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Impact of Sulphur Sources on Some Soil Properties, Status of Nutrients in Grains Maize and Productivity under Saline Soil Conditions.

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Abstract

A filed experiment was conducted at village El-Rowda, Sahl El-Hussinia, El-Sharkia Governorate, Egypt, during two successive summer seasons of 2016 and 2017, to evaluate the effect of sources and rates of sulphur on some soil properties , growth, yield and yield attributes and also contents of available macro and micronutrients as well as quality of maize (C.V Single cross173) sulphur sources Viz, agriculture sulphur, calcium sulphate and gypsum were used at different rates viz., (0,0.4 and 0.80 ton/ fed) for agriculture sulphur and (0,4 and 8 ton / fed) for calcium sulphate and gypsum in this study . The experiments consisted of 9 treatments and were laid out in split plot design with six replicates. Among the source, agriculture sulphur registered its significant superiority over other sources. With respect of rates, application of 0.80 ton /fed recorded highest yield components (weight of ear (g) , weight of grains /ear (g) , weight of 100- grains (g) , yield (grain and stover ton/fed) and grain quality of maize. This study showed that supplementation as agriculture sulphur significantly increased N, P, K Fe, Mn and Zn concentration content and uptake of maize than other sulphur sources treatments.

Key words: Macro-micronutrient contents in maize grains; Maize productivity and quality; Saline soil; Soil properties and Sulphure sources.

Introduction

Soil salinity is more than 800 million hectares of land worldwide is affected by either salinity (397 million hectares) or sodicity (434 million hectares)**(FAO 2005).** Egypt in the world of scarcity is not an exception. The present per capita availability of water is approximately 985 m^3/yr today, while the per capita availability of cultivated land is as low as 0.12 acre **(Ahmed 2013).** In Egypt total salt affected area in the world about 955 Mega ha, out of which 0.9 Mg ha in Egypt. The majority of salt-affected soils in Egypt are located in the northern-central part of the Nile Delta and on its eastern and western sides. However, fifty five percent of the cultivated lands of northern Delta region are salt-affected, twenty percent of the southern Delta and middle Egypt region and twenty five percent of the Upper Egypt region are salt-affected soils **(El-Bordiny and El-Dewiny., 2008).**

Maize crop is one of the food crops that have several uses, whether as a food for man or as animal feed. The domestic consumption was increased from about 10.1 million tons in 2000 to about 14.3 million tons in 2013. In the same period, the domestic production was raised from about 5.6 million in 2000 to about 6.9 million tons in 2014. The amount of imports was raised from about 4958.2 million tons in 2000 to about 10805.6 in 2014, **(Abd El-Fatah *et al*. , 2015).** Maize is moderately sensitive to salt stress; therefore, soil salinity is a serious threat to its production worldwide, **(Muhammad *et al*. ,2015).**

Sulphur is one of the essential macronutrients for plant growth and it accumulates 0.2 to 0.5% in plant tissue on dry matter basis. It is required in similar amount as that of phosphorus **(Ali *et al*., 2008).** Use of calcium salphate (gypsum) alone was improved soil physical and chemical properties, mainly in terms of reduction in sodium concentration and reduced salt concentration is attributed to increased soil permeability as a result of soil structural improvement, hence increased leaching of the salts**, (Muya and Macharia., 2003).**

Elemental sulphur, as a soil amendment, is of special interest to increase soil nutrient solubility since it possesses slow release acidifying characteristic and is readily available **(Chien *et al.*, 2011).** The positive effects of elemental sulphur on soil nutrient solubility reflect to soil pH reduction**, (Ye *et al*., 2010).** Incubation of soil for 40 days with sulphur application rates of 0.5, 1 and 2 g kg^{-1} soil before planting decreased the soil pH from the background of 7.51 to 6.66, 5.45 and 4.8, respectively. **(Karimizarchi *et al*., 2016).**

Gypsum ($CaSO_4$ $2H_2O$) is low cost, and used for sodic soil reclamation and to achieve sulfur fertilizer **(Jaggard and Zhao., 2011).** Gypsum is the most commonly used amendment in Egypt. Establish the usefulness of gypsum as an amendment for the reclamation of saline-sodic and sodic soils. Nevertheless, its effect in the amelioration process continues for several months until the whole of the gypsum has reacted with the exchangeable sodium (Na^+) in the soil **(Shaban *et al*., 2013).** Gypsum has a calcium content of 23 % and 19 % sulphur. The increase quantity of calcium is required thus it is a mass action process **(Gelderman *et al*., 2004).**

Calcium sulphate have an important role in alleviates the adverse effects of salinity on many plant species, that to keep Na^+ and Cl^- out of the cell, with addition to, important role of $SO_4^=$ in formation H_2So_4, which led to increasing soil acidity, removal calcareous problem, which, is in relation with salinity in soil, **(El- Sayed *et al.*, 2014).**

The present study investigated the effect of sulphur sources and rates on saline soil fertility and maize growth and yield productivity as well as, maize quality.

