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Response of Wheat to K- Fertilization under Irrigation with Drainage Water

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A FIELD experiment was conducted at El-Serw Research Station (clay soil), Domeitta Governorate (North of Nile Delta) during the growing season 1998-1999 to study the response of wheat (*Triticum aestivum*, c.v.Sakha 8) to K-fertilization at three rates (0, 24 and 48 kg K_2O/fed under irrigation with agricultural drainage water (EC ≈ 1.68 dS/m, SAR=4.6).

Using drainage water for irrigation throughout the growing season significantly decreased wheat grain and straw yields, plant height, number of tillers per plant, spike length and 1000- grain weight. The reductions in grain and straw yields were 13% and 12%, respectively, less than the control treatment (irrigated with Nile water).

Nitrogen, P and K concentrations and total content of grain and straw significantly decreased, while those of Na, Ca and Mg of grain and Na and Mg of straw increased due to irrigation with the drainage water.

Potassium fertilization alleviated the adverse effect of irrigation water salinity on all the studied parameters; the reduction in grain and straw yields were reduced to 9 and 6%, when K was added at 24 kg K_2O/fed and 7% and 4% at 48 kg K_2O/fed, respectively.

El-Serw drainage water can be used in irrigating wheat crop in the presence of K fertilization at 24 kg K_2O/fed without inducing great reduction in yield.

Key words: Drainage water, K-fertilization, Wheat, Salinity, Clay soil.

As water resources suitable for irrigation become less abundant throughout the world, water considered too saline will have to be used to meet agricultural needs.

Kovda (1958) studied the use of agricultural drainage water in Egypt for irrigation purposes. He observed a physiological toxicity of salts when the total soluble salts had reached 5000 to 6000 ppm and the strong depressing effect occurred on plants receiving water contains more than 12000 ppm of soluble salts. Recent studies have shown that saline agricultural drainage water can be used successfully to grow up crops without detrimental long term consequences to either crops or soil (Rhoades, 1989 and Rhoades *et al.*, 1989). According to this management, salt-sensitive and salt-tolerant crops are grown in rotation by irrigating sensitive crops with good quality

It is very important to increase wheat production, the major cereal crop to supply the annual demand of local requirements (El-Sherbieny *et al*., 1999). The possibility of using low quality water for wheat irrigation have been studied by numerous investigators such as Abou El-Soud & Ashour, (1970); Maliwal & Palliwal (1972); Narian *et al.* (1977); Francois *et al.* (1989); El-Leithi *et al.* (1990); Abo - Soliman *et al*. (1992) and El-Haddad *et al*. (1993). They showed, in general, that the increase in irrigation water salinity had inhibition effects on growth, yield and yield components of wheat. However, the salinity of irrigation water at which the wheat plant began to suffer and the magnitude of suffering differed among these studies.

Potassium fertilization maintains high productivity and good quality of different crops (Zohry *et al*., 2002). It is involved in several important metabolic activities associated with photosynthesis, respiration, chlorophyll development and water content of leaves (Roy *et al*., 1981). Grain and straw yields of wheat significantly increased by the addition of K (Abd El-Hadi *et al*., 2002 and Zohry *et al*., 2002). El –Argan *et al.* (2002) indicated that an interaction between potassium fertilizer rates and various irrigation water quality treatments had significant effect on plant height, dry matter production, grain, straw and total yields of barley and sorghum at El-Serw Farm near Manzala lake, Northeastern delta, Egypt.

The present study was performed to evaluate the possibility of using agricultural drainage water for wheat irrigation under different levels of K-fertilization.

Material and Methods

A field experiment was carried out in a heavy clay soil located at El-Serw Agricultural Research Farm, Domeitta Governorate, Egypt during 1998-1999 winter growing season to study the response of wheat to K-fertilization under irrigation with drainage water. Some chemical and physical properties of the studied soil (Table 1) were determined according to Black (1965) and Page *et al.* (1982).

Asplit plot design was followed with four replicates in sub-plot size of $3.5x3m^2$ the main treatments were (W_1) normal Nile water and (W_2) El Serw drain water, while the submain treatments were (K_0) no added potassium, (K_1) and (K_2) 24 and 48 kg K_2O/fed as potassium sulphate (48%K_2O). Potassium fertilizer was applied in two equal doses, *i.e.,* at planting and one month later. Wheat crop (*Triticum aestivum* L.), c.v. Sakha 8 was planted on Nov. 20^{th}, 1998 and continuously irrigated throughout the growing season with Nile or drainage water (water quality treatments). Nitrogen and P fertilizers were applied in proper rate and form as recommended for wheat crop in the studied area.

