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POTASSIUM FERTILIZATION FOR SOME MAIN FIELD CROPS IN RELATION TO IRRIGATION WATER QUALITY

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Abstract

Four factorial field trials were carried out in El-Serw Agric. Res. Station during 1994 and 1995 seasons on wheat, clover, rice and cotton. This study aimed to determine the optimum rates of K-fertilization, and evaluate the irrigation water quality from two main sources at Dammietta governorate. Results indicate that the optimum rate is 48 kg K2O/fed. for wheat, clover, rice and cotton to obtain the maximum yields of 2.245, 10.545, 3.340 ton/fed. respectively and 9.475 kentar/fed. The water of El-Serw main drain is classified as moderate in properties and has no adverse effect on crop yield in many cases when compared with El-Shoka canal water. The higher values of TSS, SSP and Adj. SAR for such drain water of 162.5%, 164.3%, 358% in crease over the normal canal water, respectively. This shows that salinity and alkalinity problems would increase on the long run usage. Data revealed that potassium fertilization efficiency depends on irrigation water quality since it increases by using drainage water for winter crops especially clover. On the other hand, use of canal water increases yields of summer crops especially cotton. That may be attributed to the indirect effects of Na+ and K+ balances and their relations.

INTRODUCTION

Several workers have found potassium fertilization gave positive responses in many field crops in Northern Delta soil (Hegzay et al., 1990, Genaidy and Hegazy, 1994 and Hegazy and Genaidy, 1995). This may be attributed to suypply insufficient amounts of available K in these soils, or balance nutritional disorders in these soils. K enhances many nutrients uptake especiallyg N, improving many physiological growth processes increasing plant tolerance to salimity as it lessens water stress and activates the enzyme system under saline conditions (Mengel and Kirkby, 1987).

Drainage water represents one of the readily available sources, especially in Northern Delta. The evaluation analysis of irrigation water quality indicated that the salimity of most drainage wate in Egypt is less than 1000 ppm and rarely exceeds 3000 ppm in winter months, and SAR's are almost invariably low (El-Shabassy et al., 1971 and El-Guindy, 1987).

Balba (1980) reported that clover and rice are of medium tolerance to sodicity (ESP 20-40), while wheat and cotton could tolerate levels of 12, 6,6 and 12 dS.m-1, respectively. On the other hand, irrigation water quality could be classified to three classes i.e. good water (TSS<700 ppm, SSP<60% of total cations), medium water (TSS 700-2000 ppm, SSP <75%) and bad water (TSS>2000 ppm, SSP>75%). El-Attar and Amer (1981) found that the use of fairly saline waters (drainage or mixed with Nile water) improved the permeability of clay soils. The use of drainage water of Adj. SAR value of 25 caused a decrease of ESP of fairly permeable soil but increased the ESP of imperneable ones.

El-Guindy (1987) summarized the principals characteristics that evaluate water quality for irrigation, whether from canals or drains as follows (FAO/UNESCO):

Salinity (TSS) [<0.75 dS.m-1 (no problem) 0.75-3.00 (increasing problems), >3.00 (severe problem)].

Sodium (Adj. SAR)[>3 (no problem), 3-9 (increased problem), >9 (severe problem)], $-Co^{-3}$ (meq/L) [1.5, 1.5-8.5, >8.5], Cl- (meq/L) [<4, 4-10, >101,- Boron (ppm) [0.75, 0.75-2.00, >2],

pH [normal range 6.5-8.4], - Fe, Zn [permissible limits 0.3, 0.5 ppm, respectively].

The drainage water salinity is affected by irrigation water salinity. In the middle part of Delta, where the soil salimity is moderate, the drainage water salinity ranges from 1000-2000 ppm. The composition of soil and, consequently, drainage water varies to a great extent from place to place and from time to time as a result of changes in soil salinity, temperature and the referential solubility of different salts at different temperatures.

The objectives of this study were as follows:

a- Evaluation of the response for some main field crops, e.g. wheat, clover, rice and cotton to potassium fertlization in Dammietta governorate soils.

b- Comparison between two sources of irrigation water which differ in their quality for such crops.

c- Indication for the interaction effects of K-fertilization X source of irrigation water on crop yields.

MATERIALS AND METHODS

Four factorial field experiments were conducted at two experimental sites at El-Serw Agric. Res Station (located at Dammietta governorate). The first site was cultivated with two winter crops i.e. wheat var. Giza 69 & clover var. Meskawy. The second site had two summer crops i.e. rice var. Giza 176 and cotton var. Giza 175 during the growth seasons of 1994 and 1995.

For each crop, a factorial field experiment was carried out comprising two factors (K-fertilization rates of 0, 24, 48, 72 96 and 120 K2O/fed as K2SO4 x sources of irrigation water (different qualities) of normal canal and drainage water. Four replicates in a split plot design were done. The main plots were designed to study the effect of irrigation water quality and the sub-plots were devoted to K-fertilization. The sub-plot area was 10.5 m2 (1/400 fed).

Soil samples from the surface (0-30 cm) and subsurface (30-60 cm) were taken before planting and after harvesting for each experiment and chemically analyzed according to Black (1965). Irrigation water samples were taken from El-Shoka main canal at El-Serw as well El-Serw main drain. The water samples were chemically analyzed every month to determine its quality according to Richards (1954). Parameters for soil and water total soluble salts determined were : TSS, pH, SSP, RSC, SAR, and Adj. SAR. As for tested crops, the standard recommendations of planting, weeding, fertilization and other agronomic practices for each crop were followed.

The crop yields data were statistically analyzed according to Snedecor and Cochran (1971).

RESULTS AND DISCUSSION

1- Characterizations of soil properties at the experimental sites:

As shown in Table 1, the important soil physical and chemical properties for surface and sub surface layers revealed that the texture class is clay with high CEC and low O.M. as well as CaCO3. Soil pH is slightly alkaline, and soil salinity (EC) besides soil sodicity (ESP) indicate that the soil is non-salime and non-alkaline, i.e.

normal. The predominant cation and anion in soil solution are Na+ and Cl-. Available N and to a less extent P & K nutrients in surface plough layer are considered of low amounts relative to the fertile soils that located in that region.

Table 1. Some selected soil physical and chemical properties at the two experimental sites.

Soil characteristics	Site1 (clover-wheat)		Site2 (rice-cotton)	
	0-30 cm	30-60 cm	0-30 cm	30-60 cm
Particle size distribution	51% clay; 24% silt; 19.5% sand Clay		55% clay; 26% silt; 14 % sand Clay	
CEC (meq/100 g)	44.30	--	43.20	--
ESP	8.78	--	9.95	--
O.M %	0.98	--	0.85	--
CaCO3 %	1.52	--	1.78	--
Soil-pH	8.10	0.143	8.20	--
Soil salinity (TSS) %	0.122	0.122	1.12	0.128
ECe (dS.m-1 25oC)	1.90	2.23	1.75	2.00
Soluble cations (meq/L)				
Ca+2	5.60	7.78	5.15	8.18
Mg+2	3.20	4.87	2.91	5.21
Na+2	9.40	8.84	8.695	7.32
K+	0.30	0.35	0.27	0.35
Soluble anions (meq/L)				
CO--3	0.00	0.12	0.00	0.23
HCO-3	4.80	6.00	4.32	5.40
Cl-	8.50	10.37	7.82	9.69
SO--4	4.94	5.55	4.59	5.79
Available-N-(ppm)	66.00	--	70.00	--
Available-P-(ppm)	8.50	--	9.00	--
Available-K-(ppm)	333.00	--	365.00	--

-- Not determined

II- Characterizations of irrigation water quality :

The chemical properties of the two irrigation sources are shown in Table 2 (a and b). With to El-Shoka main canal Table (2-a), values of pH (7.65) and EC (0.65 dSm-1/25oC) are considered in the normal range that does not cause any problem. The predominant cation and anion are Ca^{++} and $SO4^{--}$. The values of SSP, pHc, SAR, and adj. SAR were 24.47, 7.52, 0.96 and 1.81, respectively, which does not cause

any problem whether for the tested grown crops or the soil chemical properties according to Richards (1954), Balba (1980) and El-Guindy, (1987). Regarding the second source El-Serw main drain (Table 2-b) pH (7.8-07) is of no problems (EL-sunidy 1987) but with salinity, EC e.y (1.38-153 dS.m-1 /25^{0}C problems start. The predominant cations and anions were Na+, Mg++, HCO3, and SO_4 depending on growth seasons. The adjusted SAR values during growth months changes sharply to high values (7.76 in winter and to 8.83 in summer). This may increase the problems for such crops to a great extent. The values of pH which were more than 8.4 may precipitate CaCO3 in soil (Balba 1980 and Genaidy, 1995).

The comparison between the two sources of water indicate that the values of TSS, SSP and Adj. SAR for drainage water incrases by 162.5%, 164.3%, 164.5%, and 358% over the normal canal water values, respectively.

III- Effect on crops yield:

a. Main effects:

As shown in Table (3-a) the main factors of potassium fertilization and irrigation water quality affected the crops yield of winter crops (wheat and clover) as well as summer crops (rice and cotton) to different extents.

1- Potassium fertilization :

All crops, generally, responded to K-fertilization up to 48 kg K2O/fed. to give maximum yields.

For wheat, the obtained increments over the control treatment (K rate = O) were 6% and 14% for grain and straw yields, respectively. The grain/straw ratio was not affected. With regard to clover, the parallel increments were 13.5%, 8.7% and 11.7% for the three cuts, respectively. As for rice, the obtained increases were 9.7% and 7.5% over (control) for grain and straw yields, respectively. The grain/straw ratio was not affected. Regarding cotton the maximum seed cotton yield (9.475 kent./fed) gave an increment of4.5% over the control treatment.

2. Irrigation water quality:

Data presented in the same Table (3-a) indicate that no significant differences for wheat parameters. There was an increase of 2% in grain yield due to canal water over drain water. increment of 3% due to drain water occurred with clover. High yields of clover were achieved by using drain water, particularly in both first and second cuts with increments of 14%, 5% and 3.1% respectively. On the other

Table 2. Quality of irrigation water (a) Irrigation water (El-Shoka main canal-average values of 1994-1995.

(a) Irrigation water (El-Shoka main canal-average values of 1994-1995).

Chemical properties / Season	pH	EC dS.m	TSS ppm	Cations (meq/L)				Anions (meq/L)				RSC meq/L	SSP	pHc	SAR	Adj. SAR
				Ca++	MG++	Na+	K+	Co--3	HCO-3	Cl-	SO--4					
Winter season	7.7	0.50	320	2.10	1.45	1.20	0.18	0.12	1.88	0.48	2.13	-	24.34	7.61	0.91	1.63
Summer season	7.6	0.61	390	2.60	1.50	1.50	0.20	0.10	2.60	0.60	2.65	-	24.59	7.43	1.01	1.99
Mean	-	0.56	355	2.35	1.63	1.35	0.19	0.11	2.24	0.54	2.39	-	24.47	-	0.96	1.81

(b) Drainage water (El-Serw main drain-during 1994-1995 season).

Chemical properties / Season	pH	EC dS.m	TSS ppm	Cations (meq/L)				Anions (meq/L)				RSC meq/L	SSP	pHc	SAR	Adj. SAR
				Ca++	MG++	Na+	K+	Co--3	HCO-3	Cl-	SO--4					
Nov.	7.5	1.23	787	2.87	2.86	6.00	0.20	0.00	2.70	5.80	3.30	-	50.29	7.48	3.54	6.20
Dec.	7.9	1.50	960	2.90	3.90	8.20	0.30	0.08	4.10	7.20	4.20	-	53.59	7.20	4.45	9.79
Jan.	7.7	1.48	947	2.87	3.89	8.00	0.30	0.100	3.81	7.32	3.30	-	53.12	7.20	4.35	9.57
Feb.	8.0	1.83	1171	2.80	4.70	10.50	0.30	0.15	4.48	9.10	5.60	-	56.15	7.06	5.42	12.68
March	7.9	1.60	1024	2.50	4.50	8.80	0.24	0.05	4.50	7.40	4.60	-	54.86	7.05	1.20	2.83
April	7.8	1.55	992	2.80	3.60	9.00	0.25	0.00	4.54	6.80	4.50	-	57.51	7.15	5.03	11.32
Av. Winter	7.8	1.53	980	2.79	3.91	8.42	0.27	0.06	4.02	7.27	4.25	-	54.25	-	3.99	8.83
May	7.9	1.31	838	2.02	2.70	6.00	0.30	0.00	4.00	6.20	2.60	-	54.45	7.38	3.91	7.89
June	8.10	1.54	985	2.90	3.91	6.21	0.30	0.00	4.10	6.00	2.70	-	46.62	7.21	3.37	7.38
July	7.10	1.21	774	2.78	2.82	5.60	0.30	0.17	3.35	6.03	2.40	-	48.69	7.38	3.35	6.77
August	8.3	1.60	1024	2.34	2.77	5.50	0.22	0.15	3.81	6.72	2.10	-	50.78	7.27	3.44	7.33
Sept.	8.3	1.40	896	2.30	2.9	6.50	0.38	0.00	4.23	6.20	2.75	-	53.81	7.18	4.03	8.94
Oct.	8.0	1.33	851	2.10	2.75	6.05	0.35	0.00	4.10	6.00	2.50	-	85.71	7.28	3.89	8.25
Av. summer	-	1.38	894	2.41	2.98	5.98	0.31	0.05	3.93	6.19	2.51	-	51.67	-	3.67	7.76
Mean	-	1.47	938	2.60	3.44	7.19	0.29	0.06	3.98	6.73	3.32	-	52.96	-	3.83	8.29

hand, the high yields of summer crops i.e. rice and cotton were obtained by using canal water. The obtained increments were 14%, 3%, and 10% in rice grain yield, straw yield and grain/straw ratio, respectiely. An increment of 5.3% in cotton seed yield was obtained by using the drainage water.

b. Interaction effects:

Table (3-a) also showed that the crop yields were affected by the interaction between K-fertilization and irrigation water quality. As for wheat, by using canal water the higher yields were obtained by adding lower K-rates of 0,24, and 48 kg K2O/fed. caused increments of 3.5%, 7.5% and 3.6% over that obtained by using drain water. Using drain water with higher K-rates e.g. 72, 96 and 120 kg K2O/fed. gave increments of 1.5, 4.5 and 5.6% over that obtained by using canal water. Concerning clover, high yield were obtained by using drain water and application of K-fertilization. Regarding the summer crops e.g. rice and cotton gave high yields when K-fertilization was applid with the use of canal water for irrigation.

IV. Changes in soil chemical characteristics at the end of the experiment :

Data presented in Table 4 illustrate some selected soil chemical characteristics at planting and at harvesting. These data were for the two experimental sites under the effects of the two water resources. Soil-pH values were slightly affected by water sources and decreased by 0.1-0.2 unit when canal water was used and increased by 0.2 unit when drain water was applied.

Soil salinity was also slightly affected, since it was decreased by 0.2 $dS.m^{-1}$ 25°C by using canal water and was increased by about 0.0-0.2 $dS.m^{-1}$ 25°C by using drain water. Soluble cations and/or soluble anions were slightly affected by the two sources. Sodium adsorption ratio (SAR) and ESP were decreased due to canal water application while it was increased by using drain water but to a lower extent. The available forms of NPK were almost not affected by either water sources or soil experimental site since the differences were not significant.

Table 3. Effect of potassium fertilization and irrigation water quality on some field crops yields .

(a) Main effects.

Crop yields	Winter crops							Summer crops			
	Exp. 1 wheat, yield			Exp. 2 clover				Exp. 3 rice, yield			Exp. 4 cotton
	Grain Y. ton/fed	Straw Y ton/fed	Grain/Straw ratio	1st cut	2nd cut	3rd cut	Mean ton/fed.	Grain Y ton/fed.	Straw Y ton/fed.	Grain/straw ton/fed.	Seed cotton yield (kent./fed).
K-fert. rate (Kg K2O/fed.)											
0	2.109	2.925	0.721	5.220	10.975	12.352	9.507	3.045	4.320	0.705	9.075
24	2.188	3.070	0.713	5.500	11.585	12.850	9.978	0.245	4.765	0.681	9.040
48	2.245	3.340	0.672	5.925	11.935	13.775	10.595	3.340	4.645	0.719	9.175
72	2.225	3.365	0.661	6.140	12.130	14.125	10.798	3.175	4.260	0.745	8.270
96	2.158	3.355	0.643	6.125	12.655	13.750	10.843	2.715	4.335	0.626	8.920
120	2.162	3.390	0.637	5.360	12.035	12.725	10.040	3.175	4.330	0.733	8.835
LSD 0.05	0.105	0.250	n.s.	0.452	0.563	0.678	0.895	0.173	0.200	n.s.	0.340
Irrg. water quality											
Canal water	2.202	3.198	0.688	5.343	11.590	13.450	10.127	3.220	4.505	0.715	9.217
Drainage water	2.159	3.283	0.657	6.086	12.165	13.070	10.44	2.840	4.380	0.648	8.755
LSD 0.05	n.s.	n.s.	n.s.	0.400	0.335	0.107	0.213	0.274	n.s.	n.s.	0.139

(b) Interaction effects:

Crop yields	Crop yields				Summer crops			
	Wheat (grain yield) ton/fed.		Wheat (grain yield) ton/fed.		Rice (grain yield) ton/fed		Cotton (seed cotton yield kentar/fed.	
	Canal water	Drain water	Canal water	Drain water	Canal water	Drain water	Canal water	Drain water
K-fert. rate (Kg K2O/fed.)								
0	2.145	2.072	9.423	9.590	3.050	3.040	9.450	8.700
24	2.268	2.108	9.917	10.040	3.300	3.190	9.590	8.940
48	2.285	2.204	10.496	10.593	3.380	3.300	9.880	9.070
72	2.208	2.242	10.593	11.003	3.250	3.100	8.940	8.650
96	2.207	2.310	10.630	11.057	3.200	3.230	8.970	8.870
120	2.103	2.220	9.740	10.340	3.15	2.200	8.920	8.750
LSD 0.05	0.106		0.786		0.217		0.303	

Table 4. Soil chemical characteristics (0-30cm soil layer) at planting and harvesting at the two experimental sites using two sources of irrigation water.

Soil experimental site	Site1 (clover-wheat)			Site2 (rice-cotton)		
	Planting	Harvesting		Planting	Harvesting	
		Canal	drainage		Canal	drainage
Soil chemical changes:						
Soil-pH	8.10	7.90	8.30	8.20	8.10	8.40
TSS%	0.122	0.109	0.134	0.112	0.096	0.108
ECe (ds.m-1 at 25oC	1.90	1.70	2.10	1.75	1.50	1.70
Soluble ions: Cations (meq/L)						
Ca++	5.60	5.15	6.72	5.15	4.50	5.00
Mg++	3.20	2.88	358	2.91	2.47	2.80
Na+	9.40	8.55	10.34	8.65	7.35	8.50
K+	0.30	0.28	0.33	0.27	0.23	0.25
Anions (meq/L)						
CO--3	0.00	0.00	0.00	0.00	0.00	0.00
HCO-3	4.80	4.26	5.28	4.32	3.75	4.20
Cl-	8.50	8.82	9.32	7.82	6.72	6.90
SO--	4.94	4.35	5.30	4.59	4.300	4.86
SSP	50.80	50.70	49.30	51.00	52.00	51.00
SAR	4.48	4.27	4.56	4.300	2.21	4.30
ESP	8.78	8.00	8.74	9.95	8.750	10.50
Available-N-(ppm)	66.00	57.00	65.00	70.00	65.00	75.00
Available-P-(ppm)	8.50	8.75	9.00	9.00	9.500	12.00
Available-K-(ppm)	333.00	322.00	365.00	365.00	363.0	400.00

V. Conclusions :

From there findings it could be concluded that some main field crops i.e. wheat, clover, rice and cotton needs K-fertilization with an optimum rate of 48 kg K2O/fed. for obtaining maximum yields in clay soils of Dammietta governorate. There is no need to add more than 48 kg K2O/fed. as additional amount are not beneficial for such crops. With regard to water quality our irrigation, El-Serw main drain water is almost equal to El-Shoka canal in many cases concerning crop yields. While wheat yield was not affected, clover yield increased, but rice and cotton yields were lowered as a result of using the drainage water. The high values of TSS, SSP and Adj. SAR for such drain water were (162.5%, 164.3%, 358%, respective-

ly over the normal canal wate, showed that the salimity and alkalinity problems would increase on the long term usage. The interaction effects revealed that K-fertilization efficiency (expressed in crop yields) depends on irrigation water quality where it increases by using drainage water for winter crops, particularly clover and increased by using canal water for summer crops, especially cotton. This may be attributed to an indirect effect of Na+ and K+ balance and their relations in soil solution.

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التسميد البوتاسى لبعض محاصيل الحقل الرئيسية وعلاقته بصلاحية مياه الرى

محمد حسين حجازى ، سعيد جنيدى

مركز البحوث الزراعية – معهد بحوث الاراضى والمياه والبيئة – محطة البحوث الزراعية بسخا .

أجريت أربعة تجارب حقلية بمزرعة البحوث الزراعية بالسرو – بمحافظة دمياط – على محاصيل القمح والبرسيم والأرز والقطن وذلك خلال الموسم الزراعى ٩٤ / ١٩٩٥ بهدف تحديد المعدلات المثلى لاستخدام التسميد البوتاسى وتحديد صلاحية مياه الرى لتلك المحاصيل من مصدرين الأول ترعه الشوكة بالسرو (مياه عادية صالحة) والثانى المصرف الرئيسى بالسرو (مياه متوسطة الصلاحية) وكذلك تحديد التفاعل بين التسميد البوتاسى وصلاحية مياه الرى لمعرفة مدى كفاءته.

وتتلخص أهم النتائج المتحصل عليها فيما يلى :-

١ – تحتاج المحاصيل الرئيسية القمح ، البرسيم ، الأرز والقطن إلى المعدل الأمثل من التسميد البوتاسى (٤٨ كجم بو ٢أ/فدان على صورة كبريتات بوتاسيوم) وذلك لتعطى أعلا محصول مثل ٢,٢٤٥ ، ١٠,٥٤٥ ، ٢,٢٤٥ طن /فدان علي التوالي للقمح والبرسيم والارز ، ٩,٤٧٥ قنطار للفدان.

٢ – تم تقييم مياه مصرف السرو الرئيسى ووجدت انها متوسطة الصلاحية مقارنة بمياه ترعة الشوكة العادية الصلاحية وعلى الرغم من عدم وجود فروق كبيرة فى المحصول وحيث يتفوق محصول مياه الصرف أحيانا إلا أن ذلك ينذر بالخطر من استخدام هذه المياه على المدى البعيد لزيادة مشاكل الملوحة والقلوية – حيث القيم العالية للأملاح الذائبة الكلية (TSS) ، ونسبة الصوديوم الغائبة لباقى الكاتيونات (SSP) ، ونسبة الصوديوم المدمص المعدلة (Adj . SAR) قدرت بـ ١٦٢,٥٥٪، ١٦٤,٣٪ ، ٣٥٨٪ من قيم المياه العادية علي التوالى.

٣ – تعتمد كفاءة استخدام التسميد البوتاسى على صلاحية مياه الرى حيث انها تزيد باستخدام مياه الصرف للمحاصيل الشتوية خاصة البرسيم ، بينما تزيد باستخدام مياه الترعة العادية للمحاصيل الصيفية خاصة القطن ولعل ذلك يرجع إلى التأثيرات غير المباشرة للإتزان والعلاقات بين كاتيونات البوتاسيوم والصوديوم فى المحلول الأرضى.