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Alleviation of adverse effect of first irrigation to wheat crop in saline sodic soil

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Abstract

It is an established fact that temporary waterlogging occurs at first irrigation to wheat crop in rice-wheat cropping system. This is also true in saline sodic soils. Wheat crop becomes pale yellow just after first irrigation resulting in severe reduction in growth and yield. This study was planned to address this problem by various management strategies like irrigation at 25 days after sowing (DAS) without fertilizer, irrigation at 25 DAS + 120-110-70 NPK kg ha^{-1}, irrigation at 25 DAS + 120-110-70 NPK kg ha^{-1} + 25 kg sulphuric acid per hectare, irrigation at 25 DAS+ 120-110-70 NPK kg ha^{-1} +12 kg sulphuric acid per hectare and irrigation at 40 DAS +120-110-70 NPK kg ha^{-1}. A saline sodic field {pH$_s$ =8.92, EC$_e$ =5.70 (dS m^{-1}) and SAR=23.71 (mmol L^{-1})$^{1/2}$} was selected. Maximum grain yield (3.01 t ha^{-1}), number of tillers (437 m^{-2}), 1000-grain weight (35.43 g) and number of grains spike^{-1} (40) were produced with the application of 120-110-70 NPK kg ha^{-1} + 25 kg ha $^{-1}$ sulphuric acid at first irrigation applied 25 days after sowing in saline sodic soil.

Keywords: *First irrigation, saline sodic soil, H_2SO_4, wheat, grain yield*

Introduction

Pakistan is predominately an agricultural country and thus its development depends upon the improvement of the agriculture sector. Sustainable crop production in Pakistan is threatened by several factors. One of the most outstanding limitations is soil degradation due to salinity / sodicity. It is a major environmental constraint with severe negative impact on agricultural productivity and sustainability particularly in arid and semi arid regions of the world (Pitman and Lauchli, 2002, Qadir *et al.* 2006). Economics of agriculture, especially our small farmers have been getting worse year after year due to loss of productivity of soils. Sodic and saline sodic soils account for more than 50 % of world's salt affected area (Beltran and Manzure, 2005). In Pakistan, about 6.68 m ha land is salt affected (Khan, 1998). Underground water also contains excessive amount of salts which aggravate the problems of soil salinity and sodicity in Pakistan. These salts are very harmful for young plants. Accumulation of both water soluble and exchangeable sodium in excessive amount, not only minimize the water availability to plants but also adversely affects the soil properties (Nazir, 1994). These salts cause deflocculation of soil colloids, decrease in soil permeability, poor soil aeration and drainage which results in the standing of water (temporary waterlogging) at first irrigation to wheat crop. As a result, the growth of wheat crop slows down, temporarily stopps and plant leaves become pale yellow (Jamil *et al.*, 1995). Ali and Aslam (2005) reported that when urea is applied in these soils, the pH$_s$ of the soil becomes very high temporarily, urea is lost and young seedlings die when become in contact with urea. They also concluded that application of sulphuric acid at 50 liters per hectare with first two irrigations (25 liters in each) as fertigation in the standing crop of wheat improved soil environment by reducing impact of salinity / sodicity and high pH$_s$ which increased the grain yield by three times as compared to control. Similarly, Wasif *et al.* (1995) reported that soil amendments helped in increasing the crop yield on calcareous soil under saline irrigation water. Rashid *et al.* (2009) concluded that different soil amendments (Gypsum and H_2SO_4 along with deep ploughing) significantly improved the growth and grain yield of wheat. They also investigated that plant height, number of tillers plant^{-1}, number of grains spike^{-1} and 1000-grain weight significantly increased with all treatments including sulphuric acid treatment over control.

Research findings also revealed that application of H_2SO_4 had significantly positive effect on tillering, plant height, growth and straw yield of wheat (Rashid and Majid, 1983). In the light of above discussion, a field experiment was conducted to address this problem and to evaluate some of the management strategies.

Materials and Methods

The study was conducted at Agricultural Research Farm, Soil Salinity Research Institute, Pindi Bhattian, Hafizabad during 2007-08 and 2008-09. A saline sodic field with pH$_s$, 8.92; EC$_e$, 5.70 (dS m^{-1}) and SAR, 23.71 (mmol L^{-1})$^{1/2}$ was selected, leveled and well prepared for sowing the experiment. The experiment was laid out in

