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PROPER MANAGEMENT OF SOIL AND WATER UNDER SALINE CONDITIONS

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ABSTRACT

A pot experiment was conducted at the greenhouse of Soils, Water and Environment Research Institute, Giza, during the two winter seasons of 2007/2008 and 2008/2009. The study aimed to evaluate the effect of different strategies of reuse of low quality drainage water (drainage water, alternating, blended with Nile water), some, amendments application either to the soil (gypsum) or to the irrigation water (Ammonium Thio Sulfate ; ATS) and small split application of fertilizers through irrigation water at high rates on both soil properties and wheat crop response to water salinity. The irrigation water salinity levels were, 0.36, 4.42 and 2.34 dSm^{-1} for Nile water (control), drainage and blended water, respectively. The NPK fertilizers were applied at the rates of 0, 100 % and 125 % from the recommended doses, the high rate was applied to alleviating soil salinity stress. The obtained results indicated that soil salinity (EC_e), sodicity (SAR and ESP) tended to increase with increasing salinity levels of irrigation water, i.e., from 5.41 to 6.00, 7.22 and 9.87 dSm^{-1} in the first season and from 5.62 to 6.64, 7.69 and 12.74 dSm^{-1} in the second season for Nile, alternating, blended and drainage water, respectively. The values of soil SAR and ESP took place similar trend for EC_e values. Application of gypsum and ATS led to reduce the hazardous effect of irrigation water salinity and sodicity. These favourable soil amelioration were positively reflected on wheat yields of grain and straw and NPK uptake. These benefit effects were maximized by increasing the NPK doses from 100 % to 125 %.

Keywords: Soil; saline agricultural drainage water; soil &water management; amendments; gypsum; ATS; NPK rates; wheat crop

INTRODUCTION

The shortage of the Nile fresh irrigation water is one of the limiting factors for agricultural development in order to meet the growing demand for increasing population. Therefore, alternative water resources of low quality water such as agricultural drainage water can be used for irrigation to partially satisfy the need of irrigation water. The use of low or marginal quality water for irrigation without proper management could produce negative effects on both soil quality and crop-production (Ould *et al*, 2007).

The salts accumulation in soils was closely related to the salt concentration of irrigation water, however, soil salinity and sodicity parameters increased as a result of the use of drainage and mixed water (Ragabe *et al*, 2008 ; Jiang *et al*, 2008 and Amer, 2010). Thus , proper management of irrigation water regardless of its quality, is essential for good crop production. It is even more important when saline water is used. In this context several management practices were recommended (Hamdy, 1998 ; Feizi, 2004 ; Abdel Gawad *et al*, 2005 and Yurtseven *et al*, 2005).

As a general policy in reusing drainage water for irrigation, it is agreeable to obtain satisfactory yields by selecting salt-tolerant crops and varieties and proper soil and water management, but reuse of these waters should not deteriorate the irrigated soils (Qadir and Oster, 2004). The prime requirements of irrigation management for salinity control are timely irrigation, adequate leaching, adequate drainage and controlled water table (Luedeling *et al*, 2005 ; Ayars *et al*, 2006 and Feizi *et al*, 2010).The amount of water applied should be sufficient to meet both the water requirement of crops and satisfy the leaching requirement to maintain a favourable salt balance in the root zone, but not enough to overload the drainage system (Mostafazadeh-Fard *et al*, 2009). Several physical, chemical and biological soil management help and facilitate the use of saline water in crop production (Wu *et al*, 2002 ; Yang *et al*, 2006 Jalali and Ranjbar, 2009 and Bezborodov *et al*, 2010). Brackish drainage water can be used for crop production provided the soil is amended with certain chemical amendment either to the soil or to the irrigation water, i.e., gypsum (Mitchell *et al*, 2000 ; Choudhary *et al*, 2002 ; Jalali and Ranjbar, 2009 and Rashid *et al*, 2009), sulfur (Shabana *et al* , 1999 and Elsharawy, 2008), ammonium thiosulfate (ATS)Yakout (2003).

Timing and placement of proper fertilizers are important and unless properly applied, they may contribute to or cause a salinity problem. (Hart, 1998 ; Simonne and Hochmuth, 2003 and Laboski, 2008) recommended that the lower the salt index of the fertilizer, the less danger there is of salt burn and damage to seedling. A split application of small amount of fertilizers through saline irrigation water and increasing the NPK fertilizers rate more than those which are considered optimum under non saline condition, may overcome some of the inhibitory effects of water salinity (Yakout, 2003 and Esmaili *et al*., 2008).

The current investigation aims to evaluate the negative effect of saline agricultural drainage water reuse as an alternative irrigation water resources on soil properties and wheat growth plants taking into consideration the effective role of some soil and water amendments, i.e., gypsum and ammonium thiosulfate $(NH_4)_2\ S_2O_3$, respectively and proper fertilization on eliminating the adverse effect of water salinity on both soil properties and crop production.

MATERIALS AND METHODS

A pot experiment was conducted during the two winter seasons of 2007/2008 and 2008/2009 on a clay loam soil collected from the upper soil layer (0-30 cm) at Zawyet Naim, Abu-Homos Center, El-Beheira Governorate, Egypt. Some soil physical and chemical properties are presented in Table 1. Portions of 9 kg of air-dried soil were packed in plastic pots. The used plastic dimensions were 25 cm diameter and 20 cm height, with a bottom hole for water drainage.

In each pot 15 grains of wheat (*Triticum aestivum L.* Sakha 93 cv.) were planted, and three weeks after germination they were thinned to five plants per pot. The experimental design was a randomized complete block, factorial; involving three factores: (1) the kind of irrigation water includes; Nile water as a control [EC (0.36 dSm^{-1}), SAR (1.05)], agricultural drainage water from El-Omoum drain [EC (4.42 dSm^{-1}), SAR (11.9)], blended water of Nile and drainage (1:1) [EC (2.34 dSm^{-1}), SAR (8.16)] and alternating irrigation with the Nile and drainage water, i.e., one irrigation with drainage water followed by another one of the Nile and so on. Some chemical properties of irrigation water, i.e., EC and SAR were determined using Jackson (1967). Irrigation water requirements were estimated using the following equations (FAO, 1985):

1- $ET_c = ET_o \times K_c$
2- $LR = EC_{ir} / (5 \times \text{Max } EC_e - EC_{ir})$
3- $IR = ET_c / (1 - LR)$

Where :
ET_c = Crop evapotranspiration (mm/day)
ET_o = Potential evapotranspiration (mm/day)
K_c = Crop coefficient (mm/day)
LR = Leaching requirement
EC_{ir} = Electrical conductivity of irrigation water
Max EC_e (dS/m) = Maximum electrical conductivity of soil saturated extract which lead to 10 % yield decreases in wheat yield

Two soil and water amendments, i.e., gypsum ($CaSO_4.2H_2O$) and ammonium thiosulfate (ATS), $(NH_4)_2S_2O_3$ (34 % S and 16 % N), respectively were applied at a rate of 200 kg S $fed.^{-1}$. Gypsum was thoroughly mixed well with the whole soil of each pot before planting, and ATS was added in solution form with irrigation water at a rate of 50 cm^3 ATS per pot at three times (sowing, 11 and 22 days after planting, respectively). (3) fertilizer treatments of N, P and K at three rates, i.e., 0, 100 % and 125 % of the recommended doses. Ammonium nitrate (75 kg N $fed.^{-1}$) and potassium sulfate (24 kg K_2O $fed.^{-1}$) were added in five equal doses (at 21, 31, 41, 51, and 60 days after planting). Superphosphate (15 kg P_2O_5 $fed.^{-1}$) was added in one dose during the preparation of soil.

Plant samples were collected from each pot at harvest (150 days after planting), dried at 70 ^oC, crushed, digested using a perchloric-sulfuric acids mixture (1:1) and analyzed for nitrogen, phosphorus and potassium. Total nitrogen was determined using the standard procedure of micro-kjeldahl as described by Bremmer (1965). Total phosphorus was determined according to Murphy and Riley (1962). Total potassium was determined according to Horneck and Hanson (1998). Soil samples were collected after harvest.

All the obtained data were statistically analyzed and compared by using least significant difference (L.S.D) according to the procedure described by Gomez and Gomez (1984).

Table 1: Some physical-chemical properties of the studied soil before planting.

Physical properties							
Particle size distribution %				Texture class	FC	WP	AV
Coarse sand	Fine sand	Silt	Clay		(%, v/v)		
5.1	33.4	22.1	39.4	**Clay loam**	39.0	19.0	20.0

Chemical properties										
EC dSm^{-1}	Soluble ions ($meq\ L^{-1}$)							CEC	SAR	ESP
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$+ HCO_3^{-}	Cl^{-}	$SO_4^{=}$			
4.95	17.43	13.66	25.56	0.43	3.12	20.84	33.12	43.50	6.49	14.78

FC: field capacity, WP: wilting point, AV: available water, EC: in soil paste extract, CEC: cation exchangeable capacity, SAR: sodium adsorption ratio, ESP: exchangeable sodium percentage

RESULTS AND DISCUSSION

Effect of different treatments, on EC_e, SAR and ESP

Data in Table 2 show that the values of EC_e, SAR and ESP were negatively affected by the water sources (alternating, blended and drainage water) compared to the values of Nile water, and that occurred at the both successive seasons. The highest mean values of EC_e, SAR and ESP in the first season (irrespective of soil or water amendments) were 9.31. 10.91 and 15.36, respectively and that recorded in the treatments received drainage water source. These finding are in agreement with those obtained by Amer (2010), who found that the soil solution salinity (EC_e) and sodium adsorption ratio (SAR) significantly increased as salt concentration of irrigation water increased. Also, Choudhary *et al*. (2004) found that sustained sodic and saline-sodic irrigations caused increased EC_e and ESP. On the other hand, alternate irrigation with Nile water and drainage water was positively effective in reducing values of the aforementioned parameters more than the irrigation with blended water. Results in the second season (2008-2009) followed a trend resembled to that of the first season (2007-2008) but the values were rather higher in magnitude. Wahdan (2009) reported that the continuous usage of saline low quality water directly or in a mixture with the fresh Nile water build up salts in irrigated soils, and accumulated salts were proportionally increased with increasing the EC_{iw} of irrigation water.

Concerning the effect of applied soil and water amendments, results show that the values of EC_e, SAR and ESP decreased considerably with the addition of gypsum for soil or ATS with irrigation water compared to the unamended treatments. Soil and water amendments markedly differed in their effects in respect to the aforementioned parameters with superiority of gypsum as compared with ATS since it gave lower values for SAR and ESP. This could be attributed to that the gypsum is more effective and rapid source of calcium to replace exchangeable sodium and to reduce alkalinity and improve physical and chemical properties of the soil (Jalali and Ranjbar, 2009). There were no significant differences in the EC_e values between gypsum and ATS, and that occurred in both growing seasons. The values of these parameters in the second season were higher to some extent than those obtained at the first season.

Table 2. Effect of different treatments on EC_e, SAR, ESP, after 2007-2008 and 2008-2009 seasons.

