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RESEARCH ARTICLE

Effect of saline and sodic irrigation water on soil properties after harvest of *Bajra* crop

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SUMMARY

A pot experiment was conducted during summer-2020 at Net House, Department of Agricultural Chemistry and Soil Science Junagadh Agricultural University, Junagadh to assess four levels for each of salinity (2, 4, 6 and 8 dS m^{-1}) and sodicity (5.0, 10.0, 15.0 and 20.0 SAR) of irrigation water on bajra by adopting factorial CRD with three replications. The results indicated that application of different levels of saline and sodic irrigation water produced significant effect on soil properties after harvest of bajra crop. The highest organic carbon and available macronutrients (N, P_2O_5 and K_2O kg ha^{-1}) of soil were observed with with EC 2 dS m^{-1} and SAR 5.0 and the lowest with EC 8 dS m^{-1} and SAR 20.0 of irrigation water. The water soluble and exchangeable Ca, Mg and Na were found maximum with EC-8 dS m^{-1}, whereas water soluble and exchangeable K found maximum with EC-2 dS m^{-1} and soil properties like $EC_{2.5}$, EC_e, CEC found maximum with EC-8 dS m^{-1} whereas $pH_{2.5}$, pH_s and ESP found maximum with EC-2 dS m^{-1} level of saline irrigation water. The water soluble and exchangeable Na was found maximum with SAR- 20.0, whereas water soluble and exchangeable Ca, Mg and K were found maximum with SAR- 5.0. The soil properties like EC2.5, ECe, pH2.5, pHs and ESP of the soil was found minimum with SAR- 5.0 and found maximum with SAR- 20.0, but CEC was found maximum with SAR- 5.0 level of sodic irrigation water. The effect of saline and sodic irrigation water was found significant on available N and water-soluble cations Ca^{++}, Mg^{++}, Na^+, K^+, exchangeable cations Ca^{++}, Mg^{++}, Na^+, CEC, ESP, $EC_{2.5}$ and EC_e of soil after harvest of *Bajra*.

Key Words : *Bajra*, Salinity, Sodicity, Available macronutrient, Water soluble, Exchangeable cations, Soil properties

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Soil organic carbon stocks are decline in saline soils under agricultural management due to reduced input of plant C because of poor plant growth (Setia *et al*., 2011 and Tavakkoli *et al.,* 2011). However, there is conflicting evidence concerning the decomposition of SOC in saline soils, because salinity may cause a reduction in soil microbial activity (Setia *et al.,* 2011 and

Setia *et al.,* 2012). In saline soils, plant growth can be hampered by high osmotic pressure, ion imbalance, poor soil structure and poor aeration. Soil microbes can be affected by salinity, mainly by the increased osmotic pressure which may cause dehydration of microbial cells and death of sensitive microorganisms (Setia *et al.,* 2010 and Wichern *et al.,* 2006). Due to such reduction in soil microbial activity, the decomposition rate of SOM may decline which may be one of the reasons for less availability of plant nutrients in saline soils (Setia *et al.,* 2011). The presence of salts in soil may indirectly affect N availability through inhibition of microbial N mineralization and immobilization processes and also by increasing soil pH (Grattan and Grieve, 1999). Mashali *et al.* (2009) reported decrease in available P_2O_5 with increasing salinity of irrigation water was attributed to increased soil calcium and hence precipitated as Ca-phosphate compounds.The decrease in available K_2O may be due to inhibiting effect of Na on K in saline water irrigated soils, which increased as salinity of irrigation water increases.

Nitrogen availability is also affected by Cl, which inhibits NO_3^- uptake and often present at high concentration in sodic soils.This decrease in soil OC may be due to fact that at higher sodicity, conditions were becoming increasingly detrimental to microbial community and this was demonstrated by decline in percentage of organic carbon present as microbial biomass carbon (Rietz and Haynes, 2003). The reduction in phosphorus availability in sodic environment is primarily due to P occurring as NaOH-P and HCl-P is strongly adsorbed compounds and consequently results in reduced P availability (Curtin *et al.,* 1992).