At harvest, on May 28^{th}, 1999 yields of grain and straw were recorded as well as some yield components such as plant height, total tiller number per plant, spike length and a 1000- grain weight. Representative plant samples were separated to grain and straw, dried at 70° and ground for chemical analysis. Wet-ashing technique was used for plant samples digestion as described by Chapman and Pratt (1961). The digested samples were analyzed to determine nutrient concentrations in the following manner: Ca and Mg, absorption spectrophotometry; Na and K, flame emission spectrophotometry and P, spectrophotometry (molybdenum blue complex). A micro-Kjeldahl technique modified to include NO_3 was employed for total N.

All data were statistically analyzed according to Gomez & Gomez (1984).

Results and Discussion

Background

The experiment soil was heavy clay saline soil contained considerable quantity of available-K (Table 1). According to USDA (1969), salt-tolerant crops yield satisfactory in such soils.

TABLE 1. Some chemical and physical properties of the upper 30- cm surface layer of the experimental soil.

Particle size distribution (%)				
Sand	Silt	Clay	texture	
12.30	21.40	66.00	clay	
chemical properties				
EC (in soil paste) dS/m	pH (1:2.5 susp.)	ESP	OM %	$CaCO_3$ %
4.34	8.20	12.30	1.52	1.42
Macronutrient availability (ppm)				
N (in K_2SO_4)	P (in $NaHCO_3$)	k (in NH_4AOCextr.)		
34.0	7.50	264.00		

The salinity of El-Serw drainage water ranged from 1.34 dS/m in Nov. 1998 to 2.75 dS/m in Feb. 1999, with a mean value of 1.68 dS/m, the alkalinity of this water was very low, with a mean SAR value of 4.64 (Table 2). This water can be used in irrigation purposes without any restriction according to the guidelines for interpretation of water quality for irrigation (Ayers & Westcot, 1985).

Yield and yield components

Plant height, number of tillers per plant, spike length and 1000-grain weight, straw and grain yields significantly decreased as a result of irrigation with drainage water (Table 3).Compared with plots irrigated with Nile water, plots irrigated with drainage water exhibited a decrease of 7.2 and 9.5%in straw and grain yields, respectively. The adverse effect of irrigation water salinity may be attributed to the accumulation of toxic ions, which affect many metabolic reactions occurring in the plant cell and /or osmotic pressure of salts which decrease the availability of water for plants. These results are consistent with the general trend reported by Narian *et al.* (1977); El-Leithi *et al.* (1990); Abo- Soliman *et al*.(1992); El-Haddad *et al*.(1993) and Abu-Khadrah *et al.* (1999). Potassium fertilization significantly increased all the above mentioned parameters (Table 3). However, there were no significant differences between 24 and 48 kg K_2O/fed application rates except for straw yield. Similar results were obtained by Sherif *et al*. (1995); El-Sherbieny *et al*.(1999) and Abd El-Hadi *et al*.(2002).

TABLE 2. Chemical composition of El-Serw drain water during the experiment period.

Date	EC	T.S.S.	Cations (meq/L)				Anions (meq/L)				SAR
	dS/m	ppm	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$	
Nov.1998	1.34	858	2.76	3.25	7.70	0.30	Traces	3.45	6.45	4.21	4.44
Dec.	1.48	947	2.78	3.32	7.76	0.31	"	3.46	6.50	4.24	4.44
Jan.1999	1.54	986	2.90	3.42	8.80	0.30	"	4.40	6.70	4.30	4.95
Feb.	2.75	1760	2.98	4.80	9.94	0.28	"	4.43	8.60	5.00	5.04
March	1.58	1011	2.60	4.46	8.50	0.26	"	4.53	7.30	3.80	4.52
April	1.40	896	2.50	4.43	8.30	0.30	"	4.30	7.20	3.70	4.46
Mean	1.68	1076	2.75	3.95	8.50	0.29	"	4.10	7.13	4.21	4.64
SD	0.53	340	0.18	0.69	0.82	0.02	-	0.50	0.80	0.46	0.28
Chemical composition of Nile water											
Dec.98	0.42	269	2.48	2.10	1.54	0.22	-	2.58	1.20	2.50	1.02

T.S.S. = total soluble salts .
SD = standard deviation .

The interaction effect between irrigation water quality and K-fertilization on wheat growth was significant. Data reveal that application of K fertilizer alleviated the adverse effect of drainage water salinity, *i.e.*, the reduction in straw and grain yields due to irrigation with drainage water alone were 11.8 and 13.0%, while these reduction decreased to 5.5 and 8.9 % when 24 kg K_2O/ fed was added and to 4.2 and 6.7% when 48 kg K_2O/fed was added, respectively. The beneficial effect of K may be due to its role in metabolic activities associated with photosynthesis, respiration, chlorophyll development and water content of leaves (Roy *et al*.,1981).

