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Original Research Article

Effect of Different Levels of Sodic (SAR) Irrigation Water on Organic Carbon Content, Concentration and Uptake of Macro and Micro Nutrient Status of Available Nutrients after Harvest of Wheat Crop

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A B S T R A C T

Consequent to population growth and high living standards in several arid and semi-arid regions, competition for freshwater among different water-use sectors is expected to increase vis-a -vis its decreased allocation to irrigation. Non-conventional water resources, such as saline and/or sodic drainage and ground water represent complementary supply to narrow the gap between freshwater availability and demand. A pot experiment was conducted at Net House, Department of Agricultural Chemistry and Soil Science, College of Agriculture, Junagadh Agricultural University, Junagadh to assess the effect of different levels of sodic irrigation water on concentration and uptake of macro (N, P and K) and micro (Fe, Zn, Cu and Mn) nutrients and nutrient status of macro (N, P and K) and micro (Fe, Zn, Cu and Mn) nutrients after harvest of the wheat crop during the *rabi*- 2017. The experiment comprising of four levels of sodic irrigation water *viz*., 5.0, 10.0, 15.0 and 20.0 SAR (one factor) in completely randomized design (Factorial) replicated three times. Application of different levels of sodic irrigation water produced significant effect on concentration and uptake of macro and micro nutrients and available nutrients after harvest of the wheat crop. 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 SAR- 5.0. The available macro (N, P and K) and micro (Fe, Zn, Cu and Mn) nutrients and organic carbon of soil after harvest of the crop was found maximum with the sodic irrigation water level of SAR-5.0 and found lowest with SAR-20.0.

Keywords

Sodicity levels, concentration, uptake, macro and micro nutrients, Sodium Adsorption Ratio

Introduction

About one-third of the food and fiber in the world is harvested from irrigated area, which occupy only about one-sixth of the crop land (Hillel, 2000). The rate of growing global population warrants increases in the area under irrigated agriculture to fulfill the future food and fiber needs, which will need additional amounts of water. Contrasting to this, the annual renewable freshwater resources for the foreseeable future are now largely allocated. There may be some areas where freshwater resources increase or decrease according to rainfall changes due to climate change, however, these are likely to occur at the level that is small compared to the increased future demands for freshwater (Wallace, 2000).

In some parts of Rajasthan, Gujarat, Punjab, Haryana, Uttar Pradesh, Andhra Pradesh and Karnataka, the underground water available for irrigation has high sodicity (EC-variable, SAR>10 and RSC>4 me L^{-1}). The sodic water containing residual sodium carbonate (RSC) more than 2.5 me L^{-1} has been considered unsatisfactory for the irrigation (Wilcox *et al*. 1954).

With the growing shortage of fresh water supplies, relatively poorer quality water will have to be increasingly utilized for irrigation purposes. Amongst the various categories of poor quality waters, sodic water have greater irrigation potential by virtue of their low salinity and amendability to reclam especially in semi-arid regions of North-West India where their occurance in ground waters is around 30-54 % (Minhas and Bajwa, 2001).

Materials and methods

For knowing the effect of different levels of sodic irrigation water on concentration and uptake of macro and micro nutrients, organic carbon content and nutrient status of soil after harvest of the wheat crop 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.

Wheat variety GJW-463 was sown and all recommended package of practices was adopted for raising wheat.

Experiments designs was randomized complete block under one factor (water sodicity (SAR)) of the 16 water quality treatment combinations keeping 3 replications, sixteen treatments consisted of combinations of 4 levels of salinity (EC 2, 4, 6 and 8 dS m^{-1}) and 4 levels of sodicity (SAR 5, 10, 15 and 20). 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.

After harvest of the wheat crop up to the base with sickles remaining the root mass in the soil, soil samples are drawn from the pot by mixing the entire the soil thoroughly and analyzed for organic carbon, available macro and micro nutrients of the soil.

