EFFECT OF RATES AND FORMS OF POTASSIUM FERETILIZATION ON RICE CROP UNDER SALT AFFECTED SOIL CONDITIONS AT NORTHERN DELTA OF EGYPT

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INTRODUCTION

Rice (*Oryza sativa*, L.) is the staple food for more than half of the world's population. In Egypt, rice is a very important cereal crop for both consumption and export. Salinity in the Nile Delta increases progressively from less than 4 ds/m in the southern part to about 16 ds/m in the northern coastal area, which is suffering from intrusion of seawater, water shortage and poor quality of irrigation water.

Therefore, rice is considered as reclamation crop for saline soil in North Delta because of its flooding condition. Also, rice cultivars avoid Na^+ toxicity by maintaining a high level of K^+ in the terms of high affinity of K^+ uptake against Na^+ (Zayed, 2002).

Von Uexkull and Beaton (1992) pointed out that rice roots are very efficient in extracting K from the soil solution and under intensive cropping most soils will sooner or later be exhausted in K reserves and thus become responsive to applied potash fertilizer.

Also, depletion of soil K is hastened by the removal of rice straw. Although the Egyptian soils showed somewhat high K-content, sporadic response of several crops to K fertilization have been reported. This is because of the existence of dynamic equilibrium among the different forms of K in soil.

Potassium chloride or muriate of potash (MOP) accounts for some of 91% 0f world potassium consumption in agriculture. Due to its relatively low price and high K content (60% K2O), the vast majority of crops fertilized with K chloride including field and horticultural crops.

The other potash products namely sulphate of potash (SOP) and nitrate of potash (NOP) account for 7% and 2% respectively (IPI Research Topics No. 22, 2001). Thus, choosing the right kind of potash fertilizer can be as important as applying the right amount of potash to a crop.

- There is combination of soil and climate conditions where the use of potassium chloride can exacerbate the damaging effects of salinity (as in Egypt) because of its high chlorine content (48%).

- So, sulphate of potash (50% K2O and 18% S) is the most preferred K source in Egypt should reach up to 250,000 tons K_2O in the future.

The question has been recently raised whether the introduction of potassium chloride in Egypt would help to satisfy the growing demand while costing the country less hard currency and whether it can be used safely without detrimental long-term effects on crop yield and quality and soil conservation especially under prevailing conditions of increasing fertilizer rates.

This study aim to evaluate the comparative effects of SOP and MOP on rice as well as soil salinity and contents of chlorine and available potassium throughout long-term Experiments.

MATERIALS AND METHODS

Two long-term trials (LTT) were initiated in 1999/00 and lasted until 2003 growing season at El-Serw Agricultural Research Station (clayey soils), Damietta Governorate (North of Nile Delta) to compare the relative effectiveness of potassium sulphate (SOP) and potassium chloride (MOP) on various annual crops and soil contents of total soluble salts (TSS), soluble chloride and available potassium.

Damietta
Mediterranean Sea
Nicosia
Cyprus
Syria
Lebanon
Beirut
Damascus
Israel
'Amman
Jerusalem
Dead Sea
Jordan
Sallum
Matruh
Alexandria
Port Said
Libya
Tanta
Suez Canal
Ismailia
Cairo
Al Jizah
Helwan
Suez
Siwa
El Faiyum
Gulf of Suez
Gulf of Aqaba
Beni Suef
Bawiti
Ras Gharib
El Tur
El Minya
Saudi Arabia
Nile R.
Hurghada
Asyut
Bur Safaga
Egypt
Sohag
Qena
Quseir
El Kharaga
Luxor
Mut
Baris
Red Sea
Aswan
Aswan High Dam
Berenice
Lake Nasser
0 200 km
0 150 mi
Sudan
Area claimed by Sudan and Egypt, adminstered by Sudan.
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24° 28° 32° 36°

The two experiments were established on two different sites having the following characteristics:

Table 1. soil analysis of the experimental sites (sampling of 1999).

