Effect of Potassium Chloride in Comparison with Potassium Sulfate on Sugar Cane Production and some Soil Chemical Properties under Egyptian Conditions

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ABSTRACT

Two field trials were carried out at two private locations (El-Sheikh Makram and Shandaweel El- Balad) in Sohag Governorate (Upper Egypt, loamy soil) to investigate the effect of potassium fertilizer rate (115 and 230 Kg K_2O / ha) and source, i.e. potassium sulfate (SOP) and potassium chloride (MOP). The experiment at El-sheikh Makram location was initiated in the spring of 2001 while that of Shandaweel El-Balad was initiated in autumn of the same year.

The obtained results showed slight changes in melable and sugar yields of the first two cuts, at El-Sheikh Makram, due to K fertilizer application in favor of SOP with no specific trend, while melable and sugar yields of the second ratoon showed marked increases when recommended K rate was doubled in both K forms in favor of SOP also. At the second location of Shandaweel El-Balad, although some adverse effects on melable and sugar yields of plant cane were noticed due to MOP application with minor effects for SOP, the higher K rate as SOP and the recommended one as MOP induced increases in melable and sugar yields of the first ratoon but these increases did not reach the significance.

On the other hand, no salinity building up or Cl accumulation due to MOP application was detected at the soil of the two locations, while K application at both rates of the two sources resulted in different increases in the available soil K with no marked differences between the two K sources.

1. Introduction

Potassium fertilization in Egyptian agriculture have become very important since the completion of the High Dam because of the deposition of the suspended Nile silt-rich in K bearing minerals in the upstream of the formed lake. So, the demand for potash fertilization has been increased. Although the Egyptian soils showed somewhat high K-content, sporadic responses of different crops to K fertilization have been reported (Abd El-Hadi, 1989 and Abd El-Hadi et al., 1990), may be because of the existence of dynamic equilibrium among the different sources of K in the soil. However, continuous crop removal without compensation is likely to cause an irreparable damage from the soil fertility of view.

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Sugar cane is known as a potassium devourer, its need reaching 600 to 800 Kg K_2O per hectare per harvest; since potassium influences important if not all cell activities, it is difficult to speak therefore of any specific effect. It is a fact that today in most sugar cane areas, the cane crops uptake more potash from the soil than fertilization puts into it (in the forms of potash fertilizers and molasses), thus leaving a negative potash balance. Therefore unless inexhaustible potash reserves are present in young alluvial soils, this observation shows that sugar cane areas are facing gradual potassium impoverishment (Husz, 1972). Mahmoud et al. (1984) found a significant yield response to K of ratoon crop. Azeredo and Peixota (1978) and Tantawi (1979) found that fertilization with K resulted in increasing melable cane and sugar yield in the first cut as well as first and second ratoons. Abd El Hadi et al. (1992) reported that melable cane yield was increased by 11.17% and sugar yield by about 12.18% due to the addition of 48 Kg K_2O/ fed. They added that from the economical point of view, the addition of 48 Kg K_2O/ fed was more superior for higher sugar cane yield production and sugar yield than the rate of 96 Kg K_2O/ fed.

Choosing the right kind of potash fertilizer can be as important as applying the right amount of potash to sugar cane crop. Potassium chloride or muriate of potash (MOP) accounts for some of 91% of world of potassium consumption in agriculture. Due to its relatively low price and high K content (60% K_2O), the vast majority of crops fertilized with potassium chloride including field, horticultural and plantation crops. The other potash products namely sulfate of potash (SOP) and nitrate of potash (NOP) accounts for 7% and 2% respectively. The IPI research topics NO. 9 (1981) reported that much work has been done on the effects of K on sugar cane but there has been little interest in comparing forms of K fertilizer because sugar cane is not thought to be chloride sensitive. While, from the plant physiological point of view, there is no advantage in using SOP on sugar cane, there is however an advantage under technological aspects as high rates of MOP have unfavorable effects on juice purity. Thus, it was advised in the Philippines that, when more than 120 Kg K_2O / ha are applied, sulfate should be used to supply the extra K_2O instead of MOP. The question has been recently raised whether the introduction of potassium chloride in Egyptian agriculture 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 condition of increasing fertilizer rates.

In view of this, two field experiments with sugar cane were set up in Sohag Governorate (Upper Egypt) at two locations (Two private fields) i.e., El-Sheikh Makram and Shandaweel El-Balad, to evaluate the comparative effects of SOP and MOP on sugar cane production as well as soil salinity and soil contents of chlorine and available potassium.