Treatments		2007-2008 season			2008-2009 season		
Irrigation water (I)	Amendment (A)	EC_e	SAR	ESP	EC_e	SAR	ESP
Nile water	Control	5.41	6.06	14.49	5.62	6.24	13.83
	Gypsum	5.21	4.72	12.36	5.45	5.04	11.85
	ATS	5.14	5.80	13.51	5.28	6.14	13.38
	Mean	5.25	5.53	13.45	5.45	5.81	13.02
Alternating irrigation	Control	6.00	6.55	14.72	6.64	7.14	14.32
	Gypsum	5.74	5.60	13.57	6.29	6.13	13.71
	ATS	5.66	6.17	13.62	6.06	6.84	13.83
	Mean	5.80	6.11	13.97	6.33	6.70	13.95
Blended water	Control	7.22	7.01	15.32	7.69	7.55	16.10
	Gypsum	7.03	6.20	14.28	7.47	6.83	14.41
	ATS	6.81	6.80	14.56	7.30	7.36	14.96
	Mean	7.02	6.67	14.72	7.49	7.25	15.16
Drainage water	Control	9.87	11.45	16.26	12.74	14.27	18.05
	Gypsum	9.19	10.12	14.68	11.95	12.68	14.67
	ATS	8.88	11.16	15.13	11.73	13.89	15.02
	Mean	9.31	10.91	15.36	12.14	13.61	15.91
Mean effects of applied treatments							
Different irrigation water resources	Control	7.13	7.77	15.20	8.17	8.80	15.58
	Gypsum	6.79	6.66	13.72	7.79	7.67	13.66
	ATS	6.62	7.48	14.21	7.59	8.56	14.30
	Mean	6.85	7.30	14.38	7.85	8.34	14.51
LSD 0.05	(I)	0.32	0.35		0.37	0.40	
LSD 0.05	(A)	0.28	0.30		0.32	0.34	

ATS: ammonium thiosulfate, SAR: sodium adsorption ratio, ESP: exchangeable sodium percent

Grain yield

Grain yield of wheat as affected by different treatments at both successive seasons, is presented in Table 3. Data show that the different water sources significantly differ in their effect on grain yield with superiority of Nile water over the other water sources and followed in the order of effectiveness by alternating irrigation > blended water > drainage water. The values of grain yield at the second season were lower to some extent than those obtained at the first one. These results agree with those reported by Ragab *et al*. (2008), who found that increasing irrigation water salinity drastically decreases the grain yield of wheat. Also, Murtaza *et al*. (2006) found that wheat grain yield with saline-sodic water was drastically lower and the adverse effects could be further aggravated if use of saline-sodic water is continued for longer periods.

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Regarding the effect of applied NPK, results show a pronounced increase in grain yield in the two seasons due to NPK application and progressed with increasing rate of NPK from 100 to 125 %. The percentage of increase in the first season (irrespective of water sources and soil or water amendments) was 11.67 and 16.82 % for the rates of 100 and 125 %, respectively. The corresponding increases for the second season were 25.36 and 36.47 %, respectively. These results are in agreement with those of Zahran (2007), who found that grain yield of wheat significantly increased by increasing the rates of nitrogen fertilization from 60 to 100 kg N $fed.^{-1}$. Also, Yakout (2003) found that increasing the fertilization rate over that recommended under non saline conditions had significantly increase the yield. These results revealed that under irrigation with saline water, it is advisable to increase the fertilization rate than that recommended under non saline conditions.

The application of gypsum or ATS had a significant positive effect on grain yield and the treatments received these amendments recorded higher values as compared to those treatments with no soil and water amendments addition and that occurred with the two NPK rates and the four water sources. These results are in conformity with those reported by Yakout (2003) and Rehm (2005), they reported that application of ammonium thiosulfate increased the yield. Also, Zahran (2007) found that the application of gypsum gave significant increase in grain yield of wheat. Data also indicated that ATS was a better amendment compared with gypsum since it gave higher grain yield in both seasons, and the former surpassed the latter by 8.59 and 15.79 % with regard to both seasons. Because ATS is rapidly oxidized in soil to sulfate after 1 or 2 weeks. The addition of ATS significantly reduced nitrogen losses, consequently, led to an increase of spring wheat yield (Goos and Johnson, 2001).

In this concern, the greatest values of grain yield (20.01 and 19.99 $gpot^{-1}$) for the first and second season, were produced by the combined application of ATS with the rate of 125 % NPK under the Nile water irrigation. These finding agreed with that obtained by Yakout (2003).

Straw yield

Straw yield of wheat as affected by different treatments at both successive seasons, is presented in Table 4. Data show that the different water sources significantly differ in their effect on straw yield with superiority of Nile water over the other water sources and followed in the order of effectiveness by alternating irrigation > blended water > drainage water. The values of straw yield at the second season were lower to some extent than those obtained at the first season. These results could be confirmed with those reported by Ragab *et al*. (2008), Murtaza *et al*. (2006).

Regarding the effect of applied NPK, results show a pronounced increase in straw yield in the two seasons due to NPK application and progressed with increasing rate of NPK from 100 to 125 %. The percentage increases in the first season (irrespective of water sources and soil or water amendments) were 13.87 and 22.55 % for the rates of 100 and 125 %, respectively.

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The corresponding increase values for the second season were 10.56 and 21.93 %, respectively. These results are in agreement with those of Zahran (2007), Yakout (2003).

The application of gypsum or ATS had a significant positive effect on straw yield and treatments received these amendments recorded higher values as compared to those treatments with no soil and water amendments addition and that occurred with the two NPK rates and the four water sources. These results are in conformity with those reported by Yakout (2003), Rehm (2005), Zahran (2007). Data also indicated that ATS was a better amendment compared with gypsum since it gave higher straw yield in both seasons, and the former surpassed the latter by 8.11 and 10.43 % with regard to both seasons; 2007-2008 and 2008-2009. These results could be enhanced with those of (Goos and Johnson, 2001).

In this concern, the greatest values of straw yield (36.54 and 35.57 $gpot^{-1}$) for the first and second season, were produced by the combined application of ATS with the rate of 125
% NPK under the Nile water irrigation which agree with the results obtained by Yakout (2003).

Nitrogen, phosphorus and potassium uptake by grains

Nitrogen, phosphorus and potassium uptake by grains as affected by different treatments at both successive seasons, are presented in Tables 5, 6 and 7. Data show that the different water sources significantly differ in their effect on nitrogen, phosphorus and potassium uptake by grains with superiority of Nile water over the other water sources and followed in the order of effectiveness by alternating irrigation > blended water > drainage water, in both seasons. The obtained findings are in agreement with the results of Abdel-Shaheed (2006), who found that application of low quality irrigation water adversely effected nitrogen, phosphorus and potassium uptake by wheat grains since the N, P and K uptake were decreased as compared with the Nile irrigation water treatment due to the osmotic stress, nutritional imbalance and specific ion toxicity. The values of the N, P and K uptake by grains at the second season were lower to some extent than those obtained at the first season. These results are in accordance with those obtained by Sallam *et al*.(2008). There are no significant differences between Nile and alternating irrigation and between blended and drainage water for phosphorus uptake by grains only in the first season.

Regarding the effect of applied NPK, results show a pronounced increase in nitrogen, phosphorus and potassium uptake by grains in the two seasons due to NPK application and progressed with increasing rate of NPK from 100 to 125 %. For the nitrogen uptake, the percentage increases in the first season (irrespective of water sources and soil or water amendments) were 20.77 and 29.97 % for the two rates, respectively. The corresponding increases for the second season were 29.06 and 47.86 %, respectively. For the phosphorus uptake, the percentage increases in the first season (irrespective of water sources and soil or water amendments) were 23.24 and 37.78 % for the rates of 100 and 125 %, respectively. The corresponding increases for the second season were 32.28 and 55.68 %, respectively. For the potassium uptake,

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The percentage increases in the first season (irrespective of water sources and soil or water amendments) were 18.15 and 25.78 % for the rates of 100 and 125 %, respectively. The corresponding increases for the second season were 30.22 and 46.35 %, respectively. These results are in agreement with those of Selim (2004), who found that with increasing the rat of N, P, and K fertilization to 125 % from the recommended dose under saline soil conditions, i.e., 10 dSm^{-1}, increased nitrogen, phosphorus and potassium uptake by wheat grains.

The application of gypsum or ATS had a significant positive effect on nitrogen, phosphorus and potassium uptake by grains and treatments received these amendments recorded higher values as compared to those treatments with no soil and water amendments addition and that occurred with the two NPK rates and the four water sources. Data also indicated that ATS was a better amendment compared with gypsum since it gave higher N, P and K uptake by grains in both seasons, and the former surpassed the latter by 13.04 and 18.46 % with regard to both seasons; 2007-2008 and 2008-2009 for the nitrogen uptake and by 23.31 and 30.69 % with regard to both seasons for the phosphorus uptake and by 3.52 and 11.10 % with regard to both seasons for the potassium uptake. These findings agreed with those obtained by Rehm (2005), who reported that fluid sources of S, i.e., ammonium sulfate and ammonium thiosulfate rapidly oxidized to sulfate in soils more than dry sources of S, consequently, more decrease in soil pH and increasing nutrients availability and uptake to the growing plants. Also, the superiority of ATS may be due to that the availability of N, P and K was increased due to the more decrease in soil pH than gypsum, as reported by Abou-Baker (2003).

In this concern, the greatest values of nitrogen, phosphorus and potassium uptake by grains were (273.5 and 243.8 mg $Npot^{-1}$), (56.11 and 53.30 mg $Ppot^{-1}$) and (90.64 and 84.63 mg $Kpot^{-1}$) for the first and second season, respectively. Where, they were produced by the combined application of ATS with the rate of 125 % NPK under the Nile water irrigation.

Nitrogen, phosphorus and potassium uptake by straw

Nitrogen, phosphorus and potassium uptake by straw as affected by different treatments at both successive seasons, are presented in Tables 8, 9 and 10. Data show that the different water sources significantly differ in their effect on nitrogen, phosphorus and potassium uptake with superiority of Nile water over the other water sources and followed in the order of effectiveness by alternating irrigation > blended water > drainage water, in both seasons. Similar results were obtained by Abdel-Shaheed (2006). The values of nitrogen, phosphorus and potassium uptake by straw at the second season were lower to some extent than those obtained at the first season. There are no significant differences between alternating , blended and drainage water for nitrogen uptake by straw only in the first season. Also, there are no significant differences between Nile, alternating, blended and drainage water for phosphorus uptake by straw in the first season and between Nile and alternating water in the second season.

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Regarding the effect of applied NPK, results show a pronounced increase in the N, P and K uptake by straw in the two seasons due to NPK application and progressed with increasing rate of NPK from 100 to 125 %. For the nitrogen uptake, the percentage increases in the first season (irrespective of water sources and soil or water amendments) were 26.86 and 40.00 % for the rates of 100 and 125 %. The corresponding increases for the second season were 26.57 and 45.98 %, respectively. For the phosphorus uptake, the percentage increases in the first season (irrespective of water sources and soil or water amendments) were 24.18 and 49.83 % for the rates of 100 and 125 %, respectively. The corresponding increases for the second season were 23.67 and 49.72 %, respectively. For the potassium uptake, the percentage increases in the first season (irrespective of water sources and soil or water amendments) were 16.81 and 27.31 % for the rates of 100 and 125 %, respectively. The corresponding increases for the second season were 16.47 and 30.47 %, respectively. These results are in conformity with those reported by Selim (2004), who found that with increasing a rat of nitrogen, phosphorus and potassium fertilization to 125 % from the recommended dose under saline soil conditions, i.e., 10 dSm^{-1}, increased the N, P and K uptake by wheat straw.

The application of gypsum or ATS had a significant positive effect on nitrogen, phosphorus and potassium uptake by straw and treatments received these amendments recorded higher values as compared to those treatments with no soil and water amendments addition and that occurred with the two NPK rates and the four water sources. Data also indicated that ATS was a better amendment compared with gypsum since it gave higher nitrogen, phosphorus and potassium uptake by straw in both seasons, and the former surpassed the latter by 11.27 and 15.73 % with regard to both seasons; 2007-2008 and 2008-2009 for the nitrogen uptake and by 24.63 and 25.09 % with regard to both seasons for the phosphorus uptake and by 9.50 and 12.40 % with regard to both seasons for the potassium uptake. These results could be supported with those obtained by Rehm (2005) and Abou-Baker (2003).