Plant analysis

Chemical analysis of grain and straw were carried out by taking representative sample, from each pot at harvest of crop. The samples were oven dried at 60 ^{0}C for 24 hours and then powdered by using graínder and mixer. Finally, the powdered samples of grain and straw were utilized for estimation of nitrogen separately by micro Kjeldahl's method as described by Jackson (1973). While the phosphorus was determined by vanadomolybdo phosphoric yellow colour method as described by Koeing and Jahnson (1942), potassium by Flame Photometer as described by Toth and Prince (1942) and micronutrients *viz.*, Fe, Zn, Mn and Cu were estimated by Atomic Absorption Spectrophotometer (AAS) from triacid extract as described by Lindsay and Norvell (1978). (Table-1)

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

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

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

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

Soil analysis for available nutrients

The soil samples were collected from each pot of experiment after harvest of crop. All the soil samples were air dried, oven dried and powdered with a wooden mortar and pestle and passed through a 2 mm sieve.

Available N, P_2O_5, K_2O, Fe, Zn, Mn, Cu and OC at initial and at harvest (Table 2) of the crop were determined using standard procedure.

Results and Discussion

Effect of different levels of sodic irrigation water on concentration and uptake of macro nutrients

The content and uptake of N, P and K by grain and straw of wheat crop found significant with different levels of sodic irrigation water and it was found highest with S_1 (SAR-5.0) and lowest with S_4 (SAR-20.0) after harvest of wheat crop. Similar results were also obtained by Singh *et al.* (1994), Singh and Totawat (1994) and Lal *et al.* (1996) in wheat and Prasad *et al.* (2010) in lemongrass and concluded that when sodic water was applied, the mineral composition was changed with an accumulation of Na in plant tissue which decreased the macro and micro nutrient concentration in grain and straw at harvest of crop and it was found in Table-3.

Effect of different levels of sodic irrigation water on concentration and uptake of micro nutrients

The content and uptake of Fe, Zn, Mn and Cu by grain and straw of wheat crop affected significantly by different levels of sodic irrigation water and highest content and uptake by grain and straw was found with S_1 (SAR-5.0) and lowest with S_4 (SAR-20.0) after harvest of wheat crop. These findings are similar with Prasad *et al.* (2010) in lemon grass who found as the concentration of Na increases in plant tissue which reduced the micro nutrient cocentration in plant tissue with increasing sodicity level and it was found in Table-4

Effect of different levels of sodic irrigation water on organic carbon content of the soil

Different levels of sodic irrigation water affected significantly on organic carbon content of the soil after harvest of wheat. The highest OC (7.0 g kg^{-1}) was obtained with S_1(SAR-5.0) and the lowest OC (6.6 g kg^{-1}) was with S_4 (SAR-20.0) levels of sodic irrigation water. Each level of sodic irrigation water decreased the OC content of the soil significantly. (Table-5)

Effect of different levels of sodic irrigation water on macronutrients (Available N, P_2O_5 and K_2O)

Application of different levels of sodic irrigation water exert significant effect on available N, P_2O_5 and K_2O content of soil after harvest of the crop. With the S_1(SAR-5.0) sodicity level, the highest available N, P_2O_5 and K_2O content were 427, 34 and 446 kg ha^{-1} and the lowest were 371, 31 and 432 kg ha^{-1}, respectively with S_4 (SAR-20.0) sodicity level. Similar results were found by Murtaza *et al*. (2006) in wheat-cotton rotation and concluded that water and soil sodicity with high SAR values having the potential for deterioration in soil structure, low infiltration rate, specific ion effect, and deficiencies of several nutrients such as N, P, K, Cu, Fe, Mn and Zn. (Table-3)

Effect of different levels of sodic irrigation water on available micro nutrients (Fe, Mn, Zn and Cu)

The data presented in Table-5 indicated that the soil available micro nutrient content after harvest of the crop was significant with different levels of sodicity in irrigation water. The highest available Fe, Zn, Mn and Cu content were 5.731, 0.690 8.387 and 0.588 ppm observed with S_1 (SAR-5.0) and the lowest of 5.576, 0.636, 8.610 and 0.523 ppm, respectively were noticed with S_4 (SAR-20.0) sodic irrigation water level. This might be due to high SAR values having the potential for deterioration in soil structure, low infiltration rate, specific ion effect which leads to the deficiencies of several nutrients such as Cu, Fe, Mn and Zn. Similar results were found by Murtaza *et al*. (2006) in wheat-cotton rotation.