MATERIAL AND METHODS

The important physical and chemical characteristic of the soil under study and experimental techniques followed for the present investigation has been described in the first part of this paper (Kamathker *et al.,* 2021).

The soil samples were collected from each pot of experiment after harvest of crop. All the soil samples were air dried and powdered with a wooden mortar and pestle and passed through a 2 mm sieve. Available N,P_2O_5, K_2O and OC at initial and at harvest and $EC_{2.5}$, $pH_{2.5}$, ECe, pHs and ESP as well as exchangeable and water soluble cations of the soil after harvest of the crop were determined using standard procedure (Jackson, 1973).

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Effect of levels of saline irrigation water on soil properties after harvest of *Bajra* crop:

The results showed that the organic carbon and available macronutrients (N, P and K) of soil decreased with increasing salinity of irrigation water (Table1). Significantly the higher OC (6.4 g kg^{-1}), available N (241.4 kg ha^{-1}), P_2O_5(47.2 kg ha^{-1}) and K_2O (323.0 kg ha^{-1}) were recorded at EC-2.0 dSm^{-1} level of saline irrigation water. Similar results were also observed by Mashali *et al.* (2009). Whereas the water-soluble and exchangeable Ca^{+2} (1.18 and 3.35 me per 100g), Mg^{-2} (3.30 and 1.38 me per 100g) and Na^+ (2.13 and 5.94 me per 100g) were found the lowest with the EC-2.0 dSm^{-1} and the highest with EC-8.0 dSm^{-1}, respectively. The similar results were reported by Viradiya *et al.* (2008). The highest water-soluble and exchangeable K^+ (0.38 and 0.40 me per 100g) were found with EC-2.0 dSm^{-1}, but CEC [47.08 c mol (p^+) kg^{-1}] was found the highest with EC-8.0 dSm^{-1} and ESP (21.76 %) with EC-4.0 dS m^{-1} level of saline irrigation water (Table 2). Significantly the highest values of $EC_{2.5}$ (6.89 dSm^{-1}) and ECe (21.63 dSm^{-1}) were found under EC-8.0 dSm^{-1} level and $pH_{2.5}$ (8.12) and pHs (8.21) were found under EC-2.0 dSm^{-1} level of saline irrigation water (Table 1). Similar results were also reported by Ghuman *et al.* (2010) who found significant increase in soil EC with increasing irrigation water salinity in sandy soils.

Effect of levels of sodic irrigation water on soil properties after harvest of *Bajra* crop :

Data presented in Table 1 indicated that significantly the higher value of OC (5.8 g kg^{-1}), available N (239.7 kg ha^{-1}), P_2O_5 (45.7 kg ha^{-1}) and K_2O (314.4 kg ha^{-1}) were recorded at SAR- 5.0 level of sodic irrigation water and decreases with increase in sodicity. Significantly the highest water-soluble and exchangeable Ca^{+2} of 3.91 and 3.35, Mg^{+2} of 13.92 and 6.58 and K^+ of 0.44 and 0.47 me per 100 g, respectively, were obtained with the SAR-5.0 and the lowest with SAR- 20.0 level of sodic irrigation water and the water soluble and exchangeable Na^+ was found the highest with the values of 6.47 and 13.33 me per 100g, respectively, with the SAR-20.0 level of sodicity (Table 2). Significantly the highest CEC (22.06 c mol

Table 1: Effect of levels of saline and sodic irrigation water on organic carbonand available macronutrients of soil

