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EVALUATION OF GROWTH AND YIELD OF WHEAT AS AFFECTED BY WATER SALINITY IN COMBINATION WITH SOME SOIL PROPERTIES

Abo-Baker, A. A.
Soil and Water Dept., Faculty of Agric., Qena South Valley University

ABSTRACT

Two field experiments were conducted during the successive two seasons of 2006/2007 and 2007/2008 to evaluate the effect of irrigation with saline water in combination with soils different in their soil properties (sandy clay loam and loamy sand) on chemical properties of soil and growth and yield of wheat plant. Results concluded that, soil electrical conductivity and concentration of most cations and anions were increased as a result of irrigation with saline water. The increase of soil EC was more pronounced in sandy clay loam soil than in the loamy sand soil in spite of that the two soils were irrigated with the same source of water. Also, results revealed that irrigation water salinity affected all wheat growth and yield parameters.

INTRODUCTION

Water is one of the limiting factors for agricultural development in developing countries in order to face the growing demand of the increasing population. Irrigation water resources varies widely in both quality and quantity. The availability of irrigation water depending on the characteristics of both water and soil. The soil EC values were increased with increasing salinity of irrigation water in calcareous soil of Maryut, Egypt, El-Boraie, 1997). Increasing of irrigation water salinity from 0.58 to 3.67 dS m^{-1} increased total soil salinity from 1.87 to 24.83 dS m^{-1}. Dosoky, 1999). Soil salinity and alkalinity parameters relatively increased by 195.54 and 360.49 % of EC , 174.73 and 280.11 % of SAR as a result of irrigation with fresh water mixed with drainage water and drainage water, respectively as compared to those of soils irrigated with fresh water, (Zein El- Abedine *et al.*, 2004). Soluble Ca^{+2}, Mg^{+2} and Na^{+} were increased with increasing salinity level of irrigation water, while soluble K^{+} was decreased with increasing salinity levels. But soluble Ca^{+2} and Na^{+} were increased with decreasing irrigation frequency, while increasing water salinity levels and irrigation frequency decreased the hazardous effects, El-Boraie, 1997).

The new cultivated desert area in Qena depends mainly on the ground water for irrigation. Most of these groundwater wells are saline water. The need for sustainable grain production in an environment of high spatially variable soil properties prompted the author conduct this study to observe the effect of the field spatial variability in soil properties, mainly salinity, on crop growth parameters, and yield of wheat. The aim of this work is to study the effect of irrigation with saline water and two soil texture on wheat growth and yield. This study were conducted using underground water having a electrical conductivity of 6.41 dS/ m^{-1} for irrigation in Qena governorate, Upper of Egypt.

MATERIALS AND METHODS

This field study were conducted at Agricultural Research Center, Faculty of Agriculture, Qena, South Valley University, Egypt, which located at latitude 26°11' 25 N", and longitude 32° 44' 42" E, in hyperd hot dry zoon around the tropic of cancer . Wheat was grown during the two winter season of 2006/2007 and 2007/2008 to evaluate the effect of irrigation with saline groundwater on the chemical properties of soil and growth and yield of wheat cultivar Geza 168. The layout of experimental treatments in the two sites was a complete randomize design with 5 replications. Field was prepared as recommended and normal cultural practices of growing wheat. The plot area was 5.25 m^2 (3 m in length X 1.75 m in width) A basal dose of 200 kg/fed super phosphate (15.5% P_2O_5) was applied at planting time. Nitrogen fertilization at rate of 200 Kg /fed, as lime ammonium nitrate (33.0 % N), was added one month later, and 50 Kg/fed. of potassium sulphate (48% K_2O) was added after 50 days from planting.

Soil samples were collected as composited sample from 8 random points from each site taken from the top surface soil to a depth of 30 cm before the initiation of the experiment and one sample from each plot after harvesting for the two seasons. The samples were air dried, sieved and analyzed for physical and chemical properties.

Soil texture was determined using the pipette method (Piper, 1950). Total carbonates were determined using the calcimeter method (Nelson, 1982). Soil pH was measured by using a pH-meter in 1:1 soil-water suspension. Total soluble salts in the soil paste extract was measured by the electrical conductivity and soluble cations and anions, were performed according to the methods as described by Jackson, (1973).

The soil characteristics were analyzed and the results are presented in Table (1).

The two sites was irrigated with high saline groundwater well. The chemical characteristics of groundwater used in this study are shown in table (2).

