SALT DISTRIBUTION IN SALINE SODIC SOIL UNDER DIFFERENT IRRIGATION LEVELS. 1. HIGH BRACKISH GROUNDW ATER

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A field study was carried out in a saline-sodic non gypsiferous loam soil in the Mona Project area with watertable ranging between 8-188 cm. The ground water EC and SAR ranged from 1,30-3.15 dS m'l and 5.10-18.20. Wheat-sorghum crop rotation was followed during the experiment. The fertilizers applied to wheat and sorghum crops were 120:80:30 and 90:45:0 kg ha'l NPK, respectively. Irrigation treatments were: irrigation at 40% depletion of soil available soil moisture (Tl) : irrigation at 80% depletion of available soil moisture (T2) and Fallow plot with no irrigation (T3). The infiltratisn rate of soil was significantly higher in Tl compared with T2 and T3 and the increase, on an average, for Tl and T2 over T3 was 67 and 38%, respectively. The EC_e decreased in 0-15 cm (85 and 75%) and 15-30 cm (41 and 17%) in Tl and T2, respectively but increased in fallow plot (78 and 291%) in 0-15 and 15-30 cm depths, depicting the salt movement in relation to delta of water applied. At 30-60 cm soil depth minor increase was observed in both the irrigation treatments but at 60-90 cm soil depth the trend was somewhat similar to that of the upper two soil depths. Like the EC_e, SAR decreased by 77 and 71% in upper 0-15 cm depth and 26 and 15% in 15-30 cm depth for Tl and T2, respectively. In 30-60 cm soil depth slight increase was found with Tl whereas in other treatments it decreased. But at 60-90 cm the trend was like that of upper two depths. The wheat grain yield was significantly lower (41%) with T2 than that with Tl, whereas non-significant difference (31% reduction) existed in these treatments in case of sorghum fodder yield.

INTRODUCTION

In soils having high watertable where sub irrigation occurs, under traditional irrigation practice, too much water is applied, which is a waste. Crops are also damaged due to poor drainage and anaerobic conditions resulting in low yields (Ali, 1990). Furthermore in such soils when water table rises, capillary action is intensified. With capillary water salts move upward and as this water evaporates the salts are accumulated on soil surface causing higher osmotic pressure. The process of upward movement of salts is reversed by irrigation water and rainfall (Khan and Akram, 1988; Abdulla *et a!!* 1990; Cortenback *et a!! 1995).* The salt movement is mainly dependent on soil texture, structure, quantity and quality of irrigation water, natural precipitation, temperature, wind velocity and type of crops planted etc. The upward movement of salts due to capillary rise and leaching downward with surface irrigation/precipitation is not clearly understood under our conditions. This study was carried out to study the salt distribution in a saline-sodic soil with high watertable under different irrigation levels.

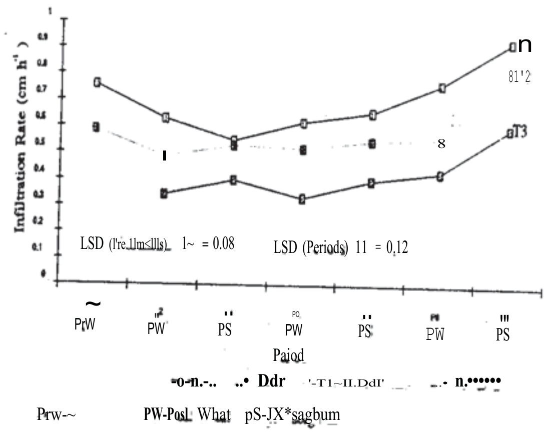
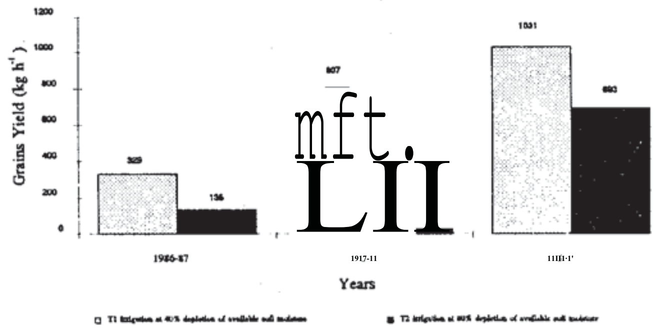


Figure 1. Effect of Treatments on the Infiltrastion Rate of Soil.



LSD (Treatments) 1% - 295.97 LSD (Years) 1% - 362.49

Figure 2. Effect of Treatments on Wheat Grain Yield.

