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RESEARCH ARTICLE

Influence of saline and sodic irrigation water on *Bajra- I* : Effect on yield and yield attributes

■ A. Kamathker, M. A. Davara and J. V. Polara

SUMMARY

A pot experiment was conducted at Net House,Department of Agricultural Chemistry and Soil Science,Junagadh Agricultural University, Junagadh to assess four levels 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 growth, yield attributes, yield and quality of bajra crop. The maximum plant height, number of effective and total tillersper plant, germination percentage, earhead girth, grain, fodder and biological yield and harvest index were observed with EC 2 dS m^{-1} and SAR 5.0 and the lowest with EC8 dS $m^{-1}$and SAR 20.0 of irrigation water. The quality parameters like seed index and protein content were found maximum with saline irrigation water level of 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 interaction effect between salinity and sodicity levels of irrigation water onfodder yield, harvest index were found significantly the highest with $C_1 \times S_1$(EC-2.0 $dSm^{-1} \times$SAR-5.0) and plant height were found significantly the highest with $C_2 \times S_1$(EC-4.0 $dSm^{-1} \times$ SAR-5.0) at 60, 90 DAS and at harvest.

Key Words : *Bajra*, Salinity, Sodicity, Growth, Yield and yield attributes, Quality

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For crop production in drylands, the major source of water is rainfall, which is often limited and erratic, especially in semiarid and arid regions. Generally, in irrigated agriculture, farmers, planners, and policy decision-makers place greater emphasis on short-term crop productivity than on long-term soil resource sustainability. When poor-quality water, particularly high-saline water, is used for irrigation, new approaches are needed that address the short-term productivity concerns and long-term sustainability issues of the soil resources simultaneously (Zwart and Bastiaanssen, 2004).

Bajra is popularly known as "pearl millet" and belongs to the family of Gramineae. This grain basically originated from India or Africa. *Bajra* is a coarse grain

MEMBERS OF THE RESEARCH FORUM

Author to be contacted :
J. V. Polara, Department of Agricultural Chemistry and Soil Science, Junagadh Agricultural University, **Junagadh (Gujarat) India**
Email : jvpolara@jau.in

Address of the Co-authors:
A. Kamathker and M. A. Davara , Department of Agricultural Chemistry and Soil Science, Junagadh Agricultural University, **Junagadh (Gujarat) India**

crop and considered to be the poor man's staple nourishment and suitable to cultivate in dry lands. *Bajra* can also be used as valuable animal fodder.

In India total bajra production is 6.67 M tonnes from area of 9.03 M ha and productivity of 1154 kg ha^{-1} and Gujarat produce 1.014 M tonnes from area of 0.454 M ha and productivity of 2292 kg ha^{-1} (Anonymous, 2017).

Bajra is an important cereal crop of Gujarat state as it covers maximum acreage as compared to any other food crops in the state. It is being grown in an area of 13 lakh hectare of the total area under cultivation. The ingress of sea water in the ground water is a matter of great concern, in several parts of Gujarat, since it leads to poor quality of well water. The quality of soils and productivity of the crops have been declining with the continuous use of the such poor-quality water from well. Salinity is one of the important constraints limiting the crop production particularly in the coastal belts of Saurashtra region (Nariya, 2005).

MATERIAL AND METHODS

A pot experiment was conducted during summer-2020 at the Department of Agricultural Chemistry and Soil Science, College of Agriculture, Junagadh Agricultural University, Junagadh. The soil of the experimental plot was clayey in texture and alkaline in reaction (pH2.5 8) without having any problem of salinity (EC2.5 0.31 dS m^{-1}). From the fertility point of view, the soil was moderately supplied with organic carbon (6.2 g kg^{-1}) and phosphorus (52.3 kg ha^{-1}), low in available nitrogen (247.7 kg ha^{-1}), but was high in available potassium (569.8 kg ha^{-1}). The treatment consists of four levels 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 required quantity of N: P_2O_5 at the rate of 120: 60 kg N: P_2O_5 ha^{-1} were dissolved in water and then applied to all the pots as basal dose through urea and DAP, respectively.