After 70 days from planting, ten wheat plants samples were taken from each plot for determination of some growth and yield parameters such as: plant height, plant fresh and dry weight, fresh and dry roots weight, number of tillers and spikes/plant . At harvest, number of spike/ plant, weight of 1000 grain and total grain and straw yields were determined on whole.

All data obtained were subjected to proper statistical analysis of variance according to the procedure outlined by Gomez and Gomez (1984). The differences between means were compared using the least significant difference (L.S.D.) at 5 % and 1 % probability.

Table (1): Some physical and chemical characteristics of the studied soil before planting.

Characteristics/ sites	Site 1	Site 2
	Physical properties	
Sand %	64.91	82.7
Silt %	13.4	11.3
Clay %	21.6	6
Soil texture	Sandy clay loam	Loamy sand
	Chemical properties	
SP %	32.0	27.0
pH	8.05	8.27
EC_e(dSm^{-1})	4.68	2.71
CaCO %	8.9	8.54
SAR	4.1	4.62
Ca^{++}, meq /L	17.5	5.4
Mg^{++}, meq /L	15.0	8.54
K^{+}, meq /L	0.47	0.94
Na^{+}, meq /L	16.5	12.2
$CO3^{-2}$ + $HCO3^{-}$, meq /L	17.5	5.5
$SO4^{=}$, meq /L	9.8	5.54
Cl^{-}, meq /L	19.4	15.54

SP%: saturation percent.

Table (2): Groundwater characteristics, used for irrigation.

characteristics	value
EC_w ($dS\ m^{-1}$)	6.55
SAR	14.702
Ca^{++}, meq /L	10.07
Mg^{++}, meq /L	10.50
Na^{+}, meq /L	47.15
K^{+}, meq /L	0.9
$CO3^{-2}$ + $HCO3^{-}$, meq /L	31.0
$SO4^{=}$, meq /L	15.5
Cl^{-}, meq /L	20.6

RESULTS AND DISCUSSION

Effect of Irrigation Water Salinity on some Chemical Properties of Soil:

Data in Table (3) showed that irrigation with saline groundwater increased the total soluble salt in the soils under investigation. Total soluble salts were increased gradually from season 2006/2007 to season 2007/2008. The increase of soil EC_e was more pronounced in sandy clay loam soil (site 1) in spite of that the two sites were irrigated with the same source of water. This may be due to the higher fine particles content at this site since it's soil contains more clay, which adsorb and keep more water, soluble and exchangeable cations. Also the sandy clay loam soil (site 1) have a water saturation and field capacity higher than sandy loam soil (site2), this cause more accumulation of salt from saline water. This finding is in agreement with those obtained by Abd El-Nour (1989), who found that the significant increases in soil EC was proportional to the salts concentrations in the irrigation water.

The salinity of sandy clay loam soil (site 1) was increased from 4.68 before cultivation to 6.23 and 9.11 dSm^{-1} by the end of 1 st and 2 nd seasons respectively. While the salinity of the loamy sand soil was increased from 2.71 before cultivation to 3.24 and 5.10 dSm^{-1} by the end of 1 st and 2 nd season respectively.

Table (3): Some physical and chemical characteristics of the studied soil at the time of harvesting.

Characteristics / sites	Site 1		Site 2	
Physical properties				
Sand %	**64.91**		**82.7**	
Silt %	**13.4**		**11.3**	
Clay %	**21.6**		**6**	
Soil texture	**Sandy clay loam**		**Loamy sand**	
Chemical properties				
	2006/2007	**2007/2008**	**2006/2007**	**2007/2008**
SP%	32.5	33.6	27	28
pH	8.01	7.71	8.3	7.7
ECe (dSm^{-1})	6.23	9.11	3.24	5.10
Total carbonate %	15.8	13.75	11	8.5
SAR ,	4.26	6.55	5.23	6.24 %
Soluble cations and anions meq/L				
Ca^{++} ,	21.6	27.0	7	15.2
Mg^{++} ,	26.6	32.0	11	13.2
K^{+} ,	0.626	0.96	0.48	0.6
Na^{+} ,	20.9	35.6	15.7	23.5
$CO3^{-2}$ + $HCO3^{-}$,	24.63	35.22	6.0	15.4
$SO4^{=}$,	13.1	17.44	6.22	14.8
Cl^{-} ,	27.27	43	20.0	29.0

It is clear that the 1st soil was already saline soil (> 4 dSm^{-1} for ECe) and its salinity was almost doubled after 2 years. However, the 2 nd site was not saline (Ece < 4 dSm^{-1}) before irrigation and turned to double its salinity and to be saline . That mean after two more years the salinity will double again. According to the procedure and equations of Ayers and Westcot, 1985; for estimate the leaching fraction (LF), and the equation of predicting soil salinity expected (ECe) using concentration factors (X) and leaching fraction (LF) the expected (ECe) calculated as follow:

a) Determining of the leaching fraction (LF):

Under climate conditions of upper Egypt, the water requirement of wheat crop needed to meet both the crop ET and the LF is 2789 m^3 (664.05 mm of water) and the evapo-transpiration (Et) is 1674 m^3 (398.57 mm of water);

$$LF = \frac{\text{Depth of water leached below the root zone}}{\text{Depth of water applied at the surface}}$$

$$LF = \frac{664.05 - 398.57}{664.05} = 0.3998$$

b) Determining of expecting soil salinity:

The equation for predicting the soil salinity expected after several years of irrigation with water of salinity ECw is:

ECe (dS/m) = ECw (dS/m). X

Were X is the concentration factors for predicting soil salinity (ECe) from irrigation water salinity (ECw) and the leaching factor (equal 0.9) for calculated LF = 0.3998.

ECe (dS/m) = ECw (dS/m). X
= 6.55 × 0.9 = 5.9 dS/m.

Determination of average root zone salinity for estimation the expecting soil salinity:

According to the procedure explained by **Ayers and Westcor, 1985,** to estimate the average root zone salinity using crop water use pattern 40,30,20,10 % of water absorbed by depth.

LF = Water leached /Water applied
LF_0 = [664.05 – 0.00 (398.57)] / 664.05 = 1
LF_1 = [664.05 – 0.40 (398.57)] / 664.05 = 0.67
LF_2 = [664.05 – 0.40 (398.57) - 0.30 (398.57)] / 664.05 = 0.58
LF_3 =[664.05 – 0.40 (398.57) - 0.30 (398.57)- 0.20 (398.57) / 664.05] = 0.46
LF_4=[664.05–0.40(398.57)-0.30(398.57)-0.20(398.57)-0.10(398.57)]/664.05= 0.40

according to the equation :

$$ECsw = \frac{ECw}{LF}$$ were ECws = soil water draining salinity.

ECws = [ECw_0 + ECw_1 + ECw_2 + ECw_3 + ECw_4] / 5
ECws = [1 + 8.62 + 11.293 + 14.249 + 16.383] / 5 = 11.42
according the equation
ECsw = 2 ECe
ECe = 5.71

This result confirm that the expecting soil salinity calculated with the previous equation. The calculation shows that soil salinity expected under investigation conditions in case of using saline groundwater (6.55 dS/m) was about 5.9 dS/m were agree with the actual ECe of loamy sand soil (site 2) which reached to 5.1 after two years; while deviation was observed at the end of 2 nd season in the sandy clay loam soil (site 2) which reached to 9.11 dS/m. This my be due to the higher clay content in site2.

Also, the concentration of soluble calcium and magnesium in the soil were increased as a result of irrigation with saline water. The rate of increasing of calcium in sandy clay loam soil (site 1) reached to 23.43 % and 54.29 % by the end of 1 st and 2 nd seasons respectively, while the increasing in loamy sand soil was 29.63 % and 181.48 % by the by the end of 1 st and 2 nd seasons respectively.

With regard to the concentration of soluble magnesium, the rate of increasing in sandy clay loam soil (site 1) was 77.33 % and 113.33 % by the end of 1 st and 2 nd seasons respectively, while the increasing in loamy sand soil (site 2) was 28.81 % and 54.57 % by the end of 1 st and 2 nd seasons respectively.

Also, soluble sodium content in the studied soils was increased as a result of irrigation with saline water (Table 3). In sandy clay loam soil, the rate of increase in the soluble sodium content was rather higher than that of the loamy sand one. This could be attributed to the higher adsorption capacity of sodium on the clay. The rate of increased soluble sodium ions in sandy clay loam soil (site 1) was 26.67 % and 115.76 % by the end of 1 st and 2 nd seasons respectively, while the increasing of loamy sand soil (site 2) was 28.69 % and 92.623 % by the end of 1 st and 2 nd seasons respectively.

The chloride ions content in both soils under investigation was increased as a result of irrigation with saline water, the increase was 40.57 and 121.65 in sandy clay loam soil by the end of 1 st and 2 nd seasons, respectively; while the increase was 29.87 and 86.62 % by the end of 1 st and 2 nd seasons respectively.

Also, increases in sulfate content reached to 33.67 % and 77.96 % in sandy clay loam soil by the end of 1 st and 2 nd seasons, respectively; while increase reached to 12.27 and 167.15 in loamy sand soil, by the end of 1 st and 2 nd seasons respectively.

This could be attributed to the fact that saline solution increasing the solubility of more readily soluble sulfate in soil media. Hassanien *et al.* (1993) found that distribution and concentration of most cations and anions were increased with increasing salt concentration in irrigation water.

The irrigation with saline water seems to increase SAR in both soils, the percentage of increases were 59.76 % and 35.07% for sandy clay loam and loamy sand by the end of 1 st and 2 nd seasons, respectively.

Effect of Irrigation with saline groundwater on the growth and yield **Parameters of Wheat:**

Results of wheat growth and yield parameters of season 2006/2007 and 2007/2008 were presented in Tables (4) and (5).

The results of the two growing seasons showed reduction in all growth and yield parameters of wheat plant as a results of increasing salinity which accumulated after irrigation with saline water in 2 nd season.

At first season 2006/2007 (Table 4), comparing the growth parameters of wheat grown in the two soils showed that, no significant differences were found in all growth parameters, except of grain and straw yield. The data showed that the yield of grain and straw of sandy clay loam soil (ECe = 6.23 dS/m) found to be less significantly than grain and straw yield of loamy sand soil by 12.24% and 12.18% for grain and straw yield respectively.

Table (4) : Effect of Irrigation with saline groundwater on the growth and yield Parameters of Wheat: (Season 2006/2007).

Growth parameters		soil type		LSD	
		1-sandy clay loam	2-loamy sand	5%	1%
Plant height (cm)		94.4*	101.00	N.S	N.S
Shoot weight (g/10 plants) after 70 days	fresh	28.70	32.90	N.S	N.S
	dry	10.10	11.50	N.S	N.S
Roots weight (g/10 plants) after 70 days	fresh	2.30	2.46	N.S	N.S
	Dry	1.64	1.41	N.S	N.S
Number of tillers /plant		3.00	3.00	N.S	N.S
Number of spikes / plant		2.50	2.50	N.S	N.S
1000 grain weight (g)		3.90	4.10	N.S	N.S
Grain yield (kg/fed)		1657.0	1888.00	201.00	292.50
Straw yield (kg/fed)		2351.0	2677.00	230.60	335.50

- **Each value is the mean of 5 replicates.**

The obtained data of growth parameters of 2 nd season 2007/2008 as shown in Table (5) revealed that, significant differences was found in most growth and yield parameters, the results showed similar trend as it previously found in the case of the first season. All growth parameters of sandy clay loam significantly lesser than the parameters of loamy sand soil.

Table (5) : Effect of Irrigation with saline groundwater on the growth and yield Parameters of Wheat: (Season 2007/2008).

Growth parameters		soil type		LSD	
		1-sandy clay loam	2-loamy sand	5%	1%
Plant height (cm)		63.00	97.80	16.6	21.16
Shoot weight (g/10 plants) after 70 days	fresh	22.50	29.60	3.934	5.724
	dry	8.10	10.17	1.956	2.846
Roots weight (g/10 plants) after 70 days	fresh	1.92	1.90	N.S	N.s
	Dry	1.167	1.16	N.S	N.s
Number of tillers /plant		2.00	2.50	N.S	N.s
Number of spikes / plant		1.80	2.30	0.3994	0.5812
1000 grain weight (g)		3.80	4.20	0.3631	0.5284
Grain yield (kg/fed)		1392.75	1693.00	231.80	337.20
Straw yield (kg/fed)		2005.70	2481.00	178.60	259.90

- **This value is the mean of 5 replicates.**

The changing in salinity level in both of two soil type by the end of 1 st and 2 nd seasons and the yield loose / unit increase in salinity were calculated as shown in Table (6).