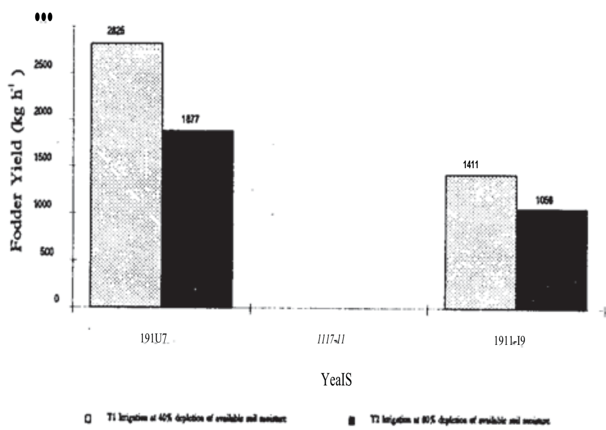


Figure 3. Effect of Different Treatments on Sorghum Fodder Yield.

Table-I. Chemical Properties of the Gandhra Soil Series

Depth (cm)	pH	ECe (dS m')	SAR (mmolr')112	B.D (gem'])	Ca+ Mg	Na	Gypsum Requirement (Tons/ae.6 inches)
					meL[1]		
0-15	8.4-9.1	4.5-29.3	17.0-126.2	1.7	6.0-280	36.0-265.5	1.4
15-30	8.3-8.8	2.2-9.0	12,6-41.0	-	4.0-9.0	18,0-81.5	-

Table 2: Water Quality used for Irrigation

	EC (dS m')	SAR (mmol L'l)112	RSC (me L-1)
Tubewell	1.90	304	-
Canal	0040	0.8	-
Mixed	1,20	1.9	-

MATERIALS AND METHODS

The study was carried out in the Gandhra Soil Series (Table 1) in the command of tubewell MN-93 in the Mona Reclamation Experimental Project, Bhalwal, District Sargodha.

The groundwater was high (8-188 cm) and brackish having EC and SAR between the range of 1.30 - 3.15 dS m,l and 5.10 to 18.20, respectively during *3V2* years study period. The gypsum requirement, on an average, was 1040 tons of upper 15 cm of an acre. Wheat-sorghum crop rotation was followed with NPK @ 120:80:30 kg ha-1 and 90:45:0 kg ha-1 to wheat and sorghum, respectively. The canal + tubewell water was used for irrigation. The quality of waters used for irrigation are reported in Table 2.

Irrigations were applied at 40% (T_1) and 80% (T_2) depletion of available soil moisture. A fallow plot (T_3) was also kept for comparison.

Infiltration rate was measured by the method described by Aronovici (1955). Soil samples were analyzed for EC_e and SAR by the methods of D.S. Salinity Lab. Staff (1954), mechanical analysis by Bouyoucos (1951), Ca + Mg by Chang and Bray (1951), CO_3 and HCO_3 by Reitmeir (1943) and S04 by difference. The statistical analysis of data was done by using Thomas and Jackson (1972) technique. Crops yield was estimated on whole plot basis to avoid any variation within the field.

RESULTS AND DISCUSSION

1. Infiltration Rate of Soil

Infiltration rate of soil was significantly higher for Tl compared with T2 and T3 (Figure 1). Similarly significant difference existed between the infiltration rate of T2 and T3. The infiltration rate generally increased post-wheat 1987-88 in Tl and T2. On an average, there was 67 and 38% higher infiltration rate of soil for T1 and T2, respectively over T3. It can be manifested that growing of crops improved the physical conditions of soil by the addition of organic matter through leaves and roots, opening of soil by roots and microbial activity resulting in more intake rate of water.

Infiltration rate taken at different periods of the study was also significantly affected and was significantly higher after sorghum 1989 (P7) compared with the infiltration rate of the preceding period. Similar results were reported by Chaudhry and Abaidullah (1985) and Chaudhry and Hameed (1992).

2. Electrical Conductivity (EC_e , dS m") of Soil

There was no significant effect of different treatments on the EC_e of soil (Table 3). However on an average higher ECe was found in T2 followed by Tl and T3, respectively. The lower EC_e in T3 is due to the fact that the initial EC_e of this soil was low. It is clearly revealed from the data that in fallow plot (T,), salt movement was upward throughout the experimental period whereas during the same period of time a trend of downward movement was found in Tl and T2 showing the effectiveness of irrigation water and rainfall. More reduction (85%) in upper 15 cm soil was found in Tl where irrigation was applied at 40% depletion of available soil moisture depicting that application of higher amount of water played it's role in flushing down the salts. The maximum increase of 296% was noticed in 30-60 cm soil depth in T3 which was expected as no irrigation water was applied to leach the salts below this depth. The EC_e was significantly high in upper 15 cm depth after about *3Y2* years period which was reduced generally with increasing the depth. Statistically significant differences existed among the later three depths. The EC_e of different soil samplings varied non-significantly. However, on an average, maximum EC_e was found in Sampling 2 (S2), i.e. after wheat 1986-87. Interactive effects among treatments, EC_e and soil depths also remained non-significant. The data further revealed that the reduction in EC_e of the upper depth was sharp during first wheat and sorghum crops but later on this process was slowed down. The results are in conformity with those ofreported by Ali and Sabir (1975), Rao *et al.* (1992) and Chaudhry (1995).

3. Sodium Adsorption Ratio (SAR) of Soil

The effect of different treatments was statistically significant and it was significantly higher in T2 compared with T3 but non-significant difference existed between TI and T2 (Table 4). The low SAR in T3 is possibly due to the fact that the initial SAR was considerably lower than the other two treatments.

The SAR of soil varied significantly at different soil depths and was significantly higher in the upper 0-15 cm compared with lower depths and the difference among the SAR of lower three depths was non-significant depicting the salt movement pattern. Data further revealed that, on an average, maximum reduction was found in the upper depth whereas slight increase was observed in the lower 30-60 and 60-90 cm soil depths indicating that some of the salts, leached down from the upper depths, could not pass beyond this depth. This indicated that either the irrigation water applied was not sufficient to flush down the sodium salts beyond this depth or some chemical amendments were needed to replace the Na from the soil exchange complex. During *3Y2* years period maximum reduction of 77 and 71% was observed in TI and T2, respectively in Sampling 7 (S7) over Sampling I (S I). Contrarily, an increase of 158% was found in T3 during the same period of time.

The SAR of different soil Samplings varied SIgnificantly but no definite trend was observed. However, in general, it was increased in the soil Samplings after wheat and decreased after sorghum crop depicting the effect of the delta of water applied and rainfall received during their growth periods. The interaction between treatments and the soil depths was non-significant. In general, the SAR of soil decreased somewhat linearly with increasing depth of soil. Similar results were reported by Khan and Akram (1988), Chaudhry and Hameed (1992) and Chaudhry (1995).

Table 3. Effect of treatments on the EC_e (dS m") of soil

Treatments	Depth (cm)	Pre Wheat 1986-87 SI	Post Wheat 1986-87 S2	Post Sorghum 1987 S3	Post Wheat 1987-88 S4	Post Wheat 1988 SS	Post Wheat 1988-89 S6	Post Sorghum 1989 S7	Mean	**Decrease / Increase** in S7 over SI (%)
T, irrigation at 40%DASM	0.15	205	10.9	4.4	6.0	5.4	5.8	3.1		-85
	15-30	7.6	10.0	4.2	4.8	4.9	5.3	4.5		-41
	30-60	4.9	6.9	4.7	4.7	5.0	5.3	5.0	5.85	2
	60-90	4.0	4.3	3.8	3.8	5.5	4.1	3.9		-3
T,Irrgation at 80% DASM	0-15	21.3	12.5	6.7	6.6	6.7	6.9	5.3		-76
	15-30	6.3	11.0	4.7	4.7	4.8	6.9	5.2		-17
	30-60	4.8	6.3	4.3	5.1	5.5	7.0	4.9	6.30	2
	60-90	4.8	5.2	4.0	4.3	6.1	5.4	3.8		-21
T,Fallow plot	0-15	4.5	5.5	7.6	8.3	8.4	9.2	8.0		78
	15-30	2.2	3.1	4.3	5.7	6.5	7.4	8.6	5.48	291
	30-60	2.4	4.9	7.1	7.3	8.6	8.9	9.5		296
	60-90	1.7	1.5	1.7	2.5	2.7	1.6	3.7		118

LSD (Depths): 1% = 2.33, DASM = Deplettion of available soil moisture,

Mean (Depths)	=	0-15	15-30	30-60	60-90			
		8.26	5.84	5.86	3.76			
	=	(a)	(b)	(b)	(b)			
Mean (Treatments)	=	11	L	L,				
		5.85	6.30	5.48				
Mean (Samplings)	=	~	S-2	S-3	S-4	S-5	S-6	S-7
		6.68	6.84	4.84	5.32	5.84	6.15	5.46
Mean (Depth x Treatments)	=	1IQl	1llli	1llli	1IQ±			
		8.01	5.90	5.21	4.29			
		LQl	Llli	Llli	1IQ±			
		9.43	6.23	5.41	4.80			
		LQl	Llli	LD}	L}Q±			
		7.36	5.40	6.96	2.20			

4. CROPS YIELD

4.1. Wheat Grain Yield

The data in Figure 2 depicted that wheat grain yield was significantly higher in TI which was due to the fact that water requirement of crop was properly met at this irrigation level and improvements in the physical and chemical properties of soil. On the average there was 41 % decrease in yield in T2 over Tl.

