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EVALUATION FOR EFFECTS OF POTASSIUM FERTILIZATION FROM SULFATE AND CHLORIDE SOURCES ON SOME MAIN FIELD CROPS

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Abstract

Four factorial field trials for some main field crops, i.e. wheat, faba bean, cotton and rice were carried out at Sakha Agric. Res. Station to evaluate potassium fertilization from two fertilizer sources, i.e. K_2SO_4 and KCl.

The important results could be summarized in the following points:

- Potassium fertilization with 24 kg K_2O/fed. (as K_2SO_4 fertilizer) increased crop's yields by 20.76, 24.45, 6.80 and 8.10 % for wheat, faba bean, cotton and rice, respectively; except for faba bean, k-fertilization with 12 kg K_2O/fed. (as KCl fertilizer) insignificantly increased such crops with parallel increments of 4.7, 16.49, 1.1 and 2.6%, respectively.
- High K-rates of 48 kg K_2O/fed. (as K-sulfate) or 24 kg K_2O/fed. (as K-chloride) were not proper rates for such crops because of the insignificant increments for the first fertilizer and side effects of chloride anion Cl^- for the second fertilizer.
- Interaction effects between K_2SO_4 and KCl fertilizers on crops' yields have revealed some antagonistic effects related to SO_2^{--} and Cl^- anions from soil and/or fertilizer especially in case of adding high K-rates which affected most nutrient's absorption by plants and subsequent crop's yields.
- For the studied soils, it may be recommended that potassium sulfate fertilizer is more effective than potassium chloride fertilizer for the crops under research.

INTRODUCTION

Some researchers have found potassium mineral fertilization responses for many field crops in different Egyptian soils (Abd El-Hady *et al.*, 1992; Genaidy and Hegazy, 1994; Hegazy and Genaidy, 1998 and Genaidy and Hegazy, 2000).

The inefficient amounts of available-K or disorders in nutritional balances in these soils enhance nutrients uptake especially N. Potassium improves many physiological growth processes where it increases plant tolerance to salinity as it lessens water stress and activates the enzyme system, even under saline conditions; in other words,

potassium enhances N uptake and improves the growth of salinized plants.

Most previous studies on K-fertilization used potassium sulfate source (K_2SO_4), but studies for experimenting potassium chloride (KCl) as a cheaper fertilizer source, are still limited except for some vegetable crops grown on sandy and loamy soils.

Hegazy and Genaidy (1998) showed that K_2SO_4 fertilizer efficiency depended on irrigation water quality, since it increased by using drainage water of moderate quality for winter crops especially clover, but it decreased by using canal water for summer crops especially cotton.

Our objectives of the present research are to elucidate potassium responses of some main field crops and to compare K-fertilizer efficiency obtained from K_2SO_4 and KCl fertilizer sources.

MATERIALS AND METHODS

Four factorial field experiments were carried out on four experimental sites at Sakha Agric. Res. Station, in Northern Delta during 1997/1998 and 1998/1999 growth seasons. Two experiments were conducted for winter crops i.e. wheat and faba bean along with two summer crops i.e. cotton and rice.

The factors for each experiment were the same and comprised K-fertilization source and rate i.e. K_2SO_4 - 48% K_20 (0, 24, 48 kg K_2O/fed.) along with KCl - 60% K_2O (0, 12, 24 kg K_2O) in a completely randomized block design with four replicates.

The recommended methods of planting, weeding, N and P-fertilization along with other agronomic practices for each crop were followed. Potassium fertilizers along with first N-fertilizer addition were added at early stages of growth.

Soil samples of the four experimental sites were analyzed according to the standard methods (Black, 1965 and Jackson, 1967) for some selected soil characteristics as listed in Table 1.

The obtained crop yield's data were statistically analyzed according to Snedecor and Cochran (1971) using the analyses of variance and the least significant difference (LSD 0.05) for the main effects and interaction effects due to potassium fertilization source and rate.

Table 1: Some selected soil characteristics of the experimental field sites

Experimental field site	Winter crops		Summer crops	
	1- Wheat	2- Faba bean	3- Cotton	4- Rice
Soil characteristics :				
Texture class	Clayey		Clayey loam	
O.M. (%) {Walkley & Black}	1.65	1.55	1.32	1.36
pH (1 : 2.5 susp.)	8.15	8.27	8.26	8.30
Salinity (ECe - ds.m^{-1} at 25°C)	2.35	1.89	3.08	3.33
Available - N (ppm) {K-sulphate}	80.0	75.0	43.6	43.3
Available - P (ppm) {Olsen}	13.0	9.50	8.13	7.35
Available - K (ppm) {Am-acetate}	285	360	275	310
Available - Zn (ppm) {DTPA}	1.20	1.01	0.75	0.87

Note: Each value in the table is an average value of a composite sample of the two experimental sites during both 1997/1998 and 1998/1999 seasons.