Soil characteristics	El-Serw-1	El-Serw-2
Soil texture	Clayey	Clayey
CEC (meq/100 g soil	44.2	44.4
Soil PH (1: 2.5 susp.)	8.2	8.7
TSS%	0.24	0.36
OM%	1.45	1.24
ESP%	12.5	16.2
Cl meq/100 g soil	2.97	4.32
Available-N (K-sulphate ext.) ppm	35	28
Available-p (Olsen ext.) ppm	11.4	9.8
Available-K (Amm. Acet. ext.) ppm	578	550

Rice (Oryza sativa L., variety Giza 178) was comprised in the crop sequences as a summer crop during 2001 and 2003 seasons at El-Serw-1 and during three summer seasons (2000, 2002 and 2003) at El-Serw-2.

The two experiments had five treatments as follows:

1-Control without K fertilizer.

2-70 kg K_2O/ha in the form of SOP (50% K_2O).

3-140 kg K_2O/ha in the form of SOP (50% K_2O).

4-70 kg K_2O/ha in the form of MOP (60% K_2O).

5-140 kg K_2O/ha in the form of MOP (60% K_2O).

The treatments were arranged in Latin square design with five replications with plot size 25 m^2. Potash fertilizers were applied in two equal doses; i.e. 2 weeks after transplanting and at panicle initiation. Urea (46% N) was used as source of nitrogen fertilizer (144 kg N/ha) in two equal doses to all treatments.

Table (2): crop sequence at each location during the experimental period

Location / Seasons	El-Serw-1	El-Serw-2
1999/00 (winter season)	Berseem	Wheat
2000 (summer season)	Maize	Rice
2000/01 (winter season)	Wheat	Berseem
2001 (summer season)	Rice	Maize
2001/02 (winter season)	Berseem	Berseem
2002 (summer season)	Maize	Rice
2002/03 (winter season)	Wheat	Berseem
2003 (summer season)	Rice	Rice

The first was applied 2 weeks after transplanting and the second was added at panicle initiation. Equal doses (36 kg P_2O_5 / ha) of triple superphosphate (46% P_2O_5), free- sulphate was applied to the soil surface before final land preparation and thoroughly mixed into the soil.

At harvest, rice grain and straw yields were recorded (ton/ha). The dry grain samples from each plot were ground and wet digested with H_2SO_4-$HClO_4$ mixture as described by Peterburgski (1968).

- Nitrogen, Phosphorus and Potassium percentages were determined according to Black (1982).
- Chloride was determined according to Piper (1947).
- Sulphate was determined according to Chapman and Pratt (1961).

Representative soil surface (0-30 cm) samples were collected from each plot after harvesting the rice crop to follow up the concentration of salinity, soluble Cl and the available K. TSS was estimated according to Jackson (1973). Soluble chloride was also determined by titration with silver nitrate according to Jackson (1973).