Table (6) : The changing in salinity level, grain yield in the two soils by the end of 1st and 2nd seasons and the yield loose/unit increase in salinity.

soil	EC (dS/m)			Grain yield (kg/fed.)			Yield loose/ ECe unite
	1st season	2nd season	Differences %	1st season	2nd season	Differences %	
Sandy clay loam	6.23	9.11	+ 2.88	1657.0	1392.75	- 15.95	5.54
loamy sand.	3.24	5.10	+ 1.86	1888.0	16963.0	- 10.33	5.555

The equation of Maas and Hoffman (1977) used for calculating the theoretical percent of yield loss (b) per 1 unit increase in soil salinity (ECe) as follow:

$$b = \frac{100}{\text{ECe at 0 \% yield} - \text{ECe at 100 yield}}$$

Ayers and Westcot, 1985; reported that , Barley and Wheat are less tolerant during germination and seedling stage; ECe should not exceed 4 – 5 dS m^{-1} (the threshold soil salinity for 100 percent yield) in the upper soil during this period.

$$b = \frac{100}{20 - 4.5} = 6.45$$

Under sandy clay loam soil, data in Table (6) showed that grain yield reduction from 1st season to 2nd season equal 15.95 % meeting increasing in soil salinity equal 2.88 dS m^{-1}; this meaning that 5.54 % of grain yield loosed per 1 unit increase in soil salinity; while under conditions of loamy sand soil, the loosing of grain and straw yield from 1 st season to 2 nd season equal 10.33 % meeting increasing in soil salinity equal 1.86 dS m^{-1}; this meaning that 5.56 % of grain loosed per 1 unit increase in soil salinity.

These results are similar to those reported by Ayers and Westcot, (1985). They reported that, he percent of yield loss per 1 unit increase in soil salinity (ECe) equal 6.45. The lower values of this investigation may be due to the variation of climate, soil conditions or cultural practices. Also, Kijne, 2003; reported that under field conditions, where plant were subjected to periodic and simultaneous water and salt stress and to non-uniform water application, yield was lowered by salt concentration above that assumed threshold values.

The responses of wheat grain and straw yields were negatively affected with the increase in soil salinity. This was similar to the finding of El-Morsy *et al.*, (1993), they reported that the partial regression showed that most of the yield variations under soil salinity are mainly due to the total soluble salts rather than specific ions effect. Also, Zein *et al* (2003) found that wheat grain and straw yields as well as plant height, spike length, and 1000 grain weight were significantly affected by increasing irrigation water salinity

The excessive salt appears to affect the growth and wheat yield by restricting nutrients uptake to extent that a deficiency take place. This may be due to a possibility that plants grown under saline condition utilize energy for osmotic adjustment process at the expense of growth and the most important factor which is the high soil water potential, hence the water flow from soil to plant is very much limited under saline conditions. (Ragab *et al.*, 2008).

Conclusion

Excessive soil salinity reduces the yields of many crops. This may range from a slight loose to complete crop failure depending on the crop and the severity of the salinity problem. Several management practices can reduce the salt level in the soil. In such conditions of soil and water salinity under this investigation; addition of leaching fraction to the soil is basic step to meet both the crop water consumption and leaching requirement, and to avoid salt accumulation and yield reduction.

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تقييم نمو ومحصول القمح متأثرا بملوحة المياه وبعض خواص التربة

أبوبكر عبد المنعم أبوبكر
قسم الأراضى والمياه – كلية الزراعة – قنا– جامعة جنوب الوادى

تجربتان حقليتان نفذتا خلال الموسمين الشتويين ٢٠٠٧/٢٠٠٦ و ٢٠٠٨/٢٠٠٧ بمزرعة كلية الزراعة – بقنا وذلك لدراسة تأثير ملوحة مياه الرى وبعض خواص التربة على نمو ومحصول القمح صنف جيزة ١٦٨ ؛ حيث تم إستخدام مياه جوفية ذات توصيل كهربائى ٦,٥٥ دس/ م تحت ظروف نوعين من التربة إحداهما ذات قوام طميى طينى رملى والأخرى ذات قوام رملى طميى وتم إستخدام نفس مصدر المياه فى ريهما.

تبين النتائج إرتفاع تركيز الأملاح الكلية وكذلك تركيز معظم الكاتيونات والأنيونات نتيجة الرى بماء عالى الملوحة ، وكان هذا التأثير أكثر وضوحا فى التربة الطمية الطينية الرملية عنه فى التربة الرملية الطمية على الرغم من أن كلا النوعين من التربة تم ريهما بنفس مصدر المياه. كما تبين النتائج أن إرتفاع ملوحة التربة أدى إلى تأثر معظم قياسات النمو وكذلك المحصول تأثيرا سلبيا.