In this concern, the greatest values of nitrogen, phosphorus and potassium uptake by straw were (212.0 and 199.2 mg $Npot^{-1}$), (69.51 and 60.46 mg $Ppot^{-1}$) and (428.7 and 409.1 mg $kpot^{-1}$) for the first and second season, respectively. Where, they were produced by the combined application of ATS with the rate of 125 % NPK under the Nile water irrigation.

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الإدارة الملائمة للأرض والمياه تحت الظروف الملحية

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أجريت تجربة أصص فى صوبة معهد بحوث الأراضي والمياه والبيئة بمحافظة الجيزة خلال الموسمين الشتويين 2008/2007 و 2009/2008 بهدف تقييم تأثير الاستراتيجيات المختلفة لإعادة استخدام مياه الصرف منخفضة الجودة (مياه الصرف و التناوب والخلط مع مياه النيل) و إضافة بعض المصلحات إما للتربة (الجبس) أو لمياه الري (ثيوكبريتات الأمونيوم) والإضافة المجزأة الصغيرة للأسمدة خلال مياه الري بمعدلات عالية على كلاً من خواص التربة واستجابة محصول القمح لملوحة مياه الري. كانت مستويات ملوحة مياه الري 0.36 ، 4.42 ، 2.34 ديسيمينز/م لمياه النيل (الكنترول) و مياه الصرف والخلط على التوالي. أضيفت الأسمدة النيتروجينية والفوسفاتية والبوتاسية بمعدلات صفر ، 100٪ ، 125٪ من الجرعات الموصى بها ، أضيف المعدل العالي لتخفيف إجهاد ملوحة التربة.

دلت النتائج المتحصل عليها علي أن :

1- اتجهت ملوحة التربة والصودية (نسبة إدمصاص الصوديوم و نسبة الصوديوم المتبادل) للتزايد مع زيادة مستويات ملوحة مياه الري أي من 5.41 إلي 6.00 ، 7.22 ، 9.87 ديسيمينز/م فى الموسم الأول ومن 5.62 إلي 6.64 ، 7.69 ، 12.74 فى الموسم الثاني في حالة الري بمياه النيل ، التناوب ، الخلط و الصرف علي التوالي.

2- أظهرت قيم نسبة إدمصاص الصوديوم و نسبة الصوديوم المتبادل للتربة اتجاهاً مشابهاً لقيم ملوحة التربة.

3- أدت إضافة الجبس وثيوكبريتات الأمونيوم إلي خفض التأثير الخطير لملوحة وصودية مياه الري. هذا التحسين المرضي للتربة انعكس إيجابياً على محصول القمح من الحبوب والقش وامتصاص النيتروجين والفوسفور والبوتاسيوم. هذا التأثير المفيد وصل أقصاه بزيادة جرعات النيتروجين والفوسفور والبوتاسيوم من 100٪ إلي 125٪.

قام بتحكيم البحث

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Table 3. Effect of different treatments on grain yield of wheat, (gpot^{-1}).

Treatments		2007-2008					2008-2009				
		Source of irrigation water					Source of irrigation water				
NPK % of the recommended dose	Amendment	Nile	Alternating	Blended	Drainage	Mean	Nile	Alternating	Blended	Drainage	Mean
0	Control	15.65	14.12	12.51	11.96	13.56	11.67	11.01	9.03	5.53	9.31
	Gypsum	15.85	14.91	12.93	12.88	14.14	13.09	11.96	9.06	7.65	10.44
	ATS	16.47	16.04	15.92	14.96	16.00	14.57	12.84	11.09	8.78	11.82
	Mean	15.99	15.02	13.79	13.27	14.57	13.11	11.94	9.73	7.32	10.53
100	Control	15.99	15.25	14.17	13.70	14.78	15.60	13.41	9.56	9.32	11.97
	Gypsum	17.86	17.11	16.42	14.87	16.62	16.99	13.61	10.92	9.88	12.85
	ATS	19.79	18.12	16.79	15.55	17.47	19.45	13.75	13.55	12.31	14.77
	Mean	17.88	16.83	15.79	14.71	16.27	17.35	13.59	11.34	10.50	13.20
125	Control	16.76	15.88	15.42	13.75	15.44	14.04	14.57	10.38	9.53	12.63
	Gypsum	17.94	17.32	16.92	16.33	17.08	17.32	15.54	11.68	11.25	13.95
	ATS	20.01	19.25	18.12	16.80	18.55	19.99	16.46	14.83	14.79	16.52
	Mean	18.24	17.48	16.82	15.63	17.02	17.78	15.52	12.30	11.86	14.37
Amendment	Control	16.13	15.08	14.03	13.12	14.59	14.44	13.00	9.66	8.13	11.31
	Gypsum	17.22	16.45	15.42	14.69	15.95	15.80	13.70	10.55	9.59	12.41
	ATS	18.76	17.80	16.94	15.77	17.32	18.00	14.35	13.16	11.96	14.37
Overall mean		17.37	16.44	15.47	14.53	15.94	16.08	13.68	11.12	9.89	12.70
LSD at 0.05		W				0.14	W				0.26
		NPK				0.12	NPK				0.22
		W x NPK				0.23	W x NPK				0.44
		Am				0.12	Am				0.22
		W x Am				0.23	W x Am				0.44
		NPK x Am				0.20	NPK x Am				0.38
		W x NPK x Am				0.41	W x NPK x Am				0.77

ATS = Ammonium thiosulfate

Table 4. Effect of different treatments on straw yield of wheat, ($gpot^{-1}$).

Treatments		2007-2008					2008-2009				
		Source of irrigation water					Source of irrigation water				
NPK % of the recommended dose	Amendment	Nile	Alternating	Blended	Drainage	Mean	Nile	Alternating	Blended	Drainage	Mean
0	Control	25.68	23.28	21.27	20.33	22.64	23.40	21.23	20.12	18.14	20.72
	Gypsum	28.12	25.28	21.98	21.89	24.32	25.42	22.18	21.61	19.65	22.22
	ATS	29.18	27.06	26.44	25.43	27.03	26.65	24.52	25.83	21.59	24.65
	Mean	27.66	25.21	23.23	22.55	24.66	25.16	22.64	22.52	19.79	22.53
100	Control	28.89	26.35	25.93	23.28	26.11	28.31	23.09	20.66	18.34	22.60
	Gypsum	30.56	28.76	28.00	26.95	28.57	29.61	26.29	22.36	21.57	24.96
	ATS	32.97	28.91	28.54	27.76	29.55	32.10	27.84	26.78	21.95	27.17
	Mean	30.81	28.01	27.49	25.99	28.08	30.01	25.74	23.27	20.62	24.91
125	Control	30.50	26.61	26.21	24.09	26.85	29.90	25.51	23.67	20.05	24.78
	Gypsum	32.64	30.36	29.44	29.09	30.38	31.91	28.05	26.31	21.77	27.01
	ATS	36.54	33.64	32.72	30.80	33.43	35.57	31.28	30.07	23.58	30.13
	Mean	33.23	30.20	29.46	27.99	30.22	32.46	28.28	27.35	21.80	27.47
Amendment	Control	28.36	25.41	24.47	22.56	25.20	27.20	23.28	21.48	18.84	22.70
	Gypsum	30.44	28.13	26.47	25.97	27.75	28.98	25.51	23.43	21.00	24.73
	ATS	32.90	29.87	29.23	28.00	30.00	31.44	27.88	27.56	22.37	27.31
Overall mean		30.57	27.81	26.73	25.51	27.66	29.21	25.56	24.27	20.74	24.95
LSD at 0.05		W				0.24	W				0.36
		NPK				0.20	NPK				0.32
		W x NPK				0.41	W x NPK				0.63
		Am				0.20	Am				0.32
		W x Am				0.41	W x Am				0.63
		NPK x Am				0.35	NPK x Am				0.55
		W x NPK x Am				0.71	W x NPK x Am				1.09

ATS = Ammonium thiosulfat

Table 5. Effect of different treatments on nitrogen uptake by wheat grains, ($mgpot^{-1}$).

Treatments		2007-2008					2008-2009				
		Source of irrigation water					Source of irrigation water				
NPK % of the recommended dose	Amendment	Nile	Alternating	Blended	Drainage	Mean	Nile	Alternating	Blended	Drainage	Mean
0	Control	169.6	162.9	150.1	143.5	156.5	127.9	128.8	106.2	67.27	107.6
	Gypsum	189.3	182.0	157.3	164.4	173.2	145.3	142.1	109.0	93.86	122.6
	ATS	198.6	196.8	201.1	198.9	198.9	165.1	154.5	135.3	110.9	141.5
	Mean	185.8	180.5	169.5	168.9	176.2	146.1	141.8	116.8	90.67	123.9
100	Control	191.8	186.0	174.7	178.5	182.8	179.4	158.9	114.4	115.9	142.2
	Gypsum	221.5	217.4	221.2	203.2	215.8	199.3	163.7	132.1	123.4	154.6
	ATS	256.0	245.9	232.7	225.0	239.9	238.1	168.2	168.9	156.0	182.8
	Mean	223.1	216.4	209.6	202.3	212.8	205.6	163.6	138.5	131.8	159.9
125	Control	206.7	200.1	194.3	183.3	196.1	190.2	176.3	128.0	120.2	153.7
	Gypsum	229.0	232.1	231.3	227.5	230.0	210.1	195.3	157.2	154.9	179.4
	ATS	273.5	266.3	255.5	248.1	260.9	243.8	209.6	202.6	210.1	216.5
	Mean	236.4	232.9	227.0	219.6	229.0	214.7	193.7	162.6	161.7	183.2
Amendment	Control	189.4	183.0	173.0	168.4	178.5	165.9	154.7	116.2	101.1	134.5
	Gypsum	213.3	210.5	203.3	198.4	206.3	184.9	167.0	132.8	124.0	152.2
	ATS	242.7	236.3	229.8	224.0	233.2	215.7	177.4	168.9	159.0	180.3
Overall mean		215.1	209.9	202.0	196.9	206.0	188.8	166.4	139.3	128.1	155.6
LSD at 0.05		W				4.07	W				4.01
		NPK				3.52	NPK				3.47
		W x NPK				NS	W x NPK				6.94
		Am				3.52	Am				3.47
		W x Am				NS	W x Am				6.94
		NPK x Am				6.10	NPK x Am				6.01
		W x NPK x Am				12.21	W x NPK x Am				12.03

ATS = Ammonium thiosulfate

Table 6. Effect of different treatments on phosphorus uptake by wheat grains, ($mgpot^{-1}$).

