-70 NPK kg ha^{-1}) and rice (110-90-60 NPK kg ha^{-1}) were used. All other agronomic practices were kept uniform for all treatments. Soil samples were collected after the harvest of each crop from each treatment throughout the study period and analyzed for pH_s, EC_e and SAR determination. The data of yield and yield components for both the crops (Wheat & Rice) were recorded at maturity. The data were subjected to analysis of variance according to RCBD and differences among treatments means were compared using Least Significant Difference (LSD) test at 5 percent probability level [22].

RESULTS AND DISCUSSION

1. Growth & yield of wheat

Data of plant height (Table 1) showed that maximum plant height (89.25 cm) was measured in the plot prepared with T_3 + chisel plough (once) followed by 85.33 cm with T_6 i.e T_2+ Chisel plough (once) used in seedbed preparation. Minimum plant height (72.10 cm) was found in T_1 where only cultivator was used in seed bed preparation.

Number of tillers m^{-2} were also found statistically significant (Table 1). Results indicated that the maximum number of tillers (409 m^{-2}) were obtained from the plots where T_3 + Chisel plough (once) was used in seed bed preparation and followed by T_6 {(T_2 + Chisel plough (once)} produced 399 tillers m^{-2} .However, which it remained statistically at par with T_4 (391 tillers m^{-2}) where Chisel plough (once) +T_1 were tested in seed bed preparation. Whereas, the minimum number of tillers (357 tillers m^{-2}) were recorded with T_1 (only cultivator). Abbas et al. [1] reported that the reduction in yield and yield component might be due to the higher sodic hazard of tubewell water (high RSC). Similar results were reported by Mass & Hoffman [10] and Aslam et al. [4].

Similarly data of spike length (Table 1) showed that the highest spike length (10.22 cm) was recorded of T_5 {(T_3 + chisel plough (once)} followed by T_6 {(T_2 + chisel plough (once)} producing spike length of 9.83 cm and it was at par statistically. However, the lowest spike length (8.29 cm) was recorded of T_1 where only cultivator was used.

The data regarding 1000-grain weight (Table 1) was also found statistically significant. The results indicated that the highest 1000-grain weight (32.90 g) was found in the plots which were prepared with T_3 + chisel plough (once) followed by 31.69 g with T_6 {(T_2 + chisel plough (once)}. The data also showed that (T_3) use of disc plough (once) +T_1 and (T_4) chisel plough (once) + T_1 used for seed preparation gave 1000-grain weight of 30.23 g and 30.71 g respectively which were statistically at par. While the lowest 1000-grain weight (29.21 g) was recorded where only cultivator was used for seed bed preparation.

The results showed that the use of brackish water without any management reduced the wheat growth and yield significantly (Table 1). Maximum wheat grain yield (3.883 $t.ha^{-1}$) was recorded with T_5 where T_3 + Chisel plough (once) were used in seed bed preparation followed by T_6 {(T_2 + chisel plough (once)} obtaining 3.817 $t.ha^{-1}$ grain yield . However, minimum grain yield (2.792 $t.ha^{-1}$) was recorded from the plots where only cultivator was used for seed bed preparation. Sadiq et al. [17] concluded the similar results. Kokhar and Nizami [8] also reported that deep tillage produced 8-12 % higher yield of wheat.

Table-1 Effect of agronomic / engineering practices for abating deleterious effects of saline sodic water on wheat crop growth and yield.

(Average of four years)

Treatments		**Plant height (cm)**	**No. of tillers m^{-2}**	**Spike length (cm)**	**1000-grain weight (g)**	**Grain yield ($t.ha^{-1}$)**
T_1	Use of cultivator in seedbed preparation	72.10 F	357 D	8.29 D	24.21 E	2.792 F
T_2	T_1+Rotavator (once) in seed bed preparation	73.55 E	362 D	8.75 CD	29.82 DE	3.273 E
T_3	T_1+Disc plough (once) in seed bed preparation1	78.61 D	375 C	9.13 BC	30.23 CD	3.422 D
T_4	T_1+Chisel plough (once) in seed bed preparation	82.43 C	391 B	9.47 ABC	30.71 C	3.618 C
T_5	T_3+Chisel plough (once) in seed bed preparation	89.25 A	409 A	10.22 A	32.90	3.883 A
T_6	T_2+Chisel plough (once) in seed bed preparation	85.33 B	399 B	9.83 AB	31.69 B	3.817 B
	LSD	**1.3672**	**10.241**	**0.8081**	**0.6552**	**0.0514**

2. Growth and yield of Rice

Data of rice plant height (Table 2) indicated that maximum plant height (123.45 cm) was measured with T_5 {(T_3 + Chisel plough (once) used in seed bed preparation)} followed by 120.23 cm in T_6 {(T_2 + Chisel plough (once) used in seed bed preparation)} which was at par with T_4 (119.37 cm) where chisel plough (once) + T_1 was used in seedbed preparation. Minimum plant height (113.71 cm) was recorded of T_1 (use of cultivator only for seed bed preparation).

Similarly data of number of tillers plant^{-1} indicated that the highest numbers of tillers plant^{-1} (22.67) were recorded in the treatment where T_3 + Chisel plough (once) were used in seed bed preparation followed by 21.00 tillers plant^{-1} with the use of T_2 + Chisel plough (once) in seed bed preparation. However, the lowest number of tillers plant^{-1} (16.00) were found of T_1 (cultivator only used in seed bed preparation).

The results also indicated that the panicle length showed significant difference among treatments means. It was obvious from the data that the maximum panicle length (24.31 cm) was measured of T_5 {(T_3 + Chisel plough (once) used in seed bed preparation)} followed by 23.73 cm with T_6 {(T_2 + Chisel plough (once) were used for seed bed preparation)}. The lowest panicle length (22.15 cm) was obtained in the treatment where cultivator was used alone in seed bed preparation (T_1).

The data regarding 1000-grain weight also showed the significant difference among treatment means. Results indicated that the highest 1000-grain weight (22.700 g) was recorded in the treatment where Disc plough (once) + Chisel plough (once) was used in seed bed preparation followed by the treatment T_6 (21.270 g) where T_2+ Chisel plough (once) were used in seed bed preparation. While Disc plough(once)+T_1 , Rotavator (once)+T_1 and Chisel plough(once)+T_1 gave 1000-grain weight of 19.150 g, 19.060g and 20.100g respectively. However, the lowest 1000-grain weight (18.750 g) was recorded in the plots where only cultivator was used in seed bed preparation.

Data of paddy yield (Table 2) was also found statistically significant. Results indicated that the maximum paddy yield (3.593 t.ha^{-1}) was obtained with T_5 {(use of T_3 + Chisel plough (once) in seed bed preparation)} which remained at par statistically with the treatment T_6 (3.575 t.ha^{-1}) where T_2 + Chisel plough (once) were used. However, the minimum paddy yield (2.641 t.ha^{-1}) was obtained with the use of cultivator alone in seed bed preparation (T_1). The increase in yield might be due to the less effects of saline-sodic water (brackish) on crop growth and yield with deep tillage implements. Ahmad et al. [2] and Sadiq et al.[17] has also reported higher yield with deep tillage.

Table-2 Effect of agronomic / engineering practices for abating the deleterious effects of saline-sodic water on rice crop growth and yield.

(Average of four years)

Treatments		Plant height (cm)	No. of tillers m^{-2}	Panicle length (cm)	1000-grain weight (g)	Grain Yield ($t.ha^{-1}$)
T_1	Use of cultivator in seedbed preparation	113.71D	16.00 E	22.15 D	18.750 D	2.641 E
T_2	T_1+Rotavator (once) in seed bed preparation	114.53 CD	17.667 D	22.65 CD	19.060 D	2.793 D
T_3	T_1+Disc plough (once) in seed bed preparation1	117.40 BC	19.333 C	22.90 C	19.150 CD	2.952 C
T_4	T_1+Chisel plough (once) in seed bed preparation	119.37 B	20.667 B	23.27 BC	20.100 C	3.211 B
T_5	T_3+Chisel plough (once) in seed bed preparation	123.45 A	22.667 A	24.31 A	22.700 A	3.593 A
T_6	T_2+Chisel plough (once) in seed bed preparation	120.23 AB	21.000 B	23.73 AB	21.270 B	3.575 A
	LSD	**3.6138**	**0.9197**	**0.6805**	**1.0389**	**0.0843**

3. Soil Health

Soil analysis for EC_e, pH_s and SAR determination after the completion of study showed that a considerable development in the soil sodicity as a result of brackish water irrigation in all the treatments. However, there was less development of soil salinity/sodicity with T_5 {(T_3+ Chisel plough (once) used in seed bed preparation)} as compared with all other treatments. It may be due to the reason that Disc plough and chisel plough cut the soil deeper and helped in leaching the salts as compared to rotavator and cultivator. These results were in confirmatory with those reported by Sadiq et al. [19].

Table-3: Effect of treatments on the salinity /sodicity parameters after the completion of study

Treatments		pH_s	EC_e (d Sm^{-1})	SAR (mmol $L^{-1})^{1/2}$
T_1	Use of cultivator in seedbed preparation	8.33	3.90	27.81
T_2	T_1+Rotavator (once) in seed bed preparation	8.28	3.02	25.94
T_3	T_1+Disc plough (once) in seed bed preparation1	8.27	2.83	23.89
T_4	T_1+Chisel plough (once) in seed bed preparation	8.25	2.70	23.76
T_5	T_3+Chisel plough (once) in seed bed preparation	8.22	2.60	22.65
T_6	T_2+Chisel plough (once) in seed bed preparation	8.22	2.61	22.67

CONCLUSION

It was concluded that the use of Disc plough (once)+Chisel plough (once) in seed bed preparation proved to be the best in combating the adverse effects of brackish tubewell water(saline sodic) on the growth and yield of wheat and rice crops as compared with other seedbed preparation methods.

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