Bajra crop was sown on 24th February, 2020. The crop was irrigated with three litres of water in each pot during first irrigation with tap water. Then after the crop was irrigated with saline-sodic water as per the treatment combination prepared by dissolving calculated quantity of soluble salts @ two L per pot. These waters were synthesized by dissolving calculated quantities of salts of NaCl, Na_2SO_4, $CaCl_2.2H_2O$ and $MgSO_4.7H_2O$ in rain water collected and stored during monsoon. The Cl: SO_4 and Mg: Ca ratios in these water were kept as 1:1 and 2:1, respectively. The pots were uniformly irrigated as and when crop required irrigation throughout the season. In all, one tap water and sixteen treatments of irrigation water were applied during the growing season of *Bajra*. The observations on growth yield and yield attributing characters and quality characters were recorded.The data recorded on various parameters were subjected to statistical analysis as for the procedure suggested by Panse and Sukhatme (1985).

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 growth, yield and yield attributes and quality parameters:

Data presented in Table 1 indicated significant effect of different levels of saline irrigation water on growth yield and yield attributes and quality parameters. Significantly the minimum days required for 50% flowering (43.25), the highest germination percentage (49.17 %), number of effective (1.86) and total (3.05) tillers $plant^{-1}$ and ear head girth (19.94 mm) were observed with EC-2.0 dS m^{-1} and the highest ear head length (17.63 cm) and plant height at 60 (82.56 cm), 90 DAS (84.06 cm) and at harvest (85.11 cm) were observed with EC-4.0 dS m^{-1} and the maximum days required for 50% flowering, the lowest germination percentage (32.92 %), number of effective (1.11) and total (2.44) tillers $plant^{-1}$, ear head length (16.39 cm) and girth (18.19 mm), plant height at 60 (77.22 cm), 90 DAS (78.72 cm) and at harvest (79.78 cm) were recorded with EC-8.0 dS m^{-1}. Similar results were also obtained byMakarana *et al.* (2017) in pearl millet crop, Meena *et al.* (2017) in groundnut-cluster bean cropping system and Mostafazadeh *et al.* (2009) in wheat and concluded the growth and yield attributing significantly decreased with increasing level of salinity of irrigation water.

The data presented in Table 2 showed that significantly the highest grain (19.53 g pot^{-1}), fodder (109.24 g pot^{-1}), biological yield (128.77 g pot^{-1}) and harvest index (14.91 %) were recorded at EC-2 dS m^{-1} whereas, the lowest grain (10.07 g pot^{-1}), fodder (99.04 g pot^{-1}), biological yield (109.10 g pot^{-1}) and harvest index (9.07 %), with the EC-8 dS m^{-1} salinity level of irrigation water which might be due to increasing levels of soluble

Table 1 : Effect of levels of saline and sodic irrigation water on growth and yield attributing characters of *Bajra*

Treatments	Growth and yield attributing characters								
	Germination percentage	Days to 50 % flowering	Tillers per plant		Ear head		Plant height (cm)		
			Effective	Total	Length (cm)	Girth (mm)	At 60 DAS	At 90 DAS	At harvest
Salinity levels (C)									
C_1: 2.0 dS m^{-1}	49.17	43.25	1.86	3.05	17.04	19.94	78.31	79.81	80.86
C_2: 4.0 dS m^{-1}	45.83	46.25	1.64	2.89	17.63	19.62	82.56	84.06	85.11
C_3: 6.0 dS m^{-1}	43.33	51.75	1.42	2.61	17.47	19.19	81.44	82.94	84.00
C_4: 8.0 dS m^{-1}	32.92	53.58	1.11	2.44	16.39	18.19	77.22	78.72	79.78
S.E.±	0.75	0.40	0.06	0.07	0.29	0.30	1.25	1.24	1.28
C.D. (P=0.05)	2.17	1.16	0.18	0.19	0.84	0.87	3.61	3.58	3.67
Sodicity levels (S)									
S_1: 5.0 SAR	50.00	46.50	1.89	3.11	18.02	20.18	82.92	84.42	85.47
S_2: 10.0 SAR	44.58	48.25	1.61	2.97	17.72	19.66	79.97	81.47	82.53
S_3: 15.0 SAR	40.00	49.25	1.31	2.47	16.78	18.75	80.25	81.75	82.80
S_4: 20.0 SAR	36.67	50.83	1.22	2.44	16.01	18.34	76.39	77.89	78.94
S.E.+	0.75	0.40	0.06	0.07	0.29	0.30	1.25	1.24	1.28
C.D. (P=0.05)	2.17	1.16	0.18	0.19	0.84	0.87	3.61	3.58	3.67
C×S interaction									
S.E.±	1.50	0.81	0.12	0.13	0.59	0.6	2.50	0.13	0.16
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	7.21	7.16	7.35
C.V.%	6.08	2.87	13.93	8.22	5.91	5.42	5.43	5.29	5.36