Treatments		2007-2008 Source of irrigation water					2008-2009 Source of irrigation water				
NPK % of the recommended dose	Amendment	Nile	Alternating	Blended	Drainage	Mean	Nile	Alternating	Blended	Drainage	Mean
0	Control	32.89	31.05	23.77	27.50	28.80	24.10	23.10	19.26	11.98	19.61
	Gypsum	35.97	34.31	28.47	35.19	33.49	27.92	25.95	21.42	19.64	23.73
	ATS	44.50	43.28	43.54	41.88	43.30	36.42	33.81	28.84	24.58	30.91
	Mean	37.79	36.22	31.93	34.85	35.20	29.48	27.62	23.17	18.73	24.75
100	Control	36.76	36.59	34.02	34.25	34.41	33.79	29.51	22.31	21.11	26.68
	Gypsum	44.63	42.80	44.31	40.18	42.98	39.05	31.30	27.30	25.70	30.84
	ATS	55.40	52.51	50.92	48.22	51.76	50.56	38.96	37.95	35.30	40.69
	Mean	45.60	43.97	43.08	40.88	43.38	41.14	33.26	29.19	27.37	32.74
125	Control	41.87	41.81	40.09	37.10	40.22	36.75	35.45	26.30	25.10	30.90
	Gypsum	49.00	47.94	45.65	47.38	47.49	42.72	42.43	30.75	31.50	36.85
	ATS	56.11	61.55	58.02	55.47	57.79	53.30	48.27	43.99	45.85	47.85
	Mean	48.99	50.43	47.92	46.65	48.50	44.25	42.05	33.68	34.15	38.53
Amendment	Control	37.17	36.48	32.63	32.95	34.81	31.55	29.36	22.63	19.39	25.73
	Gypsum	43.20	41.68	39.48	40.92	41.32	36.56	33.23	26.49	25.61	30.47
	ATS	52.00	52.45	50.83	48.52	50.95	46.76	40.35	36.93	35.24	39.82
Overall mean		44.13	43.54	40.98	40.79	42.36	38.29	34.31	28.68	26.75	32.01
LSD at 0.05		W				2.02	W				0.83
		NPK				1.75	NPK				0.72
		W x NPK				NS	W x NPK				1.44
		Am				1.75	Am				0.72
		W x Am				NS	W x Am				1.44
		NPK x Am				NS	NPK x Am				1.25
		W x NPK x Am				NS	W x NPK x Am				2.50

ATS = Ammonium thiosulfate

Table 7. Effect of different treatments on potassium uptake by wheat grains, (mgpot^{-1}).

Treatments		2007-2008					2008-2009				
		Source of irrigation water					Source of irrigation water				
NPK % of the recommended dose	Amendment	Nile	Alternating	Blended	Drainage	Mean	Nile	Alternating	Blended	Drainage	Mean
0	Control	63.15	56.96	46.67	43.44	52.56	44.33	39.66	31.60	19.14	33.68
	Gypsum	69.75	64.10	53.45	51.08	59.60	54.55	47.41	35.61	28.04	41.40
	ATS	68.61	64.15	64.18	55.82	63.19	57.79	48.36	40.68	31.29	44.53
	Mean	67.17	61.74	54.77	50.12	58.45	52.22	45.15	35.96	26.16	39.87
100	Control	70.88	62.02	55.74	52.97	60.40	62.43	49.13	34.43	33.28	44.82
	Gypsum	83.33	79.88	69.52	60.47	73.30	73.04	56.30	44.07	37.86	52.82
	ATS	87.08	76.75	69.44	60.65	73.48	79.09	55.45	51.94	45.97	58.11
	Mean	80.43	72.88	64.90	58.03	69.06	71.52	53.63	43.48	39.04	51.92
125	Control	75.46	68.28	63.69	55.47	65.73	65.02	58.28	39.08	35.56	49.49
	Gypsum	85.55	76.25	72.19	68.53	75.63	76.78	65.22	48.24	43.88	58.53
	ATS	90.64	83.42	76.11	66.67	79.21	84.63	68.02	58.83	56.71	67.05
	Mean	83.89	75.98	70.66	63.56	73.52	75.48	63.84	48.72	45.38	58.35
Amendment	Control	69.83	62.42	55.37	50.63	59.56	57.26	49.02	35.04	29.32	42.66
	Gypsum	79.54	73.41	65.06	60.03	69.51	68.13	56.31	42.64	36.59	50.92
	ATS	82.11	74.78	69.91	61.05	71.96	73.84	57.28	50.48	44.66	56.57
Overall mean		77.16	70.20	63.44	57.24	67.01	66.41	54.20	42.72	36.86	50.05
LSD at 0.05		W				1.78	W				1.27
		NPK				1.54	NPK				1.10
		W x NPK				NS	W x NPK				2.20
		Am				1.54	Am				1.10
		W x Am				NS	W x Am				2.20
		NPK x Am				2.67	NPK x Am				1.90
		W x NPK x Am				5.34	W x NPK x Am				NS

ATS = Ammonium thiosulfate

Table 8. Effect of different treatments on nitrogen uptake by wheat straw, (mgpot^{-1}).

Treatments		2007-2008					2008-2009				
		Source of irrigation water					Source of irrigation water				
NPK % of the recommended dose	Amendment	Nile	Alternating	Blended	Drainage	Mean	Nile	Alternating	Blended	Drainage	Mean
0	Control	109.6	101.7	106.3	105.7	105.8	92.79	91.26	87.17	84.61	88.96
	Gypsum	126.5	121.4	112.9	117.5	119.6	109.4	99.81	97.88	91.69	99.69
	ATS	138.1	137.1	136.6	139.1	137.7	116.3	115.2	123.1	114.5	117.3
	Mean	124.7	120.1	118.6	120.8	121.0	106.2	102.1	102.7	96.92	102.0
100	Control	135.7	138.8	143.5	128.0	136.5	129.3	108.6	98.51	89.21	106.4
	Gypsum	165.2	154.4	155.1	151.7	156.6	155.0	136.6	118.6	115.8	131.5
	ATS	185.6	162.9	159.8	161.0	167.3	172.3	154.1	147.4	123.7	149.4
	Mean	162.2	152.0	152.8	146.9	153.5	152.2	133.1	121.5	109.6	129.1
125	Control	155.5	141.9	145.1	134.9	144.3	146.5	133.5	127.8	110.3	129.5
	Gypsum	178.4	171.0	166.8	167.7	171.0	168.0	152.5	144.7	121.2	146.6
	ATS	212.0	192.9	182.2	183.8	192.7	199.2	174.3	172.5	136.0	170.5
	Mean	182.0	168.6	164.7	162.1	169.4	171.2	153.4	148.3	122.5	148.9
Amendment	Control	133.6	127.5	131.6	122.9	128.9	122.9	111.1	104.5	94.71	108.3
	Gypsum	156.7	148.9	144.9	145.7	149.1	144.1	129.6	120.4	109.6	125.9
	ATS	178.6	164.3	159.5	161.3	165.9	162.6	147.9	147.7	124.7	145.7
Overall mean		156.3	146.9	145.4	143.3	148.0	143.2	129.5	124.2	109.7	126.6
LSD at 0.05		W				3.91	W				3.50
		NPK				3.38	NPK				3.03
		W x NPK				6.76	W x NPK				6.05
		Am				3.38	Am				3.03
		W x Am				6.76	W x Am				6.05
		NPK x Am				NS	NPK x Am				5.24
		W x NPK x Am				NS	W x NPK x Am				NS