RESULTS AND DISCUSSION

1- Main effects on winter crops:

Table 2 reveals the main effects of potassium fertilization rate and source as well as the seasonal variation on the winter crop's yields.

a) Wheat crop:

Wheat grain yield significantly responded to K_2SO_4 - fertilizer. The optimum K-rate was 24 kg K_2O/fed. which obtained yield of 2.135 ton/fed. with an increment of 20.76% over (K_0) treatment. Potassium chloride fertilizer insignificantly increased wheat grain yield by adding 12 kg K_2O treatment (K_1) with an increase of 4.71% over (K_0).

The seasonal variation affected wheat yield where it was higher in the 2nd season than in the 1st one, with significant increment of 15.62%.

b) Faba bean crop:

Faba bean seed yield was significantly responded to potassium sulfate fertilizer. The optimum rate was 24 kg K_2O/fed. which resulted in seed yield of 1.522 ton/fed. with an increase of 24.45% over (K_0). Potassium chloride fertilization with 12 kg K_20 significantly increased yield by 16.49% over (K_0). Faba bean seed yield increased in the second season by 18.58% over that obtained in the first season.

Table 2: Effect of potassium fertilization on the two main studied winter crops

(a) Wheat grain yield (ton/fed.)

Growth season	1997/1998			1998/1999			T	Mean K_2SO_4	Mean KCl
KCl-fert. (kg K_2O/fed.)	0	12	24	0	12	24			
K_2SO_4-fertilizer (kg K_2O/fed.)									
0	1.51	1.67	1.85	1.81	1.84	1.94	10.61	1.77	K_0= 1.97
24	1.88	21.3	1.84	2.25	2.52	2.20	12.81	2.14	K_1= 2.07
48	2.05	1.90	1.95	2.35	2.35	3.13	12.72	2.12	K_2= 1.98
Mean	1.81	1.90	1.88	2.14	2.23	2.09			
Mean season	1.86			2.15					

LSD 0.05: K_2SO_4 0.22; KCL 0.52; Seasonal variation 0.27

(b) Faba bean seed yield (ton/fed.)

Growth season	1997/1998			1998/1999			T	Mean K_2SO_4	Mean KCl
KCl-fert. (kg K_2O/fed.)	0	12	24	0	12	24			
K_2SO_4-fertilizer (kg K_2O/fed.)									
0	0.81	0.21	1.32	0.97	1.46	1.58	7.34	1.22	K_0= 1.35
24	1.35	1.63	1.22	1.62	1.96	1.35	9.13	1.52	K_1= 1.57
48	1.55	1.43	1.20	1.78	1.72	1.44	9.12	1.52	K_2= 1.35
Mean	1.24	1.43	1.25	1.46	1.71	1.45			
Mean season	1.30			1.54					

LSD 0.05: K_2SO_4 0.23; KCL 0.16; Seasonal variation 0.23

2. Main effects on summer crops:

Table 3 indicates the main effects of potassium source and rate as well as seasonal variation on the summer crop's yields.

Table 3: Effect of potassium fertilization on the two studied summer crops

(a) Cotton seed yield (kentar/fed.)

Growth season	1997/1998			1998/1999			T	Mean K_2SO_4	Mean KCl
KCl-fert. (kg K_2O/fed.)	0	12	24	0	12	24			
K_2SO_4-fertilizer (kg K_2O/fed.)									
0	7.00	7.25	7.35	6.15	6.38	6.60	40.73	6.79	K_0= 7.09
24	7.85	8.20	7.15	6.73	6.82	6.73	43.48	7.25	K_1= 7.17
48	7.95	8.00	6.65	6.85	6.35	6.00	41.80	6.97	K_2= 6.75
Mean	7.60	7.82	7.05	6.58	6.52	6.44			
Mean season	7.49			6.51					

LSD 0.05: K_2SO_4 0.36; KCL n.s.; Seasonal variation 0.67

(b) Rice grain yield (ton/fed.)

Growth season	1997/1998			1998/1999			T	Mean K_2SO_4	Mean KCl
KCl-fert. (kg K_2O/fed.)	0	12	24	0	12	24			
K_2SO_4-fertilizer (kg K_2O/fed.)									
0	2.50	2.80	2.90	3.00	3.20	3.40	17.80	2.97	K_0= 3.08
24	2.80	3.20	3.10	3.27	3.57	3.30	19.24	3.21	K_1= 3.16
48	3.40	3.00	2.95	3.50	3.22	3.10	14.17	3.20	K_2= 3.12
Mean	2.90	3.00	2.98	3.26	3.33	3.27			
Mean season	2.96			3.28					

LSD 0.05: K_2SO_4 0.22; KCL 0.05; Seasonal variation 0.26

a) Cotton crop:

Cotton seed yield was significantly increased by adding K_2SO_4-fertilizer and insignificantly by applying KCl-fertilizer. Better yields of 7.25 and 7.17 kentar/fed. were obtained by adding 24 kg K_2O (as K_2SO_4) or 12 kg K_2O (as KCl), respectively, with parallel increments of 6.8% and 1.1% over (K_0).

The seasonal variation affected seed cotton yield where it was higher at the first season than that obtained at the second one with an increment of 15%.

b) Rice crop:

Rice grain yield was significantly increased by adding potassium sulfate fertilizer and insignificantly by adding K-chloride fertilizer. Better yields of 3.21 and 3.17 ton/fed. were obtained by applying 24 kg K_20 (as K_2SO_4) or 12 kg K_2O (as KCl), respectively, with related increments of 8.1% and 2.6% over (K_0).

Rice grain yield was affected by seasonal variation where it was higher in the second season than that obtained in the first one by 10.9%.

3. Interaction effects:

As shown in Table 4, K-sulfate x K-chloride fertilizers interaction effects on yields of wheat, faba bean, cotton and rice have been significant. With respect to wheat, the highest grain yield of 2.323 ton/fed. was obtained by adding the treatment [24 kg K_2O (as K-sulfate) + 12 kg K_2O (as K-chloride)] which led to increments of 12.60, 22 52 and 13.98% over the treatments of 24 kg K_2O whether from K-sulfate or K-chloride separately or in combination, respectively.

For faba bean, the best seed yield of 1.796 ton/fed. was obtained by adding the treatment [24 kg K_2O (K_2SO_4)+ 12kg K_2O (KCl)] with increments of 20.9, 24.20, 36.06% over the treatments of 24 kg K_2O whether from K_2SO_4 or KCl fertilizers only or in combination, respectively.

For cotton, the highest seed cotton yield of 7.52 kentar/fed. was obtained by applying the same fertilizer treatment of [24 kg K_2O (K-sulfate) + 12 kg K_2O. (K-chloride)] with parallel increase of 3.10, 7.75, 18.83% over the same previously indicated correspondent treatments, respectively.

As for rice, the highest grain yield of 3.885 ton/fed. was obtained by the same superior fertilizer treatment with the increments of 11.63, 7.46, 11.9% over the same previously indicated correspondent treatments, respectively.

Table 4: Responses of crops' yield to potassium sulfate x potassium chloride interactions

1- Winter crops:

(a) Wheat (ton/fed.) (b) Faba bean (ton/fed.)

KCl-fert. (kg K_2O/fed.)	0	12	24	0	12	24
K_2SO_4-fertilizer (kg K_2O/fed.)						
0	1.66	1.75	1.90	0.89	1.33	1.45
24	2.06	2.32	2.02	1.49	1.80	1.28
48	2.20	2.12	2.04	1.67	1.58	1.32
LSD 0.05	**0.24**			**0.37**		

2- Summer crops:

(a) Cotton (Kent/fed.) (b) Rice (ton/fed.)

KCl-fert. (kg K_2O/fed.)	0	12	24	0	12	24
K_2SO_4-fertilizer (kg K_2O/fed.)						
0	6.58	6.82	6.98	2.75	3.00	3.15
24	7.29	7.52	6.94	3.04	3.39	3.20
48	7.40	7.18	6.33	3.45	3.11	3.03
LSD 0.05	**0.52**			**0.26**		

4- Conclusion:

According to the above mentioned results, the following points could be concluded:

- Potassium fertilization with 24 kg K_2O/fed. as K_2SO_4 fertilizer significantly increased wheat, faba bean. cotton and rice yields by 20.76, 24.45, 6.8 and 8.1% for such crops, respectively.
- Potassium fertilization with 12 kg K_2O/fed. as KCl fertilizer insignificantly increased the yields of these crops except faba bean which was significantly affected. The parallel increases were 4.7, 16.49, 1.1 and 2.6%, respectively.
- High potassium rates of 48 kg K_2O (as K_2SO_4) or 24 kg K_2O/fed. (as KCl) fertilizer were not effective for such crops because of the insignificant increments related to the first fertilizer and side effects of chloride anion Cl- for the second one.
- Interaction effects between K_2SO_4 and KCl fertilizers on crops' yields may suggest some sort of antagonism between SO_4^{--}, Cl^- anions whether from soil or fertilizer, especially in adding high potassium rates which have affected SO_4^{--}, Cl^- absorption by plants and subsequent crops' yields.
- For the studied soils, it may be recommended that potassium sulfate fertilizer is more effective and beneficial than potassium chloride fertilizer, although the latter is cheaper than the first one, for the mentioned crops.

REFERENCES

1. Abd El-Hadi, A.H. 1992. "Potassium and its effects on crops yields in soils of Egypt". Soil, Water and Environment Res. Institute, ARC, Egypt.

2. Black, C.A. (ed), 1965. "Methods of soil analyses". Amer. Soc. Agron. Inc. Pub., Madison, Wisconsin, USA.

3. Genaidy, S.A. and M.H. hegazy.1994. Evaluation of mineral fertilization for main field crops: relative efficiencies and economic rates. Egypt. J. Agric. Res. 72(1): 1-12.

4. Genaidy, S.A. and M.H. Hegazy. 2000. Research and application facts in plant nutrition. Aldar Alarabia Linashar Wa Tawsea. Cairo, Egypt.

5. Hegazy, M.H. and S.A. Genaidy. 1998. Potassium fertilization for some main field crops in relation to irrigation water quality. Egypt J. Agric. Res. 76(2) 437-449.

6. Jackson, M.L. 1967. "Soil chemical analysis". Constable Co., LTD, London.

7. Snedecor, G.W. and W.G. Cochran. 1971. "Statistical methods". 6^{th} Ed. Iowa State Univ Press. Ames. Iowa, USA

تقييم مصادر التسميد البوتاسى من الكبريتات والكلوريد لبعض محاصيل الحقل الرئيسية

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أقيمت أربع تجارب حقلية عاملية على أربعة محاصيل هى القمح، الفول ابلدى، القطن والأرز بمحطة البحوث الزراعية بسخا فى موسمى ١٩٩٧/١٩٩٨، ١٩٩٨/١٩٩٩ وذلك لتقييم التسميد البوتاسى من مصدريه كبريتات البوتاسيوم K_2SO_4 وكلوريد البوتاسيوم KCl. ويمكن تلخيص أهم النتائج فى الآتى:

١- يعتبر التسميد البوتاسى بمعدل ٢٤ كجم بو٢أ/ف من مصدر كبريتات البوتاسيوم مناسباً لتلك المحاصيل، حيث حقق زيادة فى المحصول تقدر بـ ٢٠,٧٦ ٪، ٢٤,٤٥ ٪، ٦,٨ ٪، ٨,١ ٪ لتلك المحاصيل على الترتيب، بينما حقق التسميد بكلوريد البوتاسيوم بمعدل ١٢ كجم بو٢أ/ف زيادات غير معنوية فى المحصول ما عدا محصول الفول. وتقدر تلك الزيادات بـ ٤,٧ ٪، ١٦,٤٩ ٪، ١,١ ٪، ٢,٦ ٪ لمحاصيل القمح، الفول، القطن والأرز على التوالى.

٢- المعدلات العالية سواء من كبريتات البوتاسيوم (٤٨ كجم بو٢أ/ف) أو من كلوريد البوتاسيوم (٢٤ كجم بو٢أ/ف) ليس لها فائدة مؤكدة بسبب عدم المعنوية فى زيادات المحصول بالنسبة لسماد كبريتات البوتاسيوم أو بسبب التأثير الجانبى لسماد كلوريد البوتاسيوم والذى يتلخص فى خطورة زيادة أنيون الكلوريد Cl^- فى المحلول الأرضى.

٣- أوضح تأثير التفاعل بين مصدرى السماد على المحصول التضاد بين أنيونى So_4 والكلوريد Cl^- سواء من المصادر السمادية أو الأرض وذلك عند إضافة المعدلات العالية من الأسمدة والتى تؤثر على إمتصاص كثير من العناصر الغذائية اللازمة للنبات خاصة النيتروجين، البوتاسيوم والكبريت وبعض العناصر الدقيقة خاصة الزنك مما يؤثر فى النهاية على العائد من تلك المحاصيل.