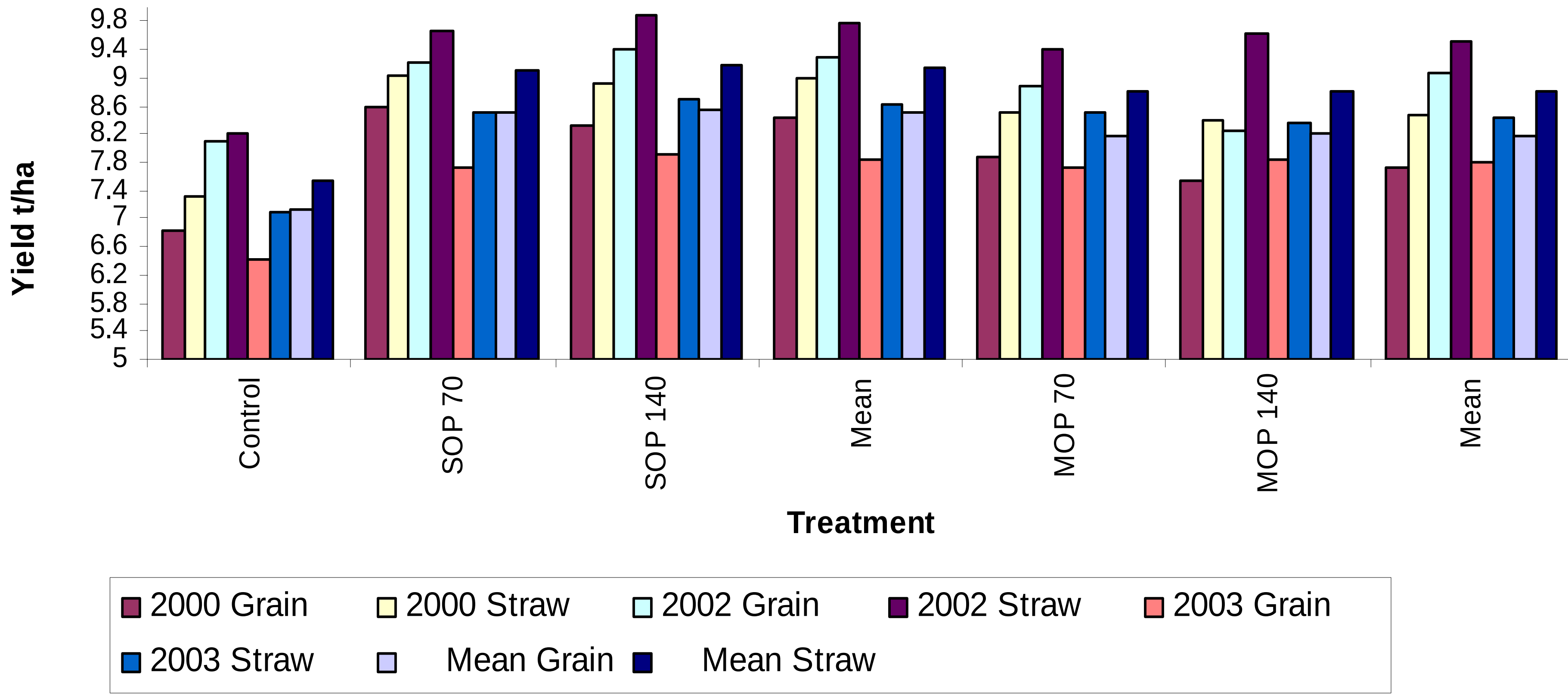
- ☞ The available K was extracted by neutral (1N) ammonium acetate and determined by flame Photometer (Jackson, 1973).
- ☞ Finally, the economic aspects of using potassium fertilizer were done.

RESULTS AND DISCUSSION

A- Rice yield data:

- The obtained results showed significant increase in both grain and straw yields as a result of using both SOP and MOP fertilizers with no significant differences between the two rates (70 and 140 kg K_2O/ha).

Effect of different sources of potassium fertilizers and its rates (Kg K_2O/ha) on rice crop production (t/ha) during the experimental period at El-Serw-2.

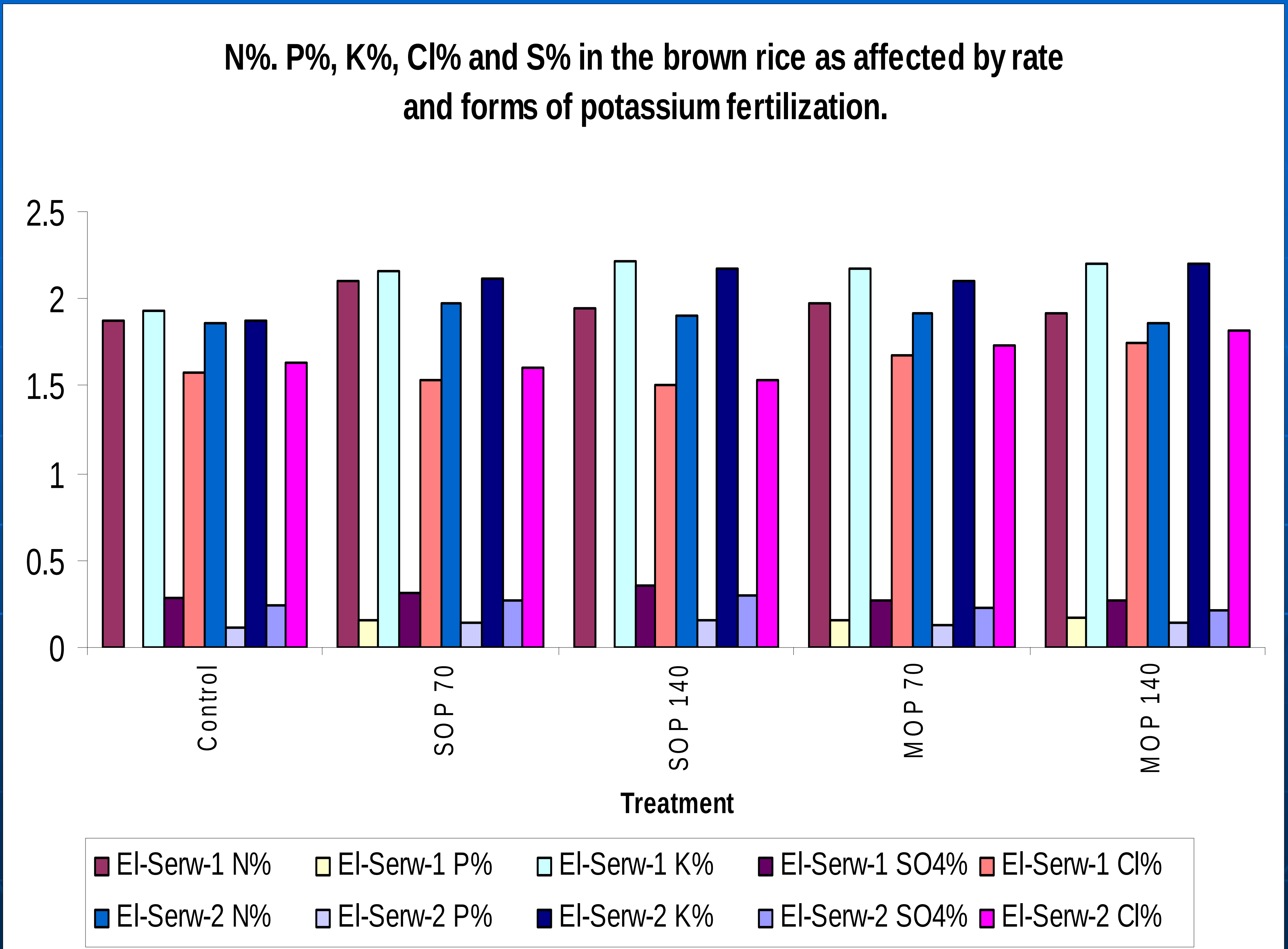


	2000		2002		2003	
	Grain	Straw	Grain	Straw	Grain	Straw
LSD at 5%	0.95	0.98	0.73	0.85	0.94	0.98

Generally (according to the mean results of two years at El-Serw-1 and three years at El-Serw-2), using SOP fertilizer resulted an increase of rice grain yield over control (0-K) treatment being 24.5% and 29.6% at El-Serw-1 and 19.55% and 20.11% at El-Serw-2 with the rates of 70 and 140 kg K2O/ha respectively.

In conclusion, the grown rice at this location in North Delta (heavy clayey soil) showed positive significant response to both SOP and MOP fertilizers in most cases. Moreover, MOP fertilizer, especially at the higher rate, induced slight reduction in rice yield compared to SOP confirming that SOP is exclusive for salt affected soils.

B- Elements concentrations:


N%. P%, K%, Cl% and S% in the brown rice as affected by rate and forms of potassium fertilization.
2.5
2
1.5
1
0.5
0
Control
SOP 70
SOP 140
MOP 70
MOP 140
Treatment
El-Serw-1 N%
El-Serw-1 P%
El-Serw-1 K%
El-Serw-1 SO4%
El-Serw-1 Cl%
El-Serw-2 N%
El-Serw-2 P%
El-Serw-2 K%
El-Serw-2 SO4%
El-Serw-2 Cl%

The results indicated that the higher N% was found in plants fertilized with SOP and MOP respectively, compared with the control (no K fertilization), which gave the lowest value of N%. However, the lower rate (70 kg K2O/ha) in both two forms gave values of N% more than those of the higher rate (140 kg K2O/ha). In this respect, Liu and Shelp (1996) pointed out that N content did not decrease in response of Cl application.