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randomized complete block design (RCBD) with three replications; keeping the plot size of 5 m x 7 m. Wheat (Inqlab -91) was sown as test variety. The crop was sown with tractor mounted Rabi drill during both the years. The strategies applied in the study were: irrigation at 25 DAS without fertilizer, irrigation at 25 DAS + 120-110-70 NPK kg ha^{-1}, irrigation at 25 DAS+ 120-110-70 NPK kg ha^{-1} + 25 kg sulphuric acid per hectare, irrigation at 25 DAS+ 120-110-70 NPK kg ha^{-1} +12 kg sulphuric acid per hectare and irrigation at 40 DAS +120-110-70 NPK kg ha^{-1}. All Phosphors, potash and ½N fertilizer were applied as basel dose. While remaining ½ N and sulphuric acid (H_2SO_4) were applied with first irrigation according to treatment plan. All other agronomic practices were kept uniform for all treatments. Soil samples were collected after the harvest of crop from each treatment and analyzed for pH_s, EC_e and SAR determination. The observations on yield and yield components were recorded at maturity of the crop and data collected were analyzed statistically using Fisher's analysis of variance techniques and differences among treatment means were compared by using least significant difference (LSD) test at 5 percent probability level (Steel *et al*., 1997).

Results and Discussion

Plant height (cm)

The data revealed that the plant height was significantly higher in all the treatments over control (Table 1). The average maximum plant height (94.24 cm) was recorded in the treatment where irrigation at 25 DAS+ 120-110-70 NPK kg ha^{-1} + 25 kg sulphuric acid per hectare followed the treatment where irrigation at 25 DAS+120-110-70 NPK kg ha^{-1} + 12 kg ha^{-1} sulphuric acid were applied through fertigation after spreading urea (90.15 cm). The lowest average plant height (76.21 cm) was found in control treatment. Among the years, the highest plant height (96.19 cm) was recorded during the year 2008-09 as compared (92.29 cm) with 2007-08 by the application of irrigation 25 DAS + 120-110-70 NPK kg ha^{-1} + 25 kg sulphuric acid per hectare through fertigation after spreading urea. The results also indicated that the application of NPK along with sulphuric acid might have diminished the injurious effects of salts by improving the soil health and decreasing salinity / sodicity which ultimately showed positive effect on plant growth and plant height. These amendments lowered the soil pH_s reacted with soluble carbonates and replaced the exchangeable Na^+ with calcium. These results are in confirmatory with finding of Rashid *et al*. (2009).

Number of tillers (m^{-2})

Number of tillers m^{-2} of wheat crop (Table 2) have been significantly affected by the treatments. The average maximum number of tillers (437 m^{-2}) were recorded with irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + 25 kg ha^{-1} sulphuric acid followed by 407 m^{-2} with irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + 12 kg sulphuric acid per hectare through fertigation after spreading urea. The average minimum numbers of tillers (295 m^{-2}) were produced in control. During 2008-09, the highest numbers of tillers (451 m^{-2}) were recorded with treatment where 120-110-70 kg NPK ha^{-1} + 12 kg sulphuric acid per hectare were applied through fertigation with first irrigation and the minimum number of tillers (292 m^{-2}) were found during the year 2007-08 with the control. These results are in harmony with findings of Rashid and Majid (1983), Ali and Aslam (2005) and Rashid *et al*. (2009).

Number of grains $spike^{-1}$

As regards the number of grains $spike^{-1}$ (Table 3), the highest average number of grains $spike^{-1}$ (43.5) were observed in treatment where irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + 25 kg sulphuric acid per hectare through fertigation after spreading urea followed by 40 grains $spike^{-1}$ irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + 12 kg sulphuric acid per hectare through fertigation after spreading urea were applied. However the lowest 34 grains $spike^{-1}$ were found in control treatment. Data also

Table 1: Alleviation of adverse effect of first irrigation to wheat crop in saline sodic soil on plant hight (cm)

Treatment	2007-08	2008-09	Average
T_1: Irrigation at 25 DAS without fertilizer (Control)	74.88 D	77.54 E	76.21 D
T_2: Irrigation at 25 DAS + 120-110-70kg NPK ha^{-1}	80.09 C	86.77 D	83.43 C
T_3: Irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + 25 kg H_2SO_4 ha^{-1} through fertigation after spreading Urea	92.29 A	96.19 A	94.24 A
T_4: Irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + 12 kg H_2SO_4 ha^{-1} through fertigation after spreading Urea	88.34 B	91.96 B	90.15 B
T_5 Irrigation at 40 DAS + 120-110-70 kg NPK ha^{-1}	86.66 B	90.04 C	88.35 B
LSD	3.0282	1.6179	3.3508

Mean sharing different letters differ significantly at $p \leq 0.05$

indicated that the number been of grains spike^{-1} of wheat in different treatments have significantly affected during the study period. The results showed that the highest (44) number of grains spike^{-1} were recorded with irrigation 25 days after sowing +120-110-70 kg ha^{-1} + 25 kg ha^{-1} sulphuric acid treatment during the year 2007-08 and 43 grains spike^{-1} in 2008-09 with the same treatment. While the control treatment produced the lowest grains spike^{-1} among all other treatments under study during both the years (34). The results are inline with those reported by Rashid *et al.* (2009).