Materials and Methods

A Field experiment was carried out at El-Rowad village, Sahl El-Hussinia , El-Sharkia Governorate, Egypt ,during two summer seasons 2016 and 2017, to study the effect of sulphur sources at different rates on some soil properties and maize yield and yield quality under saline soil conditions. The studied location lies between 32° / 00 to 32° / 15, N latitude and 30° / 50 to 31° / 15 E longitude. Surface soil sample (0- 30 cm) was taken , air –dried, ground , good mixed , sieved through a 2 mm sieve kept and analyzed according to the methods described by **(Klute (1986), Page et al (1982) and Cottenie et al (1982).** The main physical and chemical soil properties before planting were recorded in Table 1.

Table 1. Physical and chemical properties of the studied soil.

Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Texture class	O.M gkg^{-1}	$CaCO_3$ gkg^{-1}
4.66	20.80	33.90	40.64	Clay	5.8	103.5
F.C.	W.P.	A.W.	B.D (Mgm^{-3})		T.P (%)	
28.55	12.40	12.85	1.35		40.75	

Chemical properties

pH (1:2.5) Soil extract susp.	EC (dS/m)	Cations ($mmol_c L^{-1}$)				Anions ($mmol_c L^{-1}$)		
		Ca^{++}	Mg^{++}	Na^+	K^+	HCO^-_3	Cl^-	SO^{--}_4
8.05	9.75	9.43	15.87	71.37	0.83	6.79	55.98	34.73

Available macronutrients ($mg\ kg^{-1}$)			Available micronutrients ($mg\ kg^{-1}$)			
N	P	K	Fe	Mn	Zn	Cu
36.85	4.29	185	3.29	1.55	0.59	1.59

- Ec: electrical conductivity (saturated soil paste extract)
- O.M : Organic matter
- FC: Field capacity
- WP: Wilting point
- AW: Available water
- BD: Bulk density
- TP: Total porosity

The experimental plots were 54 unit including 3 sources of sulphur by 3 rates of each from by 6 replicates. Maize grains were sown on 15 and 19 of May in the first and second seasons, respectively in 30 cm – spaces hills at a rate of two grains /hill, where the area of each plot was 10.5 m^2 (3.5m length X 3 m width). After 31 days, the plants of each hole were thinned to one plant.

All farming processes were carried out before 25 days from planting. Also, at the same time sulphur sources were added during the tillage soil. Super phosphate (6.77 % P) was applied at a rate of 200 kg/fed during tillage soil. Urea (46 % N) was applied as nitrogen fertilizer at a rate of 100 kg N /fed on three equal doses after 31, 55 and 75 days from sowing. Potassium sulphate (40% K) was applied at a rate of 62 kg K /fed on two doses after 31 and 50 days from sowing. After 75 days from planting, plants were taken randomizly from the replicates of each treatment to determine total chlorophyll in fresh leaf samples, according to the method described by **Moran (1982).**

At harvesting stage the plants of other three replicates of each treatment were harvested. The harvested plants were separated into stover and ear. Both stover and ear were air –dried and oven dried at 70^0 C for 48 hr. Dry yield ear and stover (ton/fed), Weight of grains /ear (g) and weight of 100 grain (g).Also, the grains were taken, 0.5 g of each oven dried ground plant sample and digested using H_2SO_4 and $HClO_4$ mixture according to method described by **Chapman and Pratt (1961).** Nitrogen in grains was determined using modified Micro Kjeldahl method according to **A.O.A. C. (1990).** Phosphorus was calorimetrically estimated by using stannous chloride reduced ammonium sulphomolybdate method described by **Haroun (1985).** Potassium was determined using a flame photometer as described by **Jackson (1976).** Micro-nutrients (Fe, Mn, and Zn) were determined by using Atomic Absorption (model

GBC 932) according to **Cottenie *et al*. (1982).** Protein (%) was calculated as N (%) multiplied by 5.75 according **(A.O.A.C. 1990).**

- Total carbohydrate (%) was determined according to **Dubois *et al* (1956).**
- Oil % of grains was estimated by **Sockselt method (A.O.A.C. 1980).** All date were subjected to statistical analysis according to **Snedecor and Cochran (1990).**

Results and Discussions

Effect of sulphur sources rates and their interaction on soil properties.

Soil pH.

Data in Table 2 showed that the application of sulphur sources and rates slightly decreased the soil pH after harvest of maize crop, where the pH reduced from 8.05 to 7.95. This reduction may be due to the formation of $SO_4^=$ resulted from S oxidation. Further S oxidized to H_2SO_4, which reacts with soil $CaCO_3$ to produce $CaSO_4$ -$2H_2O$ led to dissolved calcium probably replaced the adsorbed sodium, (**Abd El-Hamid *et al* 2013).,** (**Bolan *et al*., 2003)** indicated that low decrease in soil pH as affected by sulphur application which results from soil buffering capacity due to generation of H^+ through C, N and S as affected with sulphur application. (**Karimizarchi *et al*., 2016)** suggested that the incubation of soil for 40 days with sulphur application at a rate of 0.5, 1 and 2 g/kg soil before planting decreased the pH from 7.51 to 6.66; 5.45 and 4.80, respectively. (**Murat et al 2013)** found that the decrease of Soil pH varied from 0.31 to 0.49, and the lowest pH value of 7.04 was observed from gypsum application at the end of 8^{th} week. **(Abd El-Azeem and Ramadan 2018)** indicated that values of soil pH was slightly reduced due to the addition of agricultural sulphur from 8.15 to 8.02; gypsum from 8.18 to 8.07 and calcium sulphate from 8.13 to 8.01 respectively.

Table 2. Effect of sulphur sources rates and their interaction on some soil properties after maize harvest (mean values of two seasons)

Sulphur source	Rate (ton/fed)	pH (1:2.5)	EC (dSm^1)	Macronutrients (mg kg^{-1})			Micronutrients (mg kg^{-1})		
				N	P	K	Fe	Mn	Zn
	0	8.01	7.947	39.84	4.85	188.00	3.423	1.890	0.643
Gypsum	**4**	7.95	6.207	41.52	4.96	195.00	3.780	1.960	0.690
	8	7.89	4.653	44.63	5.04	197.67	3.960	2.010	0.733
Mean		--	**6.270**	**42.00**	**4.95**	**193.56**	**3.721**	**1.953**	**0.689**
	0	8.02	7.810	39.85	4.89	192.00	3.440	1.917	0.667
Calcium Sulphate	**4**	7.93	5.950	42.64	5.03	198.67	3.847	1.977	0.730
	8	7.85	4.193	45.87	5.08	202.67	3.960	2.030	0.780
Mean		**7.93**	**5.980**	**42.79**	**4.99**	**197.78**	**3.749**	**1.975**	**0.726**
	0	8.00	7.850	40.24	4.94	193.33	3.460	1.930	0.693
Agric. Sulphur	**0.4**	7.92	5.883	43.93	5.06	204.00	3.940	2.016	0.750
	0.8	**7.83**	**3.857**	**47.63**	**5.12**	**209.00**	**3.980**	**2.060**	**0.830**
Mean		**---**	**5.860**	**43.94**	**5.04**	**202.11**	**3.790**	**2.002**	**0.758**
LSD .5 % of sulphur sources		-	0.053	0.094	0.040	0.766	0.009	0.008	0.022
LSD 5%of Rate		-	0.035	0.106	0.016	1.467	0.011	0.024	0.019
LSD. 5% Interaction		-	0.061	0.183	0.028	2.541	0.018	0.041	0.033

Soil salinity (EC dSm^{-1}).

The results in Table 2 showed that the effect of sulphur sources applications on saline soil (EC dSm^{-1}) after maize harvest had significant effect. The soil salinity was decreased with increasing sulphur rate in all treatments. The interaction between application of different sulphur sources and rates, significantly reduced soil EC. Sulphur and calcium sulphate applications had positive effect on EC value than gypsum application. The highest EC value (7.94 dSm^{-1}) for soil no treated with sulphure sources, while the minimum EC values (3.85 dSm^{-1}) was soil treated with agricultural sulphur at a rate of 0.80 ton /fed. The relative decreases of EC values were 21.90 and 41.45 % for soil treated with gypsum at a rates (4 and 8 ton/fed) respectively compared with without gypsum applied. Also, relative decreases of EC values of soil salinity treated with calcium sulphat at rates (4 and 8 ton /fed) were 23.82 and 46.31 % respectively compared to without calcium sulphat. As well as, the relative decreases of EC values were 25.06 and 50.87% for soil treated with agricultural sulphur at a rates (0.40 and 0.80 ton /fed) compared to without sulphur. Concerning that the relative decreases of EC mean values were 20.33 % for soil treated with gypsum; 24.02 % for soil treated with calcium sulphate and 25.54 % for soil treated with agricultural sulphur compared mean values of EC soil without sulphur sources. These results may be due to the increase the activity of microorganisms caused by low salt concentration, followed by an increase of sulphur rate led to improve soil properties. These results are in agreement by **Abd El-Hamid *et al* (2013)** suggested that the applied sulphur gave increase Ca^{+2} in soil which probably replaced the sodium in colloidal complex and improving the soil EC. The varying rates of gypsum and sulphur application to saline soil led to decrease of soil salinity and improved soil chemical properties.

Generally application of sulphur sources decreased soil salinity. The used sulphur sources could arranged in the following descending due to its effect : agricultural sulphur > calcium sulphate> gypsum > control.

Macro and micronutrients availability in the studied soil.

Soil content (mg/kg) of available N, P, K, Fe, Mn and Zn were increased significantly with the increasing added sulphur . More increases of these contents were as associated with the treatment of agricultural sulphur , especially at the high application rate These results are in agreement with those obtained by **Karimizarchi *et al* (2016)** who found that the significant and positive effect of sulphur application at high rate led to increases of macro and micronutrients availability in soil.

Data presented in Table 2 showed that the relative increases of mean values were 5.05, 1.23 and 1.28% for soil treated with gypsum; 7.03, 2.04 and 3.49 % for soil treated with calcium sulphate and 9.90, 3.07 and 5.76 % for soil treated with agricultural sulphur for N, P and K availability in soil respectively , compared with without sulphur source. **Abul Hasnat *et al*. (2009)** revealed that the available N, P and K content in soil was increased by the application of sulphur and gypsum.

Also, data in Table 2 showed that the increases in soil content of available micronutrients content(Fe, Mn and Zn) as affected by sulphur agriculture was higher compared with other treatments. The relative increases of soil content of available micronutrients were 10.43 and 15.69 % for Fe ; 3.70 and 6.35 % for Mn and 7.31 and 14.00 % for Zn as affected by increase of gypsum application at rates 4 and 8 ton/fed respectively. Also, the relative increases of Fe, Mn and Zn contents were 11.83 and 15.12%; 3.13 and 5.89 % and 9.45 and 16.94 % for soil treated with calcium sulphate at rates 4 and 8 ton /fed, respectively compared with the treatment without calcium sulphate. As well as, the relative increases of values were 13.87 and 15.03 % for Fe; 4.46 and 6.74 % for Mn and 8.23 and 19.77 % for Zn for soil treated with agricultural sulphur at rates 4 and 8 ton/ fed respectively, compared with the treatment agricultural sulphur.

Generally, the positive effects of the used different sulphur sources on the soil contents of available Fe, Mn and Zn could be arranged in the following order agriculture sulphur > calcium sulphate > gypsum > control. This is attributed to the significant decrease in soil pH resulting from the acidifying effect of elemental sulphur. **Karimizarchi *et al*. (2016)** indicated that the effect of sulphur application on availability of micro nutrients (Fe, Mn, and Zn) was significantly increased after maize harvest. It is worthy to mention that the availability of micronutrients Fe, Mn and Zn content in soil in general, lay within the sufficient limits.

Effect of sulphur sources and its rates on yield and yield component.

Data presented in Table 3 showed that the used gypsum, calcium sulphate and agricultural sulphur led to increase in ear weight (g), weight of grains /ear (g), weight of 100 grains (g) and grains yield (ton/fed) and stover yield for maize plant with increasing sulphur sources rate. The applied sulphur sources were significant for ear weight (g), weight of grains /ear (g), weight of 100 grains (g) and grains yield (ton/fed), while, stover yield (ton/fed) was not significant.

The effect of applied of sulphur rates were not significant on weight of grains yield (ton/fed) and stover yield (ton/fed), while, the ear weight (g), weight of grains /ear (g) and weight of 100 grains (g) were significantly increases with increasing sulphur rate. The interaction between sulphur sources and rates application on weight of ear (g), weight of grains /ear (g) and grains yield (ton/fed) were significant, while, the weight of 100 grains (g) and) stover yield (ton/fed) were not significant .

The relative increase of mean values of the measured yield components as a result of addition of gypsum rates of 4 ton /fed compared with without gypsum were 3.23 % for weight ear; 8.77 % for weight of grains/ear; 2.32 % for 100 grain; 19.63 % for grains yield /fed and 14.63% for stover yield respectively, while, the relative increases of mean values of the measured parameters with gypsum at rate of 8 ton/fed compared with without gypsum were 8.21; 18.45; 9.78; 25.23 and 17.01 % for weight of ear (g), weight of grains /ear (g) , weight of 100 grains (g) , grains yield (ton/fed) and stover yield (ton/fed) respectively. Concerning , that the relative increase of mean values of yield components with calcium sulphate at rate of 4 ton/fed was 5.20; 15.60; 10.58; 33.33 and 15.12 % for weight of ear (g), weight of grains /ear (g), weight of 100 grains (g) , grains yield (ton/fed) and stover yield (ton/fed) respectively, compared to without calcium sulphate , while the soil treated with 8 ton/fed for calcium sulphate the increases values were 13.04; 27.27; 12.44; 37.09 and 16.86 % respectively compared to without calcium sulphate. Also, the relative increases of mean values of yield components with agricultural sulphur at a rate of 0.40 ton/fed was 19.19 ; 23.93; 9.96; 34.88 and 13.47 % for weight of ear (g), weight of grains /ear (g) , weight of 100 grains (g) , grains yield (ton/fed) and stover yield (ton/fed) respectively compared to without sulphur application, while the relative increases of mean values were 28.90; 40.35; 12.82; 44.65 and 18.62 %

for weight of ear (g), weight of grains /ear (g) , weight of 100 grains (g) , grains yield (ton/fed) and stover yield (ton/fed) respectively, as applied of agricultural sulphur with 0.80 ton/fed compared to without sulphur.

Table 3. Effect of sulphur sources rates and their interaction on some yield components of maize plant (mean values of two seasons).

Sulphur source	Rate (ton/fed)	Weight of ear (g)	Weight of grains /ear (g)	Weight of 100 grains (g)	Grains yield (ton/fed)	Stover yield (ton/fed)
	0	145.14	113.79	38.35	2.14	3.35
Gypsum	**4**	149.83	123.77	39.24	2.56	3.84
	8	157.06	134.78	42.10	2.68	3.92
Mean		**150.68**	**124.11**	**39.56**	**2.46**	**3.70**
	0	148.16	117.28	38.66	2.13	3.44
Calcium sulphate	**4**	155.86	135.58	42.75	2.84	3.96
	8	167.48	149.26	43.47	2.92	4.02
Mean		**157.17**	**134.04**	**41.63**	**2.63**	**3.81**
	0	151.81	119.04	39.25	2.15	3.49
Agric. Sulphur	**0.4**	182.04	147.53	43.16	2.90	3.96
	0.8	195.69	167.07	44.28	3.11	4.14
Mean		**176.51**	**144.55**	**42.23**	**2.72**	**3.86**
LSD 0.0.5 % sulphur		1.53	1.32	1.13	4.99	ns
LSD 0.05 % rate		4.59	1.57	0.44	ns	ns
Interaction		***	**	ns	**	ns

So, it could be concluded that maize yield component was clearly affected by the application rates of the used sulphur sources. The highest stover and grains yield are recorded with maize plant treated with agricultural sulphur. As well as, the relative increases of mean values of different sulphur sources combined with different application rates were 1.14; 6.35; 2.09; 14.95 and 10.45 % for maize treated with gypsum while, 5.93; 14.86, 7.43; 22.90 and 13.73 % for maize treated with calcium sulphate and 18.97; 23.86; 8.98; 27.10 and 15.22 % for maize treated with agricultural sulphur for weight of ear (g), weight of grains /ear (g) , weight of 100 grains (g) , grains yield (ton/fed) and stover yield respectively, compared with mean values of without sulphur sources. It is worthy to mention that the superiority of crop yields components could be arranged in the following order: agricultural sulphur > calcium sulphate > gypsum> control. The obtained increase of yield and yield components may be attributed to multiple role of sulphur in protein and carbohydrate metabolism, activating many enzymes which influence photosynthesis, plant length and improve growth plant .These results are in agreement with those obtained by **Navatha *et al* (2017)** who indicated that the application of sulphur with different rates gave the significant increases for yield and yield components.

Macronutrient concentration and uptake content in grains of maize plant.

Concentration (%) and uptake (kg/fed) of macronutrients in maize grains as affected by different treatments of gypsum; calcium sulphate and agricultural sulphur are shown in Table 4.

It is obvious that N, P and K concentration (%) and uptake (kg/fed) were significantly increased with increasing rate of added sulphur sources as compared with control. The interaction between sulphur sources and its application rates have a significant and increase effect on K concentration and uptake in maize grain while, the concentration of N and P were not significant as well as the N uptake was significant. The relative increases with gypsum at a rates (4 and 8 ton/fed) were 4.40 and 9.34 % for N concentration, while for N uptake was 24.88 and 36.92 % compared with control. The relative increases of P concentration were 9.09 and 22.73 %, as well as the P uptake were 30.47 and 53.61 % for treated with gypsum at rates 4 and 8 ton/fed compared to without gypsum. Also, the relative increases of values were 5.13 and 9.40 % for K concentration and 25.76 and 36.98 % for K uptake in maize grain as affected by gypsum at rates (4 and 8 ton/fed). On the other hand, the relative increases of values were 13.30 and 19.68 % for nitrogen; 10.42 and 22.92 % for P and 9.84 and 18.85 % for K concentrations in grains, and were 51.07and 64.09 % for N; 47.26 and 68.59 for P and 46.44 and 62.91 % for K uptake content in maize grains as applied calcium sulphate at the rates (4 and 8 ton/fed) compared to without calcium sulphate. Concerning that the relative increases of N, P and K concentration and uptake in maize grains were 7.57 and 45.07 % for N; 10.87 and 49.54 % for P and 6.78 and 44.03 % for K as affected by agric. sulphur application at a rate of 0.4 ton/fed.

Table 4. Effect of sulphur sources rates and their interaction on Macronutrients concentration and uptake in grains of maize plant (mean values of two seasons).

Sulphur source	Rate (ton/fed)	Macronutrients concentration (%)			Macronutrients uptake (kg/fed)		
		N	**P**	**K**	**N**	**P**	**K**
Gypsum	**0**	1.820	0.440	1.170	38.950	9.420	25.040
	4	1.900	0.480	1.230	48.640	12.290	31.490
	8	1.990	0.540	1.280	53.330	14.470	34.300
Mean		**1.903**	**0.487**	**1.227**	**46.810**	**11.980**	**30.180**
Calcium Sulphate	**0**	1.880	0.480	1.220	40.040	10.220	25.990
	4	2.130	0.530	1.340	60.490	15.05	38.060
	8	2.250	0.590	1.450	65.700	17.230	42.340
Mean		**2.087**	**0.533**	**1.337**	**54.890**	**14.020**	**35.160**
Agric. Sulphur	**0**	1.850	0.460	1.180	39.780	9.890	25.370
	0.4	1.990	0.510	1.260	57.710	14.790	36.540
	0.8	2.140	0.550	1.360	66.550	17.110	42.300
Mean		**1.993**	**0. 510**	**1.267**	**54.210**	**13.872**	**34.460**
LSD A 0.05 sources (A)		**ns**	**0.027**	**0.011**	**1.180**	**1.480**	**1.960**
LSD 0.05 rate (B)		**ns**	**0.023**	**0.022**	**2.260**	**1.140**	**0.870**
LSD 0.05 Interaction (A) x (B)		**ns**	**ns**	**	**	**ns**	*

The relative increases were 15.68 and 67.30 % ; 19.57 and 73.00 % and 15.25 and 66.73 % for N, P and K concentration and uptake in maize grains respectively as treated with agric. sulphur at the rate 0.8 ton/fed compared to without sulphur. The relative increases of mean values as effected by the different sources i.e. gypsum, calcium sulphate and agric. sulphur at different rates on N, P and K concentrations and uptake content in maize grains were 2.86 and 18.24 for N ; 5.87 and 21.75 for P and 3.11 and 18.49 for K concentration and uptake in grains as affected by gypsum ; 12.81 and 38.65 % for N ; 15.87 and 42.48 % for P and 12.35 and 38.04 % for K concentration and uptake in grains as affected by calcium sulphate were 7.73 and 36.93 % for N ; 10.86 and 40.98 % for P and 6.47 and 35.30 % for K concentration and uptake in grains as affected by agric. sulphur application compared with mean without sulphur. These results are in agreement by **Badr *et al.* (2002) and Helmy and Shaban (2013)** reported that the N, P and K concentrations were increased significantly increasing due to addition of sulphur sources. Sulphur fertilization enhanced the uptake of N, P and K in the plant.

Micronutrients concentration and uptake in grain of maize plant.

Data in Table 5 show that the effect of sulphur sources and its application rates on the micronutrients concentration (mg/kg) and uptake (g/fed) in grain of maize caused markedly increases in the concentration and uptake of Fe, Mn and Zn in maize grains plant with increase the rate of sulphur sources added.

Table 5. Effect of sulphur sources rates and their interaction on Micronutrients concentration and uptake in grains of maize plant (mean values of two seasons).

Sulphur source	Rate (ton/fed)	Macronutrients concentration (mg/kg)			Micronutrients uptake (g/fed)		
		Fe	**Mn**	**Zn**	**Fe**	**Mn**	**Zn**
Gypsm	**0**	73.680	33.900	16.750	157.675	72.546	35.845
	4	72.300	36.830	19.220	185.088	94.285	49.203
	8	74.600	38.550	20.877	199.928	103.314	55.950
Mean		**73.527**	**36.427**	**18.949**	**180.876**	**89.610**	**46.611**
Calcium Sulphate	**0**	75.253	35.660	17.940	160.2890	75.955	38.212
	4	76.390	38.900	22.890	216.947	110.476	65.007
	8	79.100	42.100	24.900	230.972	122.932	72.708
Mean		**76.914**	**38.887**	**21.910**	**202.384**	**102.362**	**57.623**
Agric. Sulphur	**0**	74.880	34.770	16.980	160.992	74.755	36.507
	0.4	75.950	37.800	18.500	220.255	106.62	53.650
	0.8	77.400	40.330	21.780	240.714	125.426	67.736
Mean		**76.077**	**37.633**	**19.087**	**206.929**	**102.362**	**51.916**
LSD A 0.05 sources		1.15	1.64	1.57	3.57	1.32	1.13
LSD 0.05 Rate		2.44	0.75	1.90	3.40	2.26	3.02
Interaction		ns	ns	ns	***	***	**

These results are in harmony with those obtained by **Karimizarchi, *et al*. (2016)** who reported that the applied of sulphur at high rate gave increases of micronutrients Fe, Mn and Zn concentration in maize. The effect of sulphur sources application on Fe, Mn and Zn concentrations and uptake were significant and the rates of sulphur used were significant increasing for Fe, Mn and Zn concentration and uptake in grains of maize plants. The interaction between sulphure sources and different rates were no significantly for concentrations Fe, Mn and Zn, while the Fe , Mn and Zn uptake in maize grains were significant affect.

Generally, the increase in Fe, Mn and Zn concentration and uptake with all sulphur sources application under saline soil conditions depend upon the rates of sulphur sources and decreased soil pH and salinity soil. The relative increases of mean values Fe, Mn and Zn in maize grains plant were 1.44 % for Fe; 4.74 % for Mn and 10.04 % for Zn concentration and 13.30 % for Fe; 20.41 % for Mn and 26.49 % for Zn uptake as affected with gypsum compared with the control. Also, the relative increases of concentration of determined nutrients values were 3.10 % for Fe; 11.81 % for Mn and 27.24 % for Zn, their uptake were 26.77 for Fe; 37.55 % for Mn and 56.37 for Zn uptake content in grains maize plant as affected by calcium sulphate application than the control. As well as, the relative increases of the mean concentration of the same nutrients were 1.98 % for Fe; 8.20 % for Mn and 10.84 % for Zn their uptake were 29.61 % for Fe; 37.55 % for Mn and 40.88 % for Zn uptake in maize grains plant as affected by sulphur application

The relative increases of the studied micronutrients i.e. Fe, Mn and Zn concentrations in maize grains are mainly depend on the used suphur sources, as it could be arranged as follows: calcium sulphate > agricultural sulphur > gypsum > control, but this order according to the uptake of Fe and Mn were categorized into different orders as follows: agricultural sulphur > calcium sulphate > gypsum > without sulphur sources while, the Zn uptake was calcium sulphate > agricultural sulphur > gypsum > control.

Finally, it is concluded that the concentration and uptake of micronutrients in maize grains, generally, reflected their available contents in soil and reduced of soil pH as affected by different sources of sulphur and application rates.

Effect of different sulphur sources and its application rates on quality of maize plant.

Data are presented in Table 6 showed that the applied sulphur sources i.e. (gypsum, calcium sulphate and agriculture sulphur) and different rates gave the highest mean values of carbohydrate %, protein %, oil (%) and total chlorophyll content in maize compared with without sulphur in both seasons.

Table 6. Effect of sulphur sources rates and their interaction on quality maize (mean value of two seasons).

Sulphur source	**Rate (ton/fed)**	**Protein (%)**	**Oil (%)**	**Carbohy drate (%)**	**Total chlorophyll (mg/dm leaf)**
	0	10.47	4.40	54.68	8.32
Gypsum	**4**	10.93	4.49	74.34	8.97
	8	11.44	4.70	85.24	9.78
Mean		**10.94**	**4.53**	**71.42**	**9.02**
	0	10.81	4.45	52.93	8.41
Calcium Sulphate	**4**	12.25	4.60	79.37	10.73
	8	12.94	4.75	95.83	13.53
Mean		**12.00**	**4.60**	**76.04**	**10.89**
	0	10.64	4.47	53.18	8.44
Agric. Sulphur	**0.4**	11.44	4.82	73.90	10.27
	0.8	12.31	4.90	86.22	12.00
Mean		**11.46**	**4.73**	**71.10**	**10.24**
LSD 0.0.5 % source A		ns	ns	1.41	0.85
LSD 0.05 % rate B		ns	ns	0.75	1.14
Interaction A x B		ns	ns	**	*

The highest mean values of carbohydrate (%) are obtained for plant treated with calcium sulphate different rate. As well as the maximum mean values of chlorophyll (mg/dm leaf) are obtained for plant treated with calcium sulphate and protein (%) content in grains compared with other treatments. The using different source of sulphur and different rates on carbohydrate and total chlorophyll were significantly affected, while the oil (%) and protein (%) content in maize grain plant were not significant. The interaction between sulphur sources and different rates were significantly increased carbohydrate and total chlorophyll content with increasing rate of sulphur.

The positive effect of sulphur and calcium on grain quality may be due to that sulphur and calcium increases photosynthetic pigments content and photosynthesis rate, which in turn increased the amount of metabolites, and synthesized matter and consequently resulted in higher dry matter accumulation in grains. Also, these results may be due to the important role of sulphur and calcium in the activation synthesis of protein. This result is in agreement with **Shaban *et al*. (2013)** who indicated that the protein content of grains was significantly increased by the elemental sulphur and gypsum treatments compared to control. **Helmy and Shaban (2013)** who reveled that the protein percentage content in wheat grains and chlorophyll content in wheat plants were increased with increasing rates of sulphur in sources under saline soil conditions. **Majumdar *et al* (2002)** suggested that the crude protein increased with increasing sulphur rate. **Singh (2008) and Rahul *et al* (2017)** indicated that the increase of sulphur rates led to the improvement of maize quality like carbohydrates, starch, chlorophyll and protein yields.

Conclusion

Findings of the present study suggested that application of sulfur sources at different rates are effective on improving the chemical properties, like soil pH, EC, and macro-micronutrients available in saline soil and improve of maize yield and quality. The used agricultural sulphur at the highest rate led to effective result which improvement of soil chemical properties, increase of macro and micronutrients available in soil and improves of yield and yield component and quality for maize productivity under saline soil compared with other treatments.

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تأثير مصادر الكبريت على بعض صفات التربة وحالة العناصر فى حبوب الذرة والانتاجيه تحت ظروف الأراضى الملحية.

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اجريت دراسة حقلية فى قرية الرواد –سهل الحسينية ، محافظة الشرقية ، مصر خلال الموسمين الصيفيين متتاليين 2016و 2017م بهدف دراسة تقييم مصادر الكبريت بمعدلات مختلفة مثل)الكبريت الزراعى بمعدل 0.40– 0و 0.80طن لكل فدان –كبريتات كالسيوم بمعدل 8 – 4 – 0طن لكل فدان –والجبس بمعدل 8 – 4 – 0 طن للفدان .(على بعض خواص التربة وتركيز وامتصاص العناصر وتيسرها فى النبات والتربة وانتاجية محصول الذرة وجودتة تحت ظروف الأراضى الملحية .كان صنف الذرة 173ذرة صفراء .

اظهرت النتائج التى تم الحصول عليها ان جميع المعاملات المضافة ادت الى نقص فى حموضة التربة وملوحتها وتحسين حالة مغذيات التربة بسبب اضافة الجبس وكبريتات الكالسيوم والكبريت الزراعى عند المعدل المرتفع مقارنة بالمعاملات بدون مصادر الكبريت .وجد ان اضافة الكبريت الزراعى بمعدل 0.80طن للفدان ادى الى تيسر وتركيز العناصر النتروجين والفوسفور والبوتاسيوم والحديد والمنجنيز والزنك فى التربة والنبات

ادت اضافه المصادر الكبريتيه ذات المعدل المرتفع الي زيادة وزن الكوز)جم (ووزن الحبوب /كوز)جم (ومحصول الحبوب)طن /فدان (ومحصول القش مقارنه بالكنترول

أعطت زيادة معدلات اضافة مصادر الكبريت)الجبس ، الكالسيوم ، الكبريت ، الكبريت (الى أعلى القيم لمتوسطاتالكربوهيدرات، البروتين ٪ ، ، الزيت)٪ (، الكلوروفيل الكلي المحتوى في الذرة مقارنة بدون الكبريت .

نوصى باستخدام اضافة الكبريت الزراعى بمