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Effect of different levels of saline irrigation water on growth, yield, quality and concentration and uptake of macro and micro nutrients of wheat crop

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Abstract
The response of wheat (*Triticum aestivum* L.) to different salinity levels of irrigation water was investigated in a pot experiment at Net House, Junagadh agricultural university, Junagadh during *rabi*-2017. Saline waters with electrical conductivity values of 2.0, 4.0, 6.0 and 8.0 dS m^{-1} in completely randomized design (Factorial) replicated three times used for irrigation of wheat. Application of different levels of saline irrigation water produced significant effect on growth, yield attributes and yield, quality, concentration and uptake of nutrients of wheat crop. The maximum plant height, number of tillers per plant, length of main spike, number of spikelets per spike, number of grains per spike, number of grains per spikelet, days to heading and grain and straw yield was observed with EC-2 dS m^{-1}, whereas germination percentage and days to maturity was unaffected by different levels of saline irrigation water. The quality parameters like test weight and protein content were found maximum with the saline irrigation water level of EC-2 dS m^{-1}. The maximum concentration and uptake of the macro (N, P and K) and micro (Fe, Zn, Cu and Mn) nutrients of grain and straw of wheat crop was observed with the EC-2 dS m^{-1}.

Keywords: Wheat, salinity levels, growth, yield attributes, yield, quality, concentration and uptake

Introduction
Supplies of good quality irrigation water are expected to decrease in the future because the development of new water supplies will not keep pace with the increasing water needs of industries and municipalities. Thus, irrigated agriculture faces the challange of using less water, in many cases of poorer quality, to provide food and fiber for an expanding population. Some of the future water needs can be met by using available water supplies more efficiently, but in many cases it will prove necessary to make increased use municipal waste waters and irrigation drainage waters. Limited supplies of fresh water are increasingly in demand for competing uses and create the need to use marginal quality water in agriculture. From the viewpoint of irrigation, the use of marginal quality waters require careful planning, more complex management practices and stringent monitoring procedures, than when good quality water is used (Oster, 1994; Beltran, 1999) [28, 11]. When the availability of freshwater is limited, agriculture is likely to be forced to make increasing use of nonconventional waters, either brackish water or sewage effluents (Hamdy, 1999) [19].
Salinity problem is defined as a condition where the salts in solution within the crop root zone accumulate in high concentrations which decrease crop yield (Ayers and Westcot, 1985) [10]. Salts in the soil water solution can reduce evapotranspiration by making soil water less available for plant root extraction (Allen *et al*., 1998) [3]. The inherent ability of crop to withstand the effects of elevated solute concentration in their root zone solutions and still produce a measurable agricultural product defines the magnitude of crop tolerance or resistance to salinity (Steppuhn *et al*., 2005) [32]. However, under saline conditions, many plants are able to partially compensate for low osmotic potential of the soil water by building up higher internal solute contents (Allen *et al*., 1998) [3]. Shalhevet (1994) [31] reported that the effect of salinity and water stress are generally additives in their impacts on crop evapotranspiration. Under saline conditions, plant growth is usually reduced by reducing the rate of leaf elongation, enlargement and cells division in the leave (Allen *et al*., 1998) [3].
The higher is the electrical conductivity (EC), the less is the water available to plants, even

though a field may appear wet. The amount of water transpired through a crop is directly related to its yield and irrigation water with higher EC reduces yield potential. Saline water resources are abundant than fresh water. Bringing these resources into sustainable productive use will offer opportunities to increase food security especially in developing countries. Several physical, chemical and biological soil management measures help to facilitate the safe use of saline water in crop production.

A general consensus about the excessive accumulation of soluble salts in the rhizosphere being a major reason for reduced osmotic potential of soil or nutrient solution and for unbalanced nutrition and specific ion phytotoxicity in salt affected soils. In plants, salinity can induce damages in proteins, lipids and nucleic acids, and alterations in photosynthesis and respiration which affect plant growth and development (Manai *et al*., 2014) [27]. The extent of growth inhibition caused by salinity on may be influenced by the nutritional status of plants. Constraints to crop productivity in salt affected soils may be overcome by leaching soluble salts from soil profiles by excess irrigation. This practice is no longer acceptable due to higher salinity in the streams and accumulation of salts in the deeper soil profile. The recycling of drainage water for irrigation is being considered as a best management practice. Crop growth parameters and yield under combined deficit and saline water irrigation were different to those under separate deficit or saline irrigation. Ayers and Westcot (1985) [10] reported that the combination of drought and salinity reduced the water availability for crops at a more significant rate than the separate effect of either salinity or drought alone.