Spike length (cm)

The results indicated that the spike length was significantly affected by different treatments. The maximum spike length (12.19 cm) was measured with irrigation 25 DAS +120-110-70 kg NPK ha^{-1} + 25 kg sulphuric acid per hectare treatment during 2008-09 as compared with 10.83 cm spike length in 2007-08 with the same treatment than all other treatments (Table 4). Similarly, the maximum average spike length (11.51 cm) was measured in the treatment where irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + 25 kg sulphuric acid per hectare

Table 2: Alleviation of adverse effect of first irrigation to wheat crop in saline sodic soil on number of tillers (m^{-2})

Treatment	2007-08	2008-09	Average
T_1: Irrigation at 25 DAS without fertilizer (Control)	292 D	298 C	295 E
T_2: Irrigation at 25 DAS + 120-110-70kg NPK ha^{-1}	336 C	390 B	363 D
T_3: Irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + 25 kg H_2SO_4 ha^{-1} through fertigation after spreading urea	423 A	451 A	437 A
T_4: Irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + 12 kg H_2SO_4 ha^{-1} through fertigation after spreading urea	398 AB	416 AB	407 B
T_5: Irrigation at 40 DAS + 120-110-70 kg NPK ha^{-1}	369 B	403 B	386 C
LSD	29.459	38.532	8.725

Mean sharing different letters differ significantly at $p \leq 0.05$

Table 3: Alleviation of adverse effect of first irrigation to wheat crop in saline sodic soil on number of grains spike^{-1}

Treatment	2007-08	2008-09	Average
T_1: Irrigation at 25 DAS without fertilizer (Control)	34 B	34 C	34 D
T_2: Irrigation at 25 DAS + 120-110-70kg NPK ha^{-1}	40 A	39 B	39 C
T_3: Irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + 25 kg H_2SO_4 ha^{-1} through fertigation after spreading urea	44 A	43 A	43.5 A
T_4: Irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + 12 kg H_2SO_4 ha^{-1} through fertigation after spreading urea	40 A	40 B	40 AB
T_5: Irrigation at 40 DAS + 120-110-70 kg NPK ha^{-1}	39 AB	40 B	39.5 C
LSD	4.0819	2.0626	1.3472

Mean sharing different letters differ significantly at $p \leq 0.05$

Table 4: Alleviation of adverse effect of first irrigation to wheat crop in saline sodic soil on spike length (cm)

Treatment	2007-08	2008-09	Average
T_1: Irrigation at 25 DAS without fertilizer (Control)	7.28 B	7.90 D	7.59 D
T_2: Irrigation at 25 DAS + 120-110-70kg NPK ha^{-1}	9.51 A	10.01 C	9.76 C
T_3: Irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} 25 kg H_2SO_4 ha^{-1} through fertigation after spreading urea	10.83 A	12.19 A	11.51 A
T_4: Irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + 12 kg H_2SO_4 ha^{-1} through fertigation after spreading urea	10.44 A	11.10 B	10.77 AB
T_5: Irrigation at 40 DAS + 120-110-70 kg NPK ha^{-1}	9.84 A	11.04 B	10.44 BC
LSD	1.5921	0.2529	0.7696

Mean sharing different letters differ significantly at $p \leq 0.05$

through fertigation after spreading urea was applied that showed non-significant difference with irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + 12 kg sulphuric acid per hectare through fertigation after spreading urea where spike length was 10.77 cm. The minimum average spike length (7.59 cm) was measured in control treatment.

1000 grain weight

The data of 1000 grain weight (Table 5) revealed that the maximum 1000 grain weight (35.43 g) produced by the treatment where irrigation 25 DAS +120-110-70 kg NPK ha^{-1} + 25 kg sulphuric acid per hectare through fertigation after spreading urea was applied at par with the treatment where 120-110-70 kg NPK ha^{-1} + 12 kg ha^{-1} sulphuric acid through fertigation was applied with first irrigation (34.63 g) and first irrigation was applied after 40 days of sowing with recommended dose (33.13 g). Whereas the lowest 1000 grain weight of (32.20 g) was recorded in the control treatment. The same trend was noted during both the years of study. However, the maximum 1000 grain weight (36.23 g) was recorded during the 2008-09. It might be due to the improvement in soil health and decreasing salinity/ sodicity because of the application of H_2SO_4. The results also confirmed the help of soil amendments on the development of grains which ultimately increased the grain weight of wheat. The results are in conformity with those reported by Rashid *et al.* (2009) and Wasif *et al*. (1995).