While, MOP caused an increase of rice grain yield over control treatment being 22.7% and 26.64% at El-Serw-1 and 14.91% and 15.47% at El-Serw-2 with using the above mentioned two rates. The IPI Research Topics No. 22 (2001) mentioned that potassium application could lessen detrimental effects of drought and soil compaction on root growth and yield of upland rice. When K was applied, soil compaction did not decrease grain even with a low water supply.

Treatment	El-Serw-1					El-Serw-2				
	N%	P%	K%	SO4 %	Cl%	N%	P%	K%	SO4 %	Cl%
Control	1.88	o.14	1.93	0.28	1.58	1.86	0.12	1.88	0.24	1.64
SOP 70	2.10	0.16	2.16	0.31	1.54	1.98	0.14	2.12	0.27	1.60
SOP 140	1.94	o.18	2.22	0.36	1.50	1.90	0.16	2.18	0.30	1.54
MOP 70	1.98	0.15	2.17	0.27	1.68	1.92	0.13	2.10	0.23	1.74
MOP 140	1.92	0.17	2.20	0.27	1.75	1.86	0.14	2.20	0.21	1.82

- Results also indicated that SOP produced a high value of P% than MOP. This may be attributed to low salt index of potassium sulphate in the root zone, which caused an increasing in the uptake of phosphorus.

- Regarding K content, the results showed that K% was increased with adding the two forms of K fertilizers.

- Results of Cl% and SO4% showed that application of MOP increased Cl%, while SOP decreased its content. Vice versa, SOP increased SO4%, while MOP decreased its content.

C- Soil analysis:

☛ Soil surface samples were collected after each summer crop (rice in this study) and subjected to chemical analysis to follow up the soil contents of TSS, soluble Cl and available K under the application of the two K sources.

☛ The obtained results showed variations between the two locations according to soil contents of TSS and Cl at El-Serw-1 comparing with the 0-K treatment, minor changes in TSS and Cl contents were detected due to both SOP and MOP application.

This could be due to soil flooding under rice planting, which prevents salt accumulation because of the vertically down and predominant percolation of irrigation water taking the dissolved salts with it. This shows that the choice of potash forms is not of great important for crop rotation included rice at El-Serw-1 location (not salt affected soil).

- On the other hand, at El-Serw-2 location (salt affected soil), soil content of TSS and Cl under the two rates of SOP and the lower rate of MOP showed nearly the same trend of El-Serw-1, but the higher rate of MOP gave slight increase of soluble Cl content compared to 0-K treatment.

- On the average of years at El-Serw-2, soil Cl content increased from 1.61 to 2.73 mg/100 g soil for the 0-K and the higher rate of MOP respectively.

Treatment	2001			2003			Mean		
	TSS %	Cl meq/ 100g soil	Avail. K ppm	TSS %	Cl meq/ 100g soil	Avail. K ppm	TSS %	Cl meq/ 100g soil	Avail. K ppm
Control	0.21	1.12	482	0.28	1.45	466	0.25	1.29	474
SOP 70	0.26	1.59	551	0.25	1.54	534	0.26	1.57	542.5
SOP 140	0.21	1.01	654	0.26	1.04	559	0.24	1.03	606.5
Mean	0.24	1.30	603	0.26	1.29	546.5	0.25	1.30	574.5
MOP 70	0.25	1.24	653	0.27	1.32	589	0.29	1.28	621
MOP 140	0.28	1.55	627	0.34	1.58	560	0.31	1.57	593.5
Mean	0.27	1.40	640	0.31	1.45	574.5	0.30	1.43	607.3

Regarding the available soil K content, data showed that the extractable NH4OAC-K was fluctuated from year to year may be because of the existence of dynamic equilibrium among the various forms of K in the soil.

- Also, availability of K is controlled by its release from k bearing minerals and fixation by partially weathered minerals (Akhtar, 1993). At both sites, the available soil K content was higher by potash fertilizer application in favor of MOP rates in most cases.

On average of years and k rate, it was increased from 474 ppm for 0-K to 574.5 ppm and 607.3 ppm for SOP and MOP respectively at El-Serw-1 and from 482 ppm for 0-K to 568 ppm and 586.2 ppm for SOP and MOP respectively at El-Serw-2 .