Treatments	Organic carbon (g kg^{-1})	Available macronutrients (kg ha^{-1})			$EC_{2.5}$ (dS m^{-1})	EC_e (dS m^{-1})	$pH_{2.5}$	pH_s
		N	P_2O_5	K_2O				
Salinity levels (C)								
C_1: 2.0 dS m^{-1}	6.4	241.4	47.2	323.0	1.19	2.12	8.26	8.30
C_2: 4.0 dS m^{-1}	5.2	232.3	43.2	288.0	2.20	4.23	8.11	7.88
C_3: 6.0 dS m^{-1}	4.3	222.9	39.8	275.4	3.50	6.21	8.01	7.68
C_4: 8.0 dS m^{-1}	4.1	210.3	35.0	273.3	4.74	8.01	7.90	7.38
S.E.±	0.15	3.16	0.59	3.87	0.04	0.03	0.06	0.05
C.D. (P=0.05)	0.44	9.10	1.71	11.14	0.11	0.10	0.17	0.14
Sodicity levels (S)								
S_1: 5.0 SAR	5.8	239.7	45.7	314.4	2.80	4.94	7.90	7.63
S_2: 10.0 SAR	5.2	233.1	44.2	293.8	2.85	5.12	8.06	7.84
S_3: 15.0 SAR	4.9	224.6	40.3	282.6	2.97	5.19	8.09	7.87
S_4: 20.0 SAR	4.2	209.4	35.1	269.0	3.02	5.32	8.23	7.89
S.E.±	0.15	3.16	0.59	3.87	0.04	0.03	0.06	0.05
C.D. (P=0.05)	0.44	9.10	1.71	11.14	0.11	0.10	0.17	0.14
C×S interaction								
S.E.±	0.30	6.31	1.19	7.73	0.08	0.07	0.05	0.10
C.D. (P=0.05)	NS	18.19	NS	NS	0.22	0.2	NS	NS
C.V %	10.45	4.82	4.97	4.62	4.57	2.32	2.47	2.17

NS= Non-significant

Table 2: Effect of levels of saline and sodic irrigation water on water soluble and exchangeable (net exchangeable) cations, CEC and ESP of soil after harvest of *Bajra*

Treatments	Water soluble cations (me/100 g)				Exchangeable cations (me/100 g)				CEC(c mol (p+) kg^{-1})	ESP
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Ca^{++}	Mg^{++}	Na^{+}	K^{+}		
Salinity levels (C)										
C_1: 2.0 dS m^{-1}	1.18	3.30	2.13	0.38	3.35	1.38	5.94	0.40	11.07	53.37
C_2: 4.0 dS m^{-1}	2.11	5.89	3.31	0.34	4.50	1.79	8.44	0.38	15.11	55.29
C_3:6.0 dS m^{-1}	2.85	9.48	5.59	0.32	8.67	3.21	12.53	0.34	24.74	50.10
C_4: 8.0 dS m^{-1}	5.19	16.55	8.20	0.21	10.92	6.79	13.85	0.29	31.84	45.00
S.E.±	0.06	0.18	0.10	0.01	0.11	0.08	0.15	0.01	0.24	0.75
C.D. (P=0.05)	0.16	0.52	0.29	0.01	0.31	0.23	0.42	0.03	0.69	2.17
Sodicity levels (S)										
S_1: 5.0 SAR	3.91	13.92	3.01	0.44	9.04	6.58	5.96	0.47	22.06	30.68
S_2: 10 SAR	2.84	9.14	4.00	0.34	6.69	3.13	8.58	0.37	18.76	48.16
S_3: 15 SAR	2.48	7.36	5.75	0.25	6.10	2.00	12.88	0.30	21.29	60.40
S_4: 20 SAR	2.10	4.80	6.47	0.22	5.60	1.46	13.33	0.26	20.66	64.51
S.E.±	0.06	0.18	0.10	0.01	0.11	0.08	0.15	0.01	0.24	0.75
C.D. (P=0.05)	0.16	0.52	0.29	0.01	0.31	0.23	0.42	0.03	0.69	2.17
C ×S interaction										
S.E.±	0.11	0.36	0.20	0.01	0.21	0.16	0.29	0.02	0.48	1.51
C.D. (P=0.05)	0.32	1.04	0.57	0.03	0.62	0.47	0.84	NS	1.38	4.34
C.V.%	6.89	7.09	7.16	5.39	5.39	8.49	4.94	9.33	4.01	5.12

NS=Non-significant

Table 3: Interaction effect between levels of saline and sodic irrigation water on available nitrogen (kg ha^{-1}) in soil

	C_1: 2.0 dS m^{-1}	C_2: 4.0 dS m^{-1}	C_3: 6.0 dS m^{-1}	C_4: 8.0 dS m^{-1}	Mean
S_1: 5.0 SAR	263.7	248.2	227.5	219.6	239.7
S_2: 10.0 SAR	251.7	237.6	225.3	217.9	233.1
S_3: 15.0 SAR	230.5	229.3	217.4	221.3	224.6
S_4: 20.0 SAR	219.7	214.2	221.2	182.4	209.4
Mean	241.4	232.3	222.9	210.3	
S.E.+	6.31		C.D. (P=0.05)	18.19	

Table 4: Interaction effect between levels of saline and sodic irrigation water on water soluble Ca^{+2} (me/100 g) of soil

	C_1: 2.0 dS m^{-1}	C_2: 4.0 dS m^{-1}	C_3: 6.0 dS m^{-1}	C_4: 8.0 dS m^{-1}	Mean
S_1: 5.0 SAR	1.40	2.50	4.43	7.32	3.91
S_2: 10.0 SAR	1.11	2.38	2.54	5.32	2.84
S_3: 15.0 SAR	1.10	1.96	2.62	4.24	2.48
S_4: 20.0 SAR	1.09	1.58	1.82	3.90	2.10
Mean	1.18	2.11	2.85	5.20	
S.E.+	0.11		C.D. (P=0.05)	0.32	

Table 5: Interaction effect between levels of saline and sodic irrigation wateron exchangeable Ca^{+2} (me/100 g) of soil

	C_1: 2.0 dS m^{-1}	C_2: 4.0 dS m^{-1}	C_3: 6.0 dS m^{-1}	C_4: 8.0 dS m^{-1}	Mean
S_1: 5.0 SAR	4.17	5.17	11.92	14.92	9.04
S_2: 10.0 SAR	3.25	4.67	8.67	10.17	6.69
S_3: 15.0 SAR	3.17	4.17	7.58	9.50	6.10
S_4: 20.0 SAR	2.83	4.00	6.50	9.08	5.60
Mean	3.35	4.50	8.67	10.92	
S.E.+	0.21		C.D. (P=0.05)	0.62	

Table 6: Interaction effect between levels of saline and sodic irrigation water on water soluble Mg^{+2} (me/100 g) of soil

	C_1: 2.0 dS m^{-1}	C_2: 4.0 dS m^{-1}	C_3: 6.0 dS m^{-1}	C_4: 8.0 dS m^{-1}	Mean
S_1: 5.0 SAR	4.56	10.06	16.67	24.39	13.92
S_2: 10.0 SAR	4.64	7.32	9.31	15.31	9.14
S_3: 15.0 SAR	2.56	4.68	7.18	15.02	7.36
S_4: 20.0 SAR	1.43	1.50	4.75	11.50	4.80
Mean	3.30	5.89	9.48	16.55	
S.E.+	1.04		C.D. (P=0.05)	7.09	

Table 7: Interaction effect between levels of saline and sodic irrigation water on exchangeable Mg^{+2} (me/100 g) of soil

	C_1: 2.0 dS m^{-1}	C_2: 4.0 dS m^{-1}	C_3: 6.0 dS m^{-1}	C_4: 8.0 dS m^{-1}	Mean
S_1: 5.0 SAR	2.00	2.50	5.83	16.00	6.58
S_2: 10.0 SAR	1.17	1.83	3.33	6.17	3.13
S_3: 15.0 SAR	1.33	1.33	2.33	3.00	2.00
S_4: 20.0 SAR	1.00	1.50	1.33	2.00	1.46
Mean	1.38	1.79	3.21	6.79	
S.E.+	0.16		C.D. (P=0.05)	0.47	

Table 8: Interaction effect between levels of saline and sodic irrigation wateron water soluble Na^+(me/100 g) of soil

	C_1: 2.0 dS m^{-1}	C_2: 4.0 dS m^{-1}	C_3: 6.0 dS m^{-1}	C_4: 8.0 dS m^{-1}	Mean
S_1: 5.0 SAR	1.25	2.40	3.69	4.71	3.01
S_2: 10.0 SAR	1.92	3.01	4.58	6.48	4.00
S_3: 15.0 SAR	2.52	3.49	6.62	10.36	5.75
S_4: 20.0 SAR	2.81	4.35	7.46	11.26	6.47
Mean	2.13	3.31	5.59	8.20	
S.E.+	0.2		C.D. (P=0.05)	0.57	

Table 9: Interaction effect between levels of saline and sodic irrigation water on exchangeable Na^+ (me/100 g) of soil

	C_1: 2.0 dS m^{-1}	C_2: 4.0 dS m^{-1}	C_3: 6.0 dS m^{-1}	C_4: 8.0 dS m^{-1}	Mean
S_1: 5.0 SAR	3.75	5.15	6.91	8.03	5.96
S_2: 10.0 SAR	6.24	8.52	9.12	10.42	8.58
S_3: 15.0 SAR	6.48	9.62	17.91	17.53	12.88
S_4: 20.0 SAR	7.27	10.45	16.18	19.43	13.33
Mean	5.94	8.44	12.53	13.85	
S.E.+	0.29		C.D. (P=0.05)	0.84	

Table 10 : Interaction effect between levels of saline and sodic irrigation water on water soluble K^+ (me/100 g) of soil

	C_1: 2.0 dS m^{-1}	C_2: 4.0 dS m^{-1}	C_3: 6.0 dS m^{-1}	C_4: 8.0 dS m^{-1}	Mean
S_1: 5.0 SAR	0.52	0.49	0.42	0.35	0.44
S_2: 10.0 SAR	0.43	0.36	0.37	0.20	0.34
S_3: 15.0 SAR	0.32	0.26	0.25	0.16	0.25
S_4: 20.0 SAR	0.27	0.23	0.25	0.15	0.22
Mean	0.38	0.34	0.32	0.21	
S.E.+	0.01		C.D. (P=0.05)	0.03	

Table 11: Interaction effect between levels of saline and sodic irrigation water on CEC (c mol (p+) kg^{-1}) of soil

	C_1: 2.0 dS m^{-1}	C_2: 4.0 dS m^{-1}	C_3: 6.0 dS m^{-1}	C_4: 8.0 dS m^{-1}
S_1: 5.0 SAR	10.45	13.33	25.10	39.35
S_2: 10.0 SAR	11.09	15.44	21.48	27.02
S_3: 15.0 SAR	11.32	15.44	28.11	30.28
S_4: 20.0 SAR	11.41	16.22	24.27	30.74
Mean	11.07	15.11	24.74	31.84
S.E.+	0.48		C.D. (P=0.05)	1.38

Table 12: Interaction effect between levels of saline and sodic irrigation water on ESP (%) of soil

	C_1: 2.0 dS m^{-1}	C_2: 4.0 dS m^{-1}	C_3: 6.0 dSm^{-1}	C_4: 8.0 dS m^{-1}	Mean
S_1: 5.0 SAR	35.97	38.74	27.63	20.40	30.68
S_2: 10.0 SAR	56.35	55.36	42.41	38.54	48.16
S_3: 15.0 SAR	57.36	62.63	63.70	57.89	60.40
S_4: 20.0 SAR	63.79	64.43	66.66	63.17	64.51
Mean	53.37	55.29	50.10	45.00	
S.E.+	1.51		C.D. (P=0.05)	4.34	

Table 13: Interaction effect between levels of saline and sodic irrigation water on $EC_{2.5}$ (dS m^{-1}) of soil

	C_1: 2.0 dS m^{-1}	C_2: 4.0 dS m^{-1}	C_3: 6.0 dS m^{-1}	C_4: 8.0 dS m^{-1}	Mean
S_1: 5.0 SAR	1.34	1.96	3.43	4.48	2.80
S_2: 10.0 SAR	1.06	2.26	3.45	4.63	2.85
S_3: 15.0 SAR	1.29	2.38	3.51	4.71	2.97
S_4: 20.0 SAR	1.07	2.22	3.61	5.17	3.02
Mean	1.19	2.20	3.50	4.74	
S.E.+	0.08		C.D. (P=0.05)	0.22	

Table 14: Interaction effect between levels of saline and sodic irrigation water on EC_e (dS m^{-1}) of soil

	C_1: 2.0 dS m^{-1}	C_2: 4.0 dS m^{-1}	C_3: 6.0 dS m^{-1}	C_4: 8.0 dS m^{-1}	Mean
S_1: 5.0 SAR	2.00	4.11	6.04	7.60	4.94
S_2: 10.0 SAR	2.06	4.19	6.11	8.11	5.12
S_3: 15.0 SAR	2.12	4.28	6.25	8.13	5.19
S_4: 20.0 SAR	2.31	4.33	6.44	8.20	5.32
Mean	2.12	4.23	6.21	8.01	
S.E.+	0.07		C.D. (P=0.05)	0.20	

(p+) kg^{-1}) was observed with SAR-5.0 and the lowest with SAR-10.0 level of sodicity. The highest ESP (64.51) was observed at SAR-20.0 and the lowest was observed with SAR-5.0 level of sodicity (Table 2). Similar results were observed by Choudhary *et al.* (2006) and Choudhary *et al.* (2011). Significantly the higher value of EC2.5 (3.02 dS m^{-1}), ECe (5.32 dS m^{-1}), $pH_{2.5}$ (8.23) and pH_s (7.89) was found under SAR- 20.0 level of sodicity (Table 1). The similar results were also found by Sharma and Pal (2001) and Choudhary *et al.* (2011) who concluded that pH of soil increased significantly with increasing SAR of irrigation water.

Interaction effect of saline and sodic irrigation water:

The interaction effect of different levels of saline and sodic irrigation water on available N and water-soluble cations Ca^{++}, Mg^{++}, Na^+, K^+, exchangeable cations Ca^{++}, Mg^{++}, Na^+, CEC, ESP, EC2.5 and EC_e were found significant (Table 3 to Table 14) after harvest of crop. Significantly the highest available N (263.71kg ha^{-1}) and water-soluble K^+ (0.52 me per 100 g) was found under $C_1 \times S_1$ (EC-2 dS m^{-1}× SAR-5.0). Water soluble and exchangeable Ca^{+2}, Mg^{+2} and CEC were found the highest with $C_4 \times S_1$ (EC-8 dS m^{-1} × SAR-5.0). The water soluble and exchangeable Na^+ were found the highest with $C_4 \times S_4$ (EC-8 dS m^{-1}× SAR-20.0) and ESP was found the highest with $C_3 \times S_4$ (EC-6 dSm^{-1}× SAR-20.0). The soil $EC_{2.5}$ and EC_e were found the highest with $C_4 \times S_4$ (EC-8 dS m^{-1} × SAR-20.0) level of saline and sodic irrigation water.

Conclusion:

Based on the results, it can be concluded that application of saline irrigation water having EC 2 dS m^{-1} and sodic irrigation water having SAR-5.0 enhanced the organic carbon content, available N, P_2O_5 and K_2O, exchangeable and water- soluble K^+. Whereas the exchangeable and water-soluble Ca^{++}, Mg^{++} and CEC were found the highest with saline irrigation water having EC 8 dS m^{-1} and sodic irrigation water having SAR-5.0. ESP found the highest with saline irrigation water having EC 4 dSm^{-1} and sodic irrigation water having SAR 20. The exchangeable and water-soluble Na^+, EC2.5 and EC_e, were found the highest with saline irrigation water having EC 8 dS m^{-1} and sodic irrigation water having SAR-20.0. $pH_{2.5}$ and pH_s were found the highest with saline irrigation water having EC 2 dS m^{-1} and sodic irrigation water having SAR-20.0.

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