Grain yield

It is obvious from the data that the maximum grain yield (3.01 t ha^{-1}) was obtained with the treatment where irrigation 25 DAS + 120-110-70 kg NPK ha^{-1} + 25 kg ha^{-1} sulphuric acid through fertigation was applied followed by 2.66 t ha^{-1} with treatment where irrigation 25 DAS + 120-110-70 kg NPK ha^{-1} + 12 kg ha^{-1} sulphuric acid through fertigation was used (Table 6). The lowest grain yield (1.42 t ha^{-1}) was recorded in treatment grown without fertilizer (control). However, the maximum grain yield (3.11 t ha^{-1}) and (2.91 t ha^{-1}) were produced by the treatment where irrigation 25 DAS + irrigation 25 DAS + 120-110-70 kg NPK ha^{-1} + 25 kg ha^{-1} sulphuric acid through fertigation after spreading urea in both the years was applied. The increase in yield might be attributed to increase in the number of grains spike $^{-1}$, 1000-grain weight, number of tillers m^{-2} and amelioration of soil with H_2SO_4. These results are in accordance to the findings of Rashid and Majid (1983), Wasif *et al.* (1995), Rashid *et al.* (2009) and Ali and Aslam (2005).

Soil analysis

Soil status after the harvest of crop showed that the salinity /sodicity parameters decreased upto safe limits and the soil health was improved (Table 7) in both the years. However, the maximum decrease was recorded in treatment where sulphuric acid was used with first irrigation. Ali and

Table 5: Alleviation of adverse effect of first irrigation to wheat crop in saline sodic soil on 1000 grain weight (g)

Treatment	2007-08	2008-09	Average
T_1: Irrigation at 25 DAS without fertilizer (Control)	28.85 D	31.55 D	32.20 B
T_2: Irrigation at 25 DAS + 120-110-70kg NPK ha^{-1}	31.44 C	33.62 C	32.53 B
T_3: Irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + 25 kg H_2SO_4 ha^{-1} through fertigation after spreading urea	34.63 A	36.23 A	35.43 A
T_4: Irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + 12 kg H_2SO_4 ha^{-1} through fertigation after spreading urea	34.14 B	35.12 B	34.63 AB
T_5: Irrigation at 40 DAS + 120-110-70 kg NPK ha^{-1}	31.53 C	34.73 B	33.13 AB
LSD	0.3952	0.8012	2.7156

Mean sharing different letters differ significantly at $p \leq 0.05$

Table 6: Alleviation of adverse effect of first irrigation to wheat crop in saline sodic soil on grain yield (t ha^{-1})

Treatment	2007-08	2008-09	Average
T_1: Irrigation at 25 DAS without fertilizer (Control)	1.29 C	1.55 D	1.42 D
T_2: Irrigation at 25 DAS + 120-110-70kg NPK ha^{-1}	2.30 B	2.46 C	2.38 C
T_3: Irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + kg H_2SO_4 ha^{-1} through fertigation after spreading urea	2.91 A	3.11 A	3.01 A
T_4: Irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + 12 kg H_2SO_4 ha^{-1} through fertigation after spreading urea	2.52 B	2.80 B	2.66 B
T_5: Irrigation at 40 DAS + 120-110-70 kg NPK ha^{-1}	2.41 B	2.67 B	2.54 B
LSD	0.3137	0.1493	0.1364

Mean sharing different letters differ significantly at $p \leq 0.05$

Table 7: Post harvest soil analysis

Treatment	2007-08			2008-09		
	pH_s	EC_e (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$	pH_s	EC_e (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$
T_1: Irrigation at 25 DAS without fertilizer (Control)	8.84	5.10	22.03	8.80	5.16	21.57
T_2: Irrigation at 25 DAS + 120-110-70kg NPK ha^{-1}	8.78	4.82	22.37	8.70	5.20	21.14
T_3: Irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + 25 kg H_2SO_4 ha^{-1} through fertigation after spreading urea	8.65	3.70	19.56	8.60	2.61	17.51
T_4: Irrigation at 25 DAS + 120-110-70 kg NPK ha^{-1} + 12 kg H_2SO_4 ha^{-1} through fertigation after spreading urea	8.72	4.00	20.51	8.70	3.52	17.80
T_5 : Irrigation at 40 DAS + 120-110-70 kg NPK ha^{-1}	8.78	4.89	22.27	8.71	5.10	21.40

Aslam (2005) reported that when urea is applied in saline and sodic soils, the pH_s of the soil becomes very high temporarily, urea is lost and young seedlings die when become in contact with urea .They also concluded that application of sulphuric acid at 50 liters per hectare with first two irrigations (25 liters in each) as fertigation in the standing crop of wheat improved soil environment by reducing impact of salinity / sodicity and high pH_s.

Conclusion

It is obvious from the data that the application of recommended dose of NPK + 25 kg H_2SO_4 ha^{-1} with first irrigation (25 days after sowing) was the best management strategy to minimize the negative effects of first irrigation to wheat crop in saline sodic soil which also improved the soil health.

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