Table.1 Plant analysis for macro (%) and micronutrients (ppm) from grain and straw

Plant analysis	**Method**	**Reference**
Nitrogen	Kjeldahl digestion	Jackson (1973)
Phosphorus	Vanado-molybdo phosphoric yellow colour method (triacid digestion with HNO_3: H_2SO_4: $HClO_4$ in 9:2:1)	Koeing and Johnson (1942)
Potassium	Flame photometry (triacid extract)	Toth and Prince (1946)
Micronutrients (Zn, Fe, Cu and Mn)	Triple acid extract-AAS	Lindsay and Norwell (1978)

Table.2 Available nutrients in the soil at initial and after harvest of the crop

Soil analysis	**Method**	**Reference**
Organic carbon (g kg^{-1})	Walkley and Black (1934) method	Jackson (1973)
Available N (Kg ha^{-1})	Alkaline $KMnO_4$ method	Subbiah and Asija (1956)
Available P_2O_5 (Kg ha^{-1})	0.5 M $NaHCO_3$ (pH 8.5)	Olsen *et al.* (1954)
Available K_2O (Kg ha^{-1})	1 N NH_4OAC method	Jackson (1973)
Available micronutrients (Fe, Mn, Zn, Cu) (ppm)	DTPA extract method	Lindsay and Norvell (1978)

Table.3 Effect of levels of sodic 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
Sodicity levels (S)												
S_1: 5.0 SAR	3.70	100.5	0.308	8.63	0.39	10.8	0.367	27.7	0.0606	4.70	0.69	53.2
S_2: 10 SAR	3.67	97.2	0.297	8.34	0.38	10.1	0.343	26.3	0.0585	4.49	0.67	51.5
S_3: 15 SAR	3.61	93.4	0.285	8.06	0.37	9.6	0.330	25.1	0.0566	4.31	0.65	49.7
S_4: 20 SAR	3.54	87.0	0.274	7.57	0.35	8.8	0.316	23.7	0.0546	4.08	0.64	47.9
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**

Table.4 Effect of levels of sodic 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**
Sodicity levels (S)								
S_1: 5.0 SAR	169.17	0.46	72.76	0.198	313.89	2.42	86.53	0.668
S_2: 10.0 SAR	168.24	0.44	71.86	0.190	312.90	2.39	85.63	0.655
S_3: 15.0 SAR	167.08	0.43	70.63	0.183	311.80	2.36	84.35	0.639
S_4: 20.0 SAR	166.14	0.41	69.26	0.170	310.56	2.31	82.98	0.618
S.Em.±	**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**

Table.5 Effect of levels of sodic irrigation water on organic carbon (g kg^{-1}), available macro (kg ha^{-1}) and micro nutrients (ppm) of soil

Treatment	Organic carbon	Available macro nutrients			Available micro nutrients			
		N	P_2O_5	K_2O	Fe	Zn	Mn	Cu
Sodicity levels (S)								
S_1: 5.0 SAR	7.0	427	33.6	446	5.731	0.690	8.387	0.588
S_2: 10 SAR	6.9	404	33.1	442	5.664	0.677	8.300	0.563
S_3: 15 SAR	6.7	386	32.5	436	5.607	0.650	8.234	0.543
S_4: 20 SAR	6.6	372	31.5	432	5.576	0.636	8.160	0.523
S.Em.±	**0.02**	**1.65**	**0.08**	**0.35**	**0.016**	**0.002**	**0.029**	**0.004**
C.D. (P=0.05)	**0.05**	**4.75**	**0.23**	**1.00**	**0.047**	**0.007**	**0.082**	**0.012**

The increasing the sodicity (SAR) in irrigation water decreased the concentration and uptake of macro and micro nutrients, decreased the concentration of organic carbon and available macro and micro nutrients due to increased sodium (Na) concentration on soil surface, which may cause detioration of soil structure, reduced infiltration rate, specific ion effect and deficiencies of many nutrients due to dispersion of soil clay particles.

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