NS= Non-significant

Table 2: Effect of levels of saline and sodic irrigation water on yield and quality parameters of *Bajra*

Treatments	Grain yield (g pot^{-1})	Fodder yield (g pot^{-1})	Biological yield (g pot^{-1})	Harvest index (%)	Quality parameters	
					Weight of 1000 seeds (g)	Protein content (%)
Salinity levels (C)						
C_1: 2.0 dS m^{-1}	19.53	109.24	128.77	14.91	8.15	6.93
C_2: 4.0 dS m^{-1}	17.12	102.63	119.75	13.95	7.82	6.07
C_3: 6.0 dS m^{-1}	13.09	103.72	116.82	10.89	7.53	5.60
C_4: 8.0 dS m^{-1}	10.07	99.04	109.10	9.07	6.63	5.17
S.E.±	0.43	1.53	1.61	0.20	0.11	0.10
C.D. (P=0.05)	1.24	4.41	4.63	0.58	0.31	0.28
Sodicity levels (S)						
S_1: 5.0 SAR	22.03	108.00	130.03	16.90	8.33	7.20
S_2: 10.0 SAR	18.54	104.22	122.76	15.00	7.96	6.36
S_3: 15.0 SAR	12.63	103.03	115.67	10.78	7.23	5.47
S_4: 20.0 SAR	6.61	99.38	105.98	6.13	6.60	4.73
S.E.±	0.43	1.53	1.61	0.20	0.11	0.10
C.D. (P=0.05)	1.24	4.41	4.63	0.58	0.31	0.28
C S interaction						
S.E.±	0.86	3.06	3.21	0.41	0.22	0.19
C.D. (P=0.05)	NS	8.81	NS	1.17	NS	NS
C.V %	9.99	5.11	4.69	5.74	4.94	5.63

NS= Non-significant

Table 3: Interaction effect between levels of saline and sodic irrigation water on plant height (cm) at 60 DAS of *Bajra*

	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	82.67	86.22	83.56	79.22
S_2: 10.0 SAR	73.44	80.67	85.00	80.78
S_3: 15.0 SAR	76.00	85.22	79.44	80.33
S_4: 20.0 SAR	81.11	78.11	77.78	68.56
Mean	78.31	82.56	81.44	77.22
S.E.+	2.50		C.D. (P=0.05)	7.21

Table 4: Interaction effect between levels of saline and sodic irrigation water onplant height (cm) at 90 DAS of *Bajra*

	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	84.17	87.72	85.06	80.72	84.42
S_2: 10.0 SAR	74.94	82.17	86.50	82.28	81.47
S_3: 15.0 SAR	77.50	86.72	80.94	81.83	81.75
S_4: 20.0 SAR	82.61	79.61	79.28	70.06	77.89
Mean	79.81	84.06	82.94	78.72	
S.E.+	2.49		C.D. (P=0.05)	7.16	

Table 5: Interaction effect between levels of saline and sodic irrigation water on plant height (cm) at h *Bajra*

	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	85.22	88.78	86.11	81.78
S_2: 10.0 SAR	76.00	83.22	87.55	83.33
S_3: 15.0 SAR	78.55	87.78	82.00	82.89
S_4: 20.0 SAR	83.66	80.66	80.33	71.11
Mean	80.86	85.11	84.00	79.78
S.E.+	2.55		C.D. (P=0.05)	7.35

Table 6: Interaction effect between levels of saline and sodic irrigation water on fodder yield (g pot^{-1}) of *Bajra*

	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	117.15	112.71	107.50	94.65	108.00
S_2: 10.0 SAR	109.58	106.25	103.46	97.58	104.22
S_3: 15.0 SAR	107.28	97.08	103.16	104.61	103.03
S_4: 20.0 SAR	102.95	94.46	100.77	99.33	99.38
Mean	109.24	102.63	103.72	99.04	
S.E.+	3.06		C.D. (P=0.05)	8.81	