Wheat (Triticum aestivum) is one of the most important cereal crops of the world to nourish the mankind. It is grown in wide range of climatic zone and mostly in irrigated conditions. In the arid and semi-arid areas, saline ground water is a common feature. Irrigation with saline water throughout the growth period of crops resulted in detrimental effect on growth and yield potential of the crops. Therefore, it will be of vital interest for scientist to try to overcome the salinity menace to predict the wheat crop growth development and yield potential with varying salinity of irrigation water on the basis of long term experimentation (Chauhan and Singh, 1993) [13].

Wheat is widely grown all over the world and stands first among the cereals both in area and production. It has been described as the “King of Cereals” because of the acreage it occupies, high productivity and prominent position it holds in the international food grain trade. Wheat is a crop of global significance grown in diversified environments. It is an important cereal crop of cool climate and plays an important role in food and nutritional security of the world. It provides food for 40 % of the global population and contributes 20 % of the food calories (Bhutto *et al*., 2016) [12]. Wheat is cultivated worldwide and is grown on an area of about 224.98 million hectares and production of about 735.5 million tonnes with productivity of 3.27 tonnes per hectare (Anon., 2017) [7].

India is the second largest producer of wheat in the world with 31.47 million hectare which produces 86.50 million tonnes of wheat with a productivity of 2.75 tonnes per hectare (Anon., 2017) [7]. In Gujarat, wheat is grown in about 12.74 lakh ha with total production of 40.19 lakh metric tonnes and a productivity of 3155 kg/ha. Globally, demand for wheat by the year 2020 is forecast at around 950 million tonnes per year. This target will be achieved only, if global wheat production is increased by 2.5% per *annum* (Anon., 2016) [6].

According to soil salinity, wheat is classified to be salt tolerant (Katerji *et al.*, 2000). Khosla and Gupta (1997) [24] found that wheat height and yield increased with irrigation amount under drained conditions, but they were decreased under poor drained conditions. (Datta *et al.*, 1998) [15] reported that yields decreases with the rise in irrigation quantity under saline conditions. Saline water has been used successfully for agricultural irrigation (Abd El-Hady and Ebtisam El-dardiry, 2005; Ould Ahmed *et al.*, 2007) [1, 29]. Crop yield is the most important consideration in the utilization of saline water (Malash *et al.,* 2005) [26].

Materials and Methods

A pot experiment was done at Net House, Department of Agricultural Chemistry and Soil Science, Junagadh Agricultural University, Junagadh. The soil of the experimental plot was clay loam in texture and slightly alkaline in reaction ($pH_{2.5}$ 8.08) without having any problem of salinity ($EC_{2.5}$ 0.48 dS m^{-1}). From the fertility point of view, the soil was moderately supplied with organic carbon (6.5 g kg^{-1}), available nitrogen (297 kg ha^{-1}) and phosphorus (39.20 kg ha^{-1}) but was high in available potassium (425 kg ha^{-1}). Among the DTPA extractable micronutrients, iron (5.91 mg kg^{-1}), zinc (0.75 mg kg^{-1}) and manganese (8.72 mg kg^{-1}) status of the experimental soil found medium but was high with respect to copper (0.62 mg kg^{-1}) during *rabi*-2017 and the soil was stabilized by growing wheat crop. Of the 16 water quality treatment combinations imposed in CRD (Factorial) keeping 3 replications, 4 levels of salinity EC 2, 4, 6 and 8 dS m^{-1} are taken as 1 factor. These waters were synthesized by dissolving required quantities of NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$ in deionized water and the Cl : SO_4 and Mg : Ca ratios in above waters were kept as 1:1 and 2:1, respectively. Wheat variety GJW-463 was sown and all recommended package of practices was adopted for raising wheat. All the growth, yield attributing characters, yield, quality parameters concentration and uptake was noted down during and after harvest of the crop.