The yield was significantly higher during 1987-88 and 1988-89 compared with 1986-87 but non-significant differences existed between the yield of 1987-88 and 1988-1989. With the passage of time an improvement was observed. The better yield during later period is possibly due to improvements in the physical (Figure 1) and chemical properties (Tables 1 & 2) of soil and climatic conditions (25.1 cm rainfall during wheat 1986-87 as compared to 12.1 cm and 19.2 cm rainfall during 1987-88 and 1988-

Table 4. Effect of different treatments on the SAR (mmol [1)1/2 of Soil

Treatments	Depth (cm)	Pre-Wheat 1986-87 SI	Post-Wheat 1986-87 S2	Post-Sorgh-urn 1987 S3	Post-Wheat 1987-88 S4	Post-Sorgh-urn 1988 S5	Post-Wheat 1988-89 S6	Post-Sorghu m 1987 S7	Decrease! Increase in S7 over SI (%)
Tt. Irrigation at 40% depletion of available soil moisture	0-15	83.4	27.7	20.1	30.0	29.1	35.9	19.5	-77
	15-30	34.3	24.4	18.7	27.2	28.5	34.8	25.4	-26
	30-60	21.4	27.1	18.9	17.2	24.0	32.2	22.8	7
	60-90	18.3	21.7	16.3	16.4	25.8	31.1	14.5	-21
T2 Irrigation at 80% depletion of available soil moisture	0-15	90.4	45.9	29.2	32.7	33.6	39.9	26.2	-71
	15-30	32.4	24.9	22.5	24.7	28.5	40.6	27.5	-15
	30-60	23.0	26.0	20.5	21.8	19.4	35.7	19.8	-14
	60-90	21.6	23.3	17.7	16.3	26.0	29.8	15.9	-26
T3. Fallow Plot	0-15	17.0	13.7	23.0	29.9	30.7	56.5	43.9	158
	15-30	12.8	14.5	16.0	17.9	28.7	36.2	30.3	137
	30-60	17.2	17.7	19.0	19.2	20.3	14.0	13.6	-21
	60-90	9.2	11.2	19.0	19.6	23.9	16.9	12.6	37

LSD (Treatments): 5% = 5.76 LSD (Depths) 1% = 8.85 LSD (Samplings): 5% = 8.80

Mean (Treatments)	=	11	L	L				
		26.85	29.31	21.60				
		(ab)	(a)	(b)				
Mean (Depths)	=	0-15	15-30	30-60	60-90			
		36.35	26.47	21.48	19.39			
		(a)	(b)	(b)	(b)			
Mean (Samplings)	=	S-1	S-2	S-3	S-4	S-5	S-6	S-7
		32.2	23.6	20.1	22.7	26.5	33.6	22.7
		(ab)	(be)	(c)	(c)	(abc)	(a)	(c)
Mean (Depths x Treatments)=		IIQ.1	Illli	IIQ.1	IIQ.±			
		35.1	27.6	23.4	20.6			
		LQ.1	Llli	Llli	LQ.±			
		42.6	28.7	23.7	21.5			
		LQ.1	Llli	Llli	L1Q.±			
		30.7	22.3	17.3	16.1			

89, respectively) prevailed during the crop growth period.

4.2. Sorghum Fodder Yield

Sorghum fodder yield was not significantly affected. However, on percentage basis, 31% reduction in sorghum fodder yield in T2 over Tl was observed depicting that crop water requirements were not fully met with T2. The overall low yield may be possibly due to low salinity tolerance of sorghum as compared with wheat..

Yield during different years showed non-significant differences, however, varied considerably (Figure-S). Crop could not survive during 1988 due to heavy rains at the time of planting and germination. Reduction in sorghum fodder yield during 1989 was 47% compared with that of 1987 which was possibly due to weather conditions, i.e. uneven distribution of rainfall and high temperature etc. which prevailed during the crop growth period.

CONCLUSIONS

For economically acceptable crop growth on salt-affected soils, irrigation at 40% depletion of available soil moisture is a must. The usefulness of this irrigation practice seems to become more favourable if some amount of Ca containing amendment, like gypsum, is added. Farm level studies are further needed under different soil and climatic conditions to have more logical and. site specific recommendations for the end users.

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