Table 7: Interaction effect between levels of saline and sodic irrigation water on harvest index (%) of *Bajra*

	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	18.10	17.13	16.35	16.04	16.90
S_2: 10.0 SAR	17.19	16.21	13.44	13.16	15.00
S_3: 15.0 SAR	14.61	14.42	9.24	4.85	10.78
S_4: 20.0 SAR	9.73	8.06	4.52	2.21	6.13
Mean	14.91	13.95	10.89	9.07	
S.E.+	0.41		C.D. (P=0.05)	1.17	

salts which might be toxic to plants and that might cause disturbances in metabolic and physiological functions leading to poor crop production. Similar results were observed by Essa (2002) in soybean, Mostafazadeh *et al.* (2009) and Makarana *et al.* (2019) in pearl millet. The highest seed index (8.15 g) and protein content (6.93 %) were recorded at EC-2 dS m^{-1} and the lowest was with the EC-8 dS m^{-1}. Similar results were observed by Mostafazadeh *et al.* (2009) and Makarana *et al.* (2019) in wheat and found that protein content decreased with increasing level of salinity stress.

Effect of levels of sodic irrigation water on growth, yield, yield attributes and quality parameters

Data presented in Table 1 indicated that significantly the minimum days required for 50% flowering (46.50) and the highest germination percentage (50.00 %), number of effective (1.89) and total (3.11) tillers $plant^{-1}$, ear head length (18.02 cm) and girth (20.18 mm), plant height at 60 (82.92 cm), 90 DAS (84.42 cm) and at harvest (85.47 cm) were observed with sodicity level of irrigation water having SAR- 5.0 and the maximum days required for 50% flowering (50.83) and the lowest germination percentage (36.67 %), number of effective (1.22) and total (2.44) tillers $plant^{-1}$, ear head length (16.01 cm) and girth (18.34 mm), plant height at 60 (76.39 cm), 90 DAS (77.89 cm) and at harvest (78.94 cm) were recorded with SAR- 20.0.

The data presented in Table 2 showed that significantly the highest grain (22.03 g pot^{-1}), fodder (108.00 g pot^{-1}), biological yield (130.03 g pot^{-1}) and harvest index (16.90 %) were recorded at SAR- 5.0 whereas, the lowest grain (6.61 g pot^{-1}), fodder (99.38 g pot^{-1}), biological yield (105.98 g pot^{-1}) and harvest index (6.13 %) with the SAR- 20.0 sodicity level of irrigation water. While the weight of 1000 grain and protein content significantly decreased from 8.33 to 6.00 g and 7.20 to 4.73 % due to increase in level of sodicity of irrigation water from SAR-5 to 20, respectively. Similar result were observed by Pathan *et al.* (2000) in cluster bean crop.

Interaction effect of saline and sodic irrigation water on growth, yield, yield attributes and quality parameters:

The combined effect of saline and sodic irrigation water on growth parameter like germination percentage, days to 50% flowering, number of effective and totaltillers $plant^{-1}$, ear head length and girth, grain yield, biological yield, weight of 1000 grain and protein content were found non-significant, While the combined effect of saline and sodic irrigation water on plant height, fodder yield and harvest index were found significant. The data presented in Table 3, 4 and 5 showed that the highest plant height at 60 (86.22 cm), 90 DAS (87.72 cm) and at harvest (88.78 cm) were obtained with EC- 4.0 dS m^{-1} × SAR- 5.0 level of irrigation water, and Table 6 and 7 showed that highest fodder yield (117.15 g pot^{-1}) and harvest index (18.10 %) were obtained with EC- 2.0 dS m^{-1} × SAR- 5.0.Similar results were observed by Javid *et al*. (2012) in mustard, Pathan *et al.* (2000) in cluster bean and concluded that the application of saline and sodic irrigation water resulted in decrease in growth and yield.

Conclusion :

It was concluded that the growth, yield and yield attributes and quality parameter decreased with increasing EC and SAR levels of irrigation water. The application of saline irrigation water having EC-2 dS m^{-1} and sodic irrigation water having SAR-5.0 enhanced the growth, yield attribute, yield and protein content. The interaction between salinity and sodicity levels of irrigation water on plant height, fodder yield and harvest index were found significant.

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