2. Materials and methods

To compare the relative effectiveness of potassium sulfate and potassium chloride on sugar cane productivity and soil contents of total soluble salts (TSS), soluble chloride and available potassium, two field experiments were conducted in Sohag Governorate (Upper Egypt) at two locations, i.e. El-Sheikh Makram and Shandaweel El-Balad (two private fields).

Each field experiment comprised five treatments as follows:

(1) 0-K: control with no K fertilization.
(2) SOP1: The recommended rate of K fertilizer (115 Kg K_2O /ha) as K-sulfate.
(3) SOP2: Twice recommended rate of K fertilizer (230 Kg K_2O /ha) as K sulfate.
(4) MOP1: The recommended rate of K fertilizer (115 Kg K_2O /ha) as K-chloride.
(5) MOP2: Twice recommended rate of K fertilizer (230 Kg K_2O /ha) as K-chloride.

The treatments were arranged in Latin Square design with five replications. Potash fertilizer rates of both sources were applied in two equal doses, i.e. at planting and one month later. N and P fertilizers were applied in proper rate and form at the right time of application for sugar cane. Representative soil surface (0-30 cm) samples were collected from each plot, in the two experiments, after harvesting the crop for every year to follow up the concentrations of TSS, soluble
Cl and available K. TSS were estimated by measuring the electrical conductivity of the 1:5, soil: water extract in dS/m then multiplied by 0.32 to obtain the TSS percentage according to Jackson (1973). Soluble Cl was also determined by titration with silver nitrate using a chromate indicator (Chapman and Pratt, 1961). The available K was extracted by neutral (1N) ammonium acetate and determined by flame photometer.

3. Results and discussion

3.1 Crop Yield Data

Sugar cane was grown in two locations in Sohag Governorate: El- Sheikh Makram where the experiment was initiated in the spring season of 2001 and Shandaweel El-Balad where it was initiated in the autumn season of the same year.

3.1.1. El-Sheikh Makram experiment:

The obtained data in Table (1) showed that melable cane, sugar yield and sucrose percentage of the plant cane, as well as the first and second ratoons were not significantly affected by either potassium fertilizer rate or potassium source. However, the recommended K levels as SOP recorded increases in sugar yield of plant cane and first ratoon by 14 and 16 % respectively and in melable cane yield of the two cuts by 9 %. The second ratoon showed the contrary, since the higher K level (the twice recommended rate) in both sources induced increases in both plant cane and sugar yields in favor of SOP which increased melable cane yield and sugar yield by 19 and 16 % respectively. Minor changes in sucrose percentage of the three cuts were detected due to K fertilization in favor of SOP as shown in Table (2). Worth mentioning that high K rate in the form of MOP showed some adverse effects on melable cane yield, sugar yield and sucrose percentage of plant cane (first cut).

3.1.2. Shandaweel El-Balad experiment:

At this location, the crop yield data was recorded for plant cane and first ratoon while that of the second ratoon have not taken yet since the experiment is still going on. The obtained results in Table (2) indicated that although the melable cane yield, sugar yield and sucrose percentage of plant cane were not statistically significant, both melable cane and sugar yields were adversely affected by MOP application especially the higher rates which caused reduction by about 6% and 7 % respectively. In contrary, both melable and sugar yields of the first ratoon were augmented by 13 and 20% respectively over the 0-K treatment when the recommended K rate as SOP were doubled and by 16% and 12% respectively by the recommended K rate as MOP.

In this respect Mengle and Kirkby (1987) stated that as soon as the K reserves were exhausted because of the crop high K requirements, responses due to potassium fertilization may be expected. However they concluded that the better the crop is supplied with N, the greater the yield increase due to K is expected because applied N is only fully utilized for crop production when K supply is adequate. It could be concluded that the soil available-K was not enough to supply sugar cane plants with its high K demands through its long growth period.

The IPI research topics No. 9 (1981) mentioned that there has been little interest in comparing forms of K fertilizer because sugar is not thought to be chloride sensitive. While from the plant physiological point of view there is no advantage in using SOP on sugar cane, there is however an advantage under the technological aspects as high rates of MOP have unfavorable effect on juice purity. Thus, it was advised in the Philippines that, when more than 120 Kg K2O/ ha are applied, sulfate should be used to supply the extra K_2O instead of MOP.

It could be concluded that, at El-Sheikh Makram location, slight changes in melable and sugar yields of the first two cuts were observed in favor of SOP with no specific trend. Melable and sugar yields of the second ratoon showed marked increases when recommended K rate was doubled in both forms but in favor of SOP. At the second location of Shandaweel El-Balad, although adverse effects on melable and sugar yields of plant cane were noticed due to MOP application with minor effect for SOP, the higher K rate of SOP and recommended K rate as MOP induced increase in melable and sugar yields of the second ratoon, but these increases did not reach the significance.

3.2. Soil Analysis

Soil analysis follow up for total soluble salts (TSS), soluble Cl and available K (NH4OAc-K) at the two sites is quoted in Table (3). It was noticed that there were minor changes and indefinite trends in TSS soil content at El-Sheikh Makram while it increased from 0.11% for 0-K to 0.16% for the MOP2 treatment at Shandaweel El-Balad, however salinity is still far below the critical TSS level for all treatments. Meanwhile MOP treatments caused slight increases in soluble Cl over the 0-K treatments at the two sites. On average, it augmented from 0.25 meq/100 g soil for the 0-K treatment to 0.30 meq/100 g soil for the two MOP rates at El-Sheikh

Makram, and from 0.17 meq/100 g soil for O-K to 0.21 and 0.23 meq/100 g soil for MOP1 and MOP2 respectively at Shandaweel El- Balad as shown in Table (3).

It was also observed that soil available K fill in the sufficient range for sugar cane plants even under no K application and this may be the cause of insignificant effects of K application in sugar cane yield as mentioned before. It was noticed that the available soil K content increased by the time under all K-treatments (Table 3). However, application of K fertilizer at both rates and sources caused somewhat increases in the available soil K with no definite differences between the two K-sources at the two sites. On average, it was increased from 460 ppm for 0-K treatment at El-Sheikh Makram to 493, 486, 473 and 487 ppm for SOP1, SOP2, MOP1 and MOP2 respectively. At Shandaweel El- Balad, it increased from 421 ppm for 0-K treatment to 456, 429, 461 and 466 ppm for SOP1, SOP2, MOP1 and MOP2 respectively.

Finally, it could be concluded that no salinity building up or Cl accumulation due to MOP application was detected at the two sites may be because of the soil texture of these sites as well as the high amounts of irrigation water used for sugar cane which caused the leachability of soluble Cl and salts .On the other hand, the application of K fertilizer at both rates and sources showed some increases in the available soil K content with no marked differences between the two K sources.

3.3. Plant Analysis

Plant leaves of the second ratoon at El- Sheikh Makram and the first ratoon at Shandaweel El-Balad were subjected to chemical analysis to investigate the effect of K levels and sources on leaf contents of N, P and K. It was noticed that no or minor changes in leaf contents of N, P or K were detected due to K application at the two rates or sources (Table 4) .The insignificant effects of K treatments could be attributed to the high soil K content at these sites. According to Golden and Ricaud (1965) in Louisiana, USA, the leaf contents of the analyzed nutrients fill in the high range for N (1.75-2.00 %), the medium range for P (0.18-0.22 %) and the high range for K (1.75 -2.00 %) at the two sites.

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Table (1): Effect of SOP and MOP on sugar cane production at El-Sheikh Makram.

K Treatments	Plant cane (2002)						First ratoon (2003)					
	Sugar yield (t/ha)	Relative yield	Melable cane (t/ha)	Relative yield	Sucrose %	Relative yield	Sugar yield (t/ha)	Relative yield	Melable cane (t/ha)	Relative yield	Sucrose %	Relative yield
0-K	20	100	170.5	100	11.82	100	17	100	134.0	100	12.66	100
SOP1	23	115	185.5	109	12.25	104	20	118	146.6	109	13.39	106
SOP2	20	100	165.6	97	12.26	104	18	106	135.7	101	13.79	109
Mean	21	105	175.6	103	12.26	104	19	112	141.2	105	13.59	107
MOP1	20	100	159.6	94	12.93	109	19	112	143.9	107	13.59	107
MOP2	19	95	178.0	104	11.3	96	19	112	141.9	106	13.51	107
Mean	20	100	168.8	99	12.12	103	19	112	142.9	107	13.30	105
C.V %	11		10.5		6.91		14		11.22		-	
LSD(5%)	NS		NS		NS		NS		NS			

K Treatments	Second ratoon (2004)					
	Sugar yield (t/ha)	Relative yield	Melable cane (t/ha)	Relative yield	Sucrose %	Relative yield
0-K	11.55	100	90.53	100	12.76	100
SOP1	11.31	98	88.82	98	12.73	100
SOP2	13.38	116	107.95	119	12.40	97
Mean	12.35	107	98.38	109	12.57	99
MOP1	10.98	95	86.82	96	12.65	99
MOP2	12.71	110	103.95	115	12.23	96
Mean	11.85	103	95.38	106	12.40	97
C.V %	-		25.04		8.10	
LSD(5%)			NS		NS	

Table (2): Effect of SOP and MOP on sugar cane production at Shandaweel El-Balad.

K Treatments	Plant cane (2002)						First ratoon (2003)					
	Sugar yield (t/ha)	Relative yield	Melable cane (t/ha)	Relative yield	Sucrose %	Relative yield	Sugar yield (t/ha)	Relative yield	Melable cane (t/ha)	Relative yield	Sucrose %	Relative yield
0-K	20.6	100	177	100	11.6	100	21.21	100	140.98	100	15.05	100
SOP1	21.0	102	187	106	11.2	97	21.74	102	145.01	103	14.99	100
SOP2	21.9	106	192	108	11.4	98	25.43	120	158.83	113	16.01	106
Mean	21.4	104	190	107	11.3	98	23.58	111	151.92	108	15.50	103
MOP1	20.4	99	178	100	11.4	98	23.66	112	163.30	116	14.49	96
MOP2	19.2	93	167	94	11.5	99	22.27	105	148.46	105	15.00	100
Mean	19.8	96	173	98	11.5	99	22.97	108	155.88	111	14.75	98
C.V %	14.8		13.8						19.4		5.01	
LSD(5%)	NS		NS						NS		NS	

Table (3): Soil contents of TSS, available K and soluble Cl after crop harvesting at El-Sheikh Makram and Shandaweel El-Balad.

Year	0-K			SOP1			SOP2			MOP1			MOP2		
	TSS (%)	Cl meq/100g soil	K (ppm)	TSS (%)	Cl meq/100g soil	K (ppm)	TSS (%)	Cl meq/100g soil	K (ppm)	TSS (%)	Cl meq/100g soil	K (ppm)	TSS (%)	Cl meq/100g soil	K (ppm)
El-Sheikh Makram															
0-Time	0.08	0.10	378	0.08	0.10	378	0.08	0.10	378	0.08	0.10	378	0.08	0.10	378
2002	0.13	0.10	381	0.10	0.10	381	0.14	0.12	375	0.13	0.22	356	0.14	0.14	353
2003	0.26	0.28	417	0.10	0.13	426	0.18	0.25	526	0.26	0.34	394	0.12	0.34	420
2004	0.18	0.37	581	0.16	0.31	672	0.13	0.31	656	0.14	0.33	669	0.19	0.41	687
Mean	0.19	0.25	460	0.12	0.18	493	0.15	0.23	486	0.18	0.30	473	0.15	0.30	487
Shandaweel El-Balad															
0-Time	0.12	0.10	254	0.12	0.10	254	0.12	0.10	254	0.12	0.10	254	0.12	0.10	254
2002	0.12	0.13	372	0.10	0.12	352	0.16	0.13	344	0.13	0.21	413	0.14	0.22	407
2003	0.09	0.20	470	0.10	0.17	561	0.08	0.19	513	0.10	0.21	508	0.17	0.23	524
Mean	0.11	0.17	421	0.10	0.15	456	0.12	0.16	429	0.12	0.21	461	0.16	0.23	466

Table (4): Effect of potassium fertilizer rate and source on sugar cane leaf contents of N, P and K (%).

Treatments	El-Sheikh Makram (second ratoon)			Shandaweel El-Balad (first ratoon)		
	N	P	K	N	P	K
0-K	2.24	0.20	2.12	2.40	0.26	1.78
SOP1	2.02	0.23	2.11	2.44	0.24	1.84
SOP2	2.22	0.20	2.21	2.44	0.23	1.90
Mean	2.12	0.22	2.16	2.44	0.24	1.87
MOP1	2.16	0.21	2.17	2.46	0.23	1.90
MOP2	2.12	0.23	2.23	2.56	0.24	1.80
Mean	2.14	0.22	2.20	2.51	0.24	1.85
C.V %	9.81	18.54	7.76	8.51	22.75	6.45
LSD(5%)	NS	NS	NS	NS	NS	NS