TABLE 3. Yield components and yield of wheat plants as affected by irrigation water quality (W) and potassium fertilization (K).

Growth component		Plant height (cm)			Tillers no./plant			Spike length(cm)			1000-grain weight (gm)			Straw yield (ton/fed.)			Grain yield (Ard./fed)		
Teatments		W_1	W_2	Mean	W_1	W_2	Mean	W_1	W_2	Mean	W_1	W_2	Mean	W_1	W_2	Mean	W_1	W_2	Mean
k-fertilizer kg K_2O /fed.	K_0	9220	9007	91.13	570	430	500	957	920	938	3623	3527	35.75	363	320	342	1277	11.11	1193
	K_1	9267	92.10	9238	700	530	620	973	957	965	3650	3620	3635	377	353	365	1297	1183	1240
	K_2	9283	9233	9258	670	600	630	973	967	9.70	3650	3630	3640	383	367	375	1300	1213	1257
	Mean	9257	9150		640	520		968	948		3641	3592		374	347		1291	1169	
		L.S.D at 0.05 level of error probability																	
W		0.30			0.59			0.12			0.27			0.27			0.11		
K		0.37			1.11			0.16			0.13			0.26			0.07		
W * K^+		0.52			1.45			0.22			0.31			0.41			0.14		

W_1= Nile water, W_2= drainage water.

Nutrient Content

Nutrient contents of grain and straw were affected by irrigation water quality (Table 4, 5). Nitrogen, P and K concentrations and uptake by wheat grain significantly decreased while those of Na and Ca increased as a result of using drainage water in irrigation compared with Nile water. However, Mg concentration and uptake by grain followed a different trend (Table 4). Nutrient concentration and uptake by wheat straw followed the same trend with few exceptions, *i.e.*, N and P concentrations and K uptake were not significantly affected by drainage water irrigation (Table 5). The decrease in P concentration and uptake could be due to the competition between Cl and phosphate ions in the root zone or the restricted root growth caused by salinity (Khalil *et al*.,1967). The reduction in K concentration and uptake may be due to the competition between Na and K ions (Maas *et al*.,1972). In general, these results can be interpreted on basis of the following: 1. the relatively lower physical availability of water which in turn might result in a lower absorption rate for either water or elements, 2. antagonistic state between Na and one or more of the tested nutrients present in the growth media, and 3. A possible substitution mechanism of Na for K, Ca or Mg ions (Dahdoh & Hassan, 1977). These results are in agreement with those reported by Khalifa *et al*.(1995); Sarhan & Abd El-Salam (1999) and Abu Khadrah *et al*. (1999) . The interaction effect between water quality and K-fertilization occurred for concentration and uptake of all nutrients by grain and uptake of all nutrients by straw. Again, the addition of K fertilizer alleviated the adverse effect of irrigation water salinity.

Conclusion

Utilization of El-Serw drainage water for wheat irrigation significantly reduced straw and grain yields. However, the decline in grain and straw yields was only 13 and 12%, respectively. Application of K fertilizer alleviated the adverse effects of drainage water salinity and so declined the reduction in grain and straw yields to 9 and 6% at 24 kg K_2O/fed rate, respectively. There were no significant differences among the two rates of K-fertilization.

TABLE 4. Effect of irrigation water quality (W) and potassium fertilization (K) on nutrient concentration(%) and uptake(kg/fed) by wheat grain.

Nutrient	N			P			K			Na			Ca			Mg		
treatment	W_1	W_2	Mean	W_1	W_2	Mean	W_1	W_2	Mean	W_1	W_2	Mean	W_1	W_2	Mean	W_1	W_2	Mean
	Concentration																	
K_0	121	1143	1177	0238	0152	0195	0315	0265	0290	0175	0222	01999	0042	0054	0048	0026	0034	0030
K_1	124	1217	1228	0243	0176	0210	0411	0359	0385	0161	0212	0187	0037	0050	0043	0021	0027	0024
K_2	129	1247	1268	0244	0215	0230	0461	0397	0429	0150	0167	0159	0037	0040	0034	017	0024	0020
Mean	1247	1202		0242	0181		0395	0340		0162	0200		0035	0048		0021	0028	
	L.S.D at 0.05 level																	
W	0.032			0.004			0.015			0.009			0.008			0.003		
K	0.026			0.007			0.009			0.004			0.002			0.003		
W * K	n.s			0.009			0.018			0.010			n.s			n.s		
	Uptake																	
K_0	2311	1903	2107	456	2527	3543	5960	4460	5210	3350	3709	3530	0805	0905	0855	0505	0572	0539
K_1	2439	2160	2250	473	3123	3927	7987	6433	7210	3175	3763	3460	0713	0882	0798	0408	0485	0447
K_2	2516	2269	2393	4763	3920	4342	8917	7160	8040	2933	3032	2983	0657	0722	0689	0325	0431	0378
Mean	2422	2110		4684	3190		7621	6180		3147	3503		0725	0836		0413	0496	
	L.S.D at 0.05 level																	
W	0.95			0.101			0.268			0.207			0.101			0.058		
K	0.77			0.190			0.254			0.111			0.152			0.051		
W * K	1.02			0.198			0.317			0.200			0.166			0.066		

W_1= Nile water, W_2= drainage water.
K_0, K_1, K_2; 0,24 and 48 kg K_2O/fed, respectively.