The uptake of N, P and K by grain and straw of wheat was computed by using the following formulae.

$$\text{Macronutrient uptake (mg/plant)} = \text{Nutrient concentration (\%)} \times \text{grain or straw yield (g plant}^{-1}) \times 10$$

The uptake of Fe, Mn, Zn and Cu by grain and straw of wheat was calculated with the help of following formulae.

$$\text{Micronutrient uptake (mg/plant)} = \frac{\text{Nutrient conc. (ppm) x grain or straw yield (mg plant}^{-1})}{1000}$$

Result and Discussion

Effect of levels of saline irrigation water on growth and yield attributing characters

The data concerned with growth, yield attributing characters like days to heading, plant height (cm), number of tillers per plant, number of grains per spike, number of grains per spikelet, number of spikelets per spike, length of main spike (cm) were significantly affected by different levels of saline irrigation water and it was found highest with C_1 (2.0 ds m^{-1}) and found lowest with C_4 (8.0 ds m^{-1}). Similar resutls are also obtained by Hendawy *et al.* (2005) [20] in wheat, work reported at Deptt. of Agril Chemistry and Soil Science, JAU, Junagadh (Anon., 2014, 2017a and 2018) [5, 8, 9] in wheat crop and it was found non significant with germination percentage and days to maturity and it was presented in Table: 1

Table 1: Effect of levels of saline irrigation water on yield attributing characters of wheat

Treatment	Yield attributing characters								
	Germination percentage	Days to heading	Plant height (cm)	No. of tillers per plant	Length of main spike \ (cm)	No. of grains per spike	No. grains per spikelet	No. of spikelets per spike	Days to maturity
Salinity levels (C)									
C_1: 2.0 dS m^{-1}	100.0	62.3	53.85	2.12	9.85	47.12	2.85	16.88	107.0
C_2: 4.0 dS m^{-1}	100.0	59.7	53.51	2.02	9.45	41.42	2.73	15.72	107.0
C_3: 6.0 dS m^{-1}	100.0	57.5	52.76	1.92	9.26	40.26	2.65	14.87	104.0
C_4: 8.0 dS m^{-1}	81.8	56.1	50.04	1.63	8.65	35.66	2.57	13.58	100.0
S.Em.±	5.6	0.18	0.43	0.05	0.08	0.40	0.04	0.16	0.00
C.D. (P=0.05)	NS	0.51	1.24	0.13	0.23	1.16	0.10	0.47	NS

Effect of levels of saline irrigation water on growth and yield parameters

Yield parameters like grain and straw yield (g $plant^{-1}$) were found significant with different levels of saline irrigation water it was found highest with C_1 (2.0 ds m^{-1}) and found lowest with C_4 (8.0 ds m^{-1}) and similar results were found Chauhan and Singh (1993) [13], Datta *et al.* (1998) [15] and Kumar *et al.* (2016) [25] in case of wheat crop, Chowdary (2014) [14] in sorghum crop and work done at Deptt. of Agril Chemistry and Soil Science, JAU, Junagadh (Anon., 2010 and 2014) [4, 5] on groundnut crop and concluded that the application of saline water resulted in decreased dry matter production when compared to good quality water and it was presented in Table: 2

Table 2: Effect of levels of Saline water on grain and straw yield, weight of 1000 grain and protein content of wheat

Treatments	Grain yield (g $plant^{-1}$)	Straw yield (g $plant^{-1}$)	Wt. of 1000 grain (g)	Protein content (%)
Salinity levels (C)				
C_1: 2.0 dS m^{-1}	3.02	8.02	49.69	24.93
C_2: 4.0 dS m^{-1}	2.63	7.71	47.22	23.10
C_3:6.0 dS m^{-1}	2.41	7.41	44.95	21.93
C_4: 8.0 dS m^{-1}	2.26	7.18	42.50	20.83
S.Em.±	0.04	0.03	0.40	0.05
C.D. (P=0.05)	0.11	0.09	1.15	0.14

Effect of levels of saline irrigation water on quality parameters

Quality parameters like weight of 1000 grain (g) was found significant with different levels of saline irrigation water and it was found highest with C_1 (2.0 ds m^{-1}) and found lowest with C_4 (8.0 ds m^{-1}). Similar results were also observed by Chauhan and Singh (1993) [13], Datta *et al.* (1998) [15] and Kumar *et al.* (2016) [25] in wheat and Chowdary (2014) [14] in sorghum and earlier work done at Deptt. of Agril Chemistry and Soil Science, JAU, Junagadh (Anon., 2010 and 2014) [4, 5] on groundnut crop.