ATS = Ammonium thiosulfate

Table 9. Effect of different treatments on phosphorus uptake by wheat straw, (mgpot^{-1}).

Treatments		2007-2008					2008-2009				
		Source of irrigation water					Source of irrigation water				
NPK % of the recommended dose	Amendment	Nile	Alternating	Blended	Drainage	Mean	Nile	Alternating	Blended	Drainage	Mean
0	Control	27.38	30.29	27.67	29.14	28.62	21.06	24.07	22.16	21.15	22.11
	Gypsum	32.78	37.07	30.80	32.10	33.19	27.95	28.84	29.54	28.13	28.61
	ATS	43.73	42.42	43.18	39.84	42.29	34.73	34.34	39.59	31.69	35.09
	Mean	34.63	36.59	33.89	33.70	34.70	27.91	29.08	30.43	26.99	28.60
100	Control	37.52	36.02	38.04	34.14	36.43	33.96	32.28	26.17	26.29	29.68
	Gypsum	41.83	42.22	42.04	44.86	42.74	38.50	39.40	31.31	31.53	35.19
	ATS	52.79	48.20	49.50	49.98	50.12	45.01	44.56	41.05	34.41	41.26
	Mean	44.05	42.15	43.19	42.99	43.09	39.16	38.75	32.84	30.74	35.37
125	Control	41.72	41.71	38.44	39.35	40.30	38.87	37.48	34.01	29.49	34.96
	Gypsum	49.01	49.54	50.07	53.37	50.50	44.69	41.12	39.37	34.81	40.00
	ATS	69.51	64.03	65.44	61.64	65.15	60.46	56.28	54.05	43.23	53.51
	Mean	53.41	51.76	51.31	51.45	51.99	48.00	44.96	42.48	35.84	42.82
Amendment	Control	35.54	36.00	34.72	34.21	35.12	31.30	31.28	27.44	25.64	28.91
	Gypsum	41.20	42.95	40.97	43.45	42.14	37.05	36.45	33.41	31.49	34.60
	ATS	55.34	51.55	52.71	50.49	52.52	46.73	45.06	44.90	36.44	43.28
Overall mean		44.03	43.50	42.80	42.71	43.26	38.36	37.60	35.25	31.19	35.60
LSD at 0.05		W				NS	W				1.94
		NPK				2.21	NPK				1.68
		W x NPK				NS	W x NPK				3.35
		Am				2.21	Am				1.68
		W x Am				NS	W x Am				NS
		NPK x Am				3.83	NPK x Am				2.90
		W x NPK x Am				NS	W x NPK x Am				NS

ATS = Ammonium thiosulfate

Table 10. Effect of different treatments on potassium uptake by wheat straw, (mgpot^{-1}).

Treatments		2007-2008					2008-2009				
		Source of irrigation water					Source of irrigation water				
NPK % of the recommended dose	Amendment	Nile	Alternating	Blended	Drainage	Mean	Nile	Alternating	Blended	Drainage	Mean
0	Control	289.0	255.4	222.6	211.5	244.6	253.5	212.4	190.5	162.6	204.8
	Gypsum	315.8	281.4	240.4	232.0	267.4	279.7	239.5	225.4	186.0	232.7
	ATS	328.7	302.2	291.7	276.4	299.8	296.7	266.4	271.3	220.9	263.8
	Mean	311.2	279.7	251.6	240.0	270.6	276.6	239.4	229.1	189.8	233.7
100	Control	327.3	293.4	285.2	252.3	289.6	312.5	243.9	215.6	186.4	239.6
	Gypsum	352.5	328.0	310.0	295.5	321.5	332.6	288.2	243.8	229.4	273.5
	ATS	381.3	331.4	325.5	310.9	337.3	363.9	310.9	296.3	242.2	303.3
	Mean	353.7	317.6	306.9	286.2	316.1	336.3	281.0	251.9	219.4	272.2
125	Control	348.7	301.6	291.8	265.1	301.8	334.9	283.0	255.8	213.9	271.9
	Gypsum	379.6	349.2	331.7	321.9	345.6	363.8	315.2	290.3	237.2	301.6
	ATS	428.7	391.3	377.4	347.1	386.1	409.1	354.7	337.8	262.7	341.1
	Mean	385.7	347.3	333.6	311.3	344.5	369.2	317.6	294.6	237.9	304.9
Amendment	Control	321.7	283.5	266.5	242.9	278.6	300.3	246.5	220.6	187.6	238.8
	Gypsum	349.3	319.5	294.0	283.1	311.5	325.3	281.0	253.2	217.6	269.3
	ATS	379.6	341.7	331.6	311.5	341.1	356.6	310.7	301.8	241.9	302.7
Overall mean		350.2	314.9	297.4	279.2	310.4	327.4	279.4	258.5	215.7	270.3
LSD at 0.05		W				5.02	W				5.79
		NPK				4.35	NPK				5.01
		W x NPK				NS	W x NPK				10.03
		Am				4.35	Am				5.01
		W x Am				NS	W x Am				10.03
		NPK x Am				7.53	NPK x Am				NS
		W x NPK x Am				15.06	W x NPK x Am				NS

ATS = Ammonium thiosulfate