TABLE 5. Effect of irrigation water quality (W) and potassium fertilization (K) on nutrient concentration(%) and uptake(kg/fed) by wheat by straw.

Nutrient	N			P			K			Na			Ca			Mg		
treatment	W_1	W_2	Mean	W_1	W_2	Mean	W_1	W_2	Mean	W_1	W_2	Mean	W_1	W_2	Mean	W_1	W_2	Mean
	Concentration																	
K_0	0250	022	0235	0025	0021	0023	1307	1250	1278	0246	0358	0302	0152	0174	0163	0185	0193	0189
K_1	0267	0242	0255	0027	0025	0026	1360	1270	1315	0232	0313	0273	0142	0162	0152	0171	0183	0177
K_2	0270	0250	0260	0028	0026	0027	1370	1317	1343	0221	0266	0244	0132	0153	0143	0162	0172	0167
Mean	0262	0237		0027	0024		1346	1279		0233	0313		0142	0163		0173	0183	
	L.S.D at 0.05 level																	
W	n.s			n.s			0.020			0.006			0.004			0.008		
K	0.018			0.001			0.018			0.006			0.004			0.004		
W * K'	n.s			n.s			n.s			0.008			n.s			n.s		
	Uptake																	
K_0	9083	7037	8060	0921	0685	0803	4748	4023	4386	894	1147	1020	551	558	555	672	616	644
K_1	1004	8477	9260	1015	0896	0957	5124	4489	4807	873	1106	993	536	571	554	645	644	645
K_2	1035	9167	9758	1070	0966	1018	6253	4829	5541	846	977	911	500	556	532	621	632	627
Mean	9826	8227		1003	0849		5375	4447		871	1077		532	562		646	631	
	L.S.D at 0.05 level																	
W	0.180			0.041			n.s			0.49			0.17			0.15		
K	0.629			0.072			n.s			0.34			0.18			0.23		
W * K'	0.620			0.076			0.076			0.48			0.22			0.25		

W_1= Nile water, W_2= drainage water.

K_0, K_1, K_2; 0, 24 and 48 kg K_2O/fed, respectively.

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إستجابة القمح للتسميد البوتاسي تحت ظروف الري بمياه الصرف الزراعي

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أجريت دراسة حقلية خلال الموسم الزراعي ١٩٩٨-١٩٩٩ بمحطة بحوث السرو- محافظة دمياط لتقييم استجابة القمح للتسميد البوتاسي تحت ظروف الري بمياه الصرف الزراعي و استخدم في هذا البحث ثلاث مستويات من البوتاسيوم (٢٤، ٤٨ كجم بو٢ أ/ف) بالإضافة لمعاملة مقارنة لم تسمد بالبوتاسيوم و مصدرين لمياه الري (مياه النيل و مياه مصرف السرو).

انخفض محصول القمح من الحبوب و القش معنويا باستخدام ماء الصرف في الري وبلغ هذا الإنخفاض ١٣، ١٢٪ مقارنة بمعاملة الكنترول (الري بمياه النيل وعدم إضافة البوتاسيوم) على الترتيب.

إنخفض تركيز و امتصاص النيتروجين و الفسفور و البوتاسيوم بينما زاد تركيز الصوديوم و الكالسيوم والمغنسيوم في كل من الحبوب و القش نتيجة الري بمياه الصرف الزراعي.

أدي التسميد البوتاسي إلى تخفيف الأثر الضار لملوحة مياه الري علي القمح حيث أدت إضافة البوتاسيوم عند مستوى ٢٤ كيلو جرام بو٢ا/ف إلي تقليل الإنخفاض في محصول الحبوب من ١٣٪ الى ٨٪ و محصول القش من ١٢٪ الى ٦٪ بينما أدت إضافة البوتاسيوم عند معدل ٤٨ كيلو جرام بو٢ا/ف إلى تقليل الإنخفاض في محصول الحبوب الى ٧٪ و محصول القش إلي ٤٪.

ومن ثم يمكن التوصية باستخدام مياه مصرف السرو في ري القمح دون ما انخفاض كبير في محصول القمح بشرط استخدام التسميد البوتاسي ويكفى عند مستوى ٢٤ كيلو جرام بو٢ا/ف.