Protein content (%) was found significant with different levels of saline irrigation water these findings are similar with Garga and Gupta (1997) [17] in clusterbean, Katerji *et al.* (2003) [23] in different crops and reported that the protein content declined with increasing NaCl levels associated with a concomitant decrease in free amino acid in seed and it was presented in Table:2

Effect of levels of saline irrigation water on concentration and uptake of macro and micro nutrients

Concentration and uptake of macro nutrients

The concentration and uptake of N, P and K by grain and straw of wheat crop found significant with different levels of saline irrigation water and it was found highest with C_1 (EC-2.0 dS m^{-1}) and lowest with C_4 (EC-8.0 dS m^{-1}) after harvest of wheat crop. Similar findings were reported by De Pascale *et al.* (2003) [16] on some vegetable crops, Ragab *et al.* (2008) [30] on wheat, Joshi *et al.* (2010) [21] on chrysanthemum, work done at Deptt. of Agril Chemistry and Soil Science, JAU, Junagadh (Anon., 2010 and 2014) [4, 5] on groundnut and wheat and reported that in salinized plants N, P and K concentration decreased because of higher salt concentration which competes with the other nutrient concentrations and decrease their availability and also increasing salinity reduced the content of free amino acids in wheat. (Table-3)

Table 3: Effect of levels of saline irrigation water on concentration (%) and uptake (mg $plant^{-1}$) of macronutrients by grain and straw of wheat

Treatment	Grain						Straw					
	N		P		K		N		P		K	
	Concentration	uptake	Concentration	uptake	Concentration	uptake	Concentration	uptake	Concentration	uptake	Concentration	Uptake
Salinity levels (C)												
C_1: 2.0 dS m^{-1}	3.99	120.4	0.336	10.07	0.45	13.6	0.417	33.5	0.0695	5.58	0.76	60.9
C_2: 4.0 dS m^{-1}	3.70	97.4	0.321	8.48	0.40	10.5	0.360	27.8	0.0617	4.76	0.70	53.8
C_3:6.0 dS m^{-1}	3.51	84.7	0.269	7.47	0.35	8.5	0.310	22.9	0.0531	3.93	0.63	46.5
C_4: 8.0 dS m^{-1}	3.33	75.5	0.239	6.59	0.29	6.6	0.260	18.7	0.0460	3.31	0.57	40.9
S.Em.±	0.01	1.4	0.001	0.12	0.00	0.2	0.001	0.2	0.0002	0.02	0.00	0.3
C.D. (P=0.05)	0.02	4.0	0.004	0.33	0.01	0.5	0.003	0.4	0.0005	0.07	0.01	0.8

Concentration and uptake of micro nutrients

The concentration and uptake of Fe, Zn, Mn and Cu by grain and straw of wheat crop affected significantly by different levels of saline irrigation water and highest content and uptake by grain and straw was found with C_1 (EC-2.0 dS m^{-1}) and lowest with C_4 (EC-8.0 dS m^{-1}) after harvest of wheat crop. Similar results was found by Vaghasiya (2002) [33] on brinjal, Akhtar *et al.* (2003) [2] in maize, Ragab *et al.* (2008) [30] in wheat crop, Joshi *et al.* (2010) [21] on chrysanthemum, work done at Deptt. of Agril Chemistry and Soil Science, JAU, Junagadh (Anon., 2010 and Anon., 2014) [4, 5] in groundnut and wheat and found that increase in levels of salinity in irrigation water resulted in decreasing the micro nutrient content and it was found in Table-4.

Table 4: Effect of levels of saline irrigation water on concentration (ppm) and uptake (mg plant^{-1}) of micronutrients by grain and straw of wheat

Treatment	Grain				Straw			
	Fe		Zn		Fe		Zn	
	Concentration	Uptake	Concentration	Uptake	Concentration	Uptake	Concentration	Uptake
Salinity levels (C)								
C_1: 2.0 dS m^{-1}	174.02	0.53	78.62	0.237	319.08	2.56	92.03	0.738
C_2: 4.0 dS m^{-1}	170.47	0.45	73.51	0.194	314.58	2.43	87.40	0.674
C_3: 6.0 dS m^{-1}	165.28	0.40	68.60	0.166	310.52	2.30	82.40	0.610
C_4: 8.0 dS m^{-1}	160.86	0.36	63.78	0.144	304.98	2.19	77.65	0.558
S.Em.$\pm$	0.13	0.01	0.04	0.003	0.19	0.01	0.03	0.003
C.D. (P=0.05)	0.36	0.02	0.11	0.008	0.54	0.03	0.08	0.008

Conclusion

The results of present experiment may over all be concluded that the different levels of saline irrigation water may produce significant effect on growth, yield, quality and concentration and uptake of macro and micro nutrient content of the wheat crop. The highest growth, yield, quality and concentration and uptake of nutrients of wheat crop was obtained with salinity level of 2 dS m^{-1} and the lowest was obtained with 8 dS m^{-1}. It clearly indicates that the increase in salinity in irrigation water decrease's crop yields due to high increase in the osmotic potential at the soil surface which may decrease the water and nutrient uptake at the soil-water interface.

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