Also, the IPI Research Topics No. 22 (2001) mentioned that under reducing conditions (as a result of flooding conditions in Paddy field), Fe^{+2}, Mn^{+2} and NH^{4} are released in the soil solution by various processes and displace K from the exchange sites, increasing its concentration in the soil solution and its availability to rice.

Treatment	2001			2002			2003			Mean		
	TSS %	Cl meq/ 100g soil	Avail. K ppm	TSS %	Cl meq / 100g soil	Avail. K ppm	TSS %	Cl meq / 100g soil	Avail. K ppm	TSS %	Cl meq / 100g soil	Avail. K ppm
Control	0.19	1.78	486	0.30	1.74	492	0.25	1.34	468	0.25	1.61	482
SOP 70	0.20	1.79	566	0.29	1.63	553	0.26	1.46	545	0.25	1.63	554.7
SOP 140	0.17	1.36	636	0.30	1.36	560	0.28	1.23	548	0.25	1.32	581.3
Mean	0.19	1.58	601	0.30	1.50	557	0.27	1.35	546.5	0.25	1.48	568
MOP 70	0.26	2.79	502	0.37	2.51	566	0.34	2.34	564	0.32	2.55	544
MOP 140	0.34	3.11	720	0.41	2.67	587	0.38	2.42	578	0.38	2.73	628.3
Mean	0.30	2.95	616	0.39	2.59	577	0.36	2.38	571	0.35	2.64	586.2

D- Economic aspects of potassium fertilizer use:

Despite the two sites of this experiment are rich in their available potassium (Table 1), adding both SOP and MOP show significant effect on this study. This could be attributed to the fact that soil tests for K often fail in many cases to reveal the true fertilizer demand in the field, resulting in frequently unreliable and inefficient fertilizer recommendations.

Also, because soil tests measure primarily only the soluble and exchangeable forms of K, any uncontrolled or unrecognized transitions of K among its forms between the time of testing and the time of attempted uptake by the plant roots will produce an erroneous prediction of available K (Shen and Stuki, 1994).

Because of the price differential between the two forms of potash under study, it is important to compare the economics of using both SOP and MOP on rice crop at North Delta. It can be seen that at El-Serw-1, the high rate of MOP (140 kg K2O/ha) resulted a larger net return (LE 1618) than the same rate of SOP (LE 1576), this is because of its low cost than that of SOP.

On contrast, at El-Serw-2 (salt affected soil) data showed that the low rate of SOP resulted the highest net return (LE 1138/ha) followed by the low rate of MOP (LE 934/ha) and the high rate of SOP (LE 926/ha). While, the high rate of MOP resulted the lowest net return (LE 848/ha) as a result of the harmful effect of high Cl anions around the root zone of rice plants in this location, and these are in harmony with the values of the parameter of kg rice grain/kg K2O.

Treatment	El-Serw-1						El-Serw-2					
	Rice grain yield, kg/ha	Yield increase, kg/ha	Value of yield increase, L.E/ha	Cost of K ferti., L.E/ha	Net return L.E/ha	Kg rice grain//kg K_2O	Rice grain yield, kg/ha	Yield increase, kg/ha	Value of yield increase, L.E/ha	Cost of K ferti., L.E/ha	Net return L.E/ha	Kg rice grain//kg K_2O
Control	7020	--	--	--	--	--	7710	--	--	--	--	--
SOP 70	8740	1720	1720	252	1468	24.6	8500	1390	1390	252	1138	19.9
SOP 140	9100	2080	2080	504	1576	14.9	8540	1430	1430	504	926	10.2
MOP70	8610	1590	1590	126	1464	22.7	8170	1060	1060	126	934	15.1
MOP140	8890	1870	1870	252	1618	13.4	8210	1100	1100	252	848	7.9

CONCLUSION

The choice of potash form is not of great important for crop rotation included rice in soil having low TSS and Cl contents; maintaining an adequate K supply and high net profit is the prime consideration. On the other hand, only chloride- free potash fertilizers such as SOP could be recommended at location having the trait of high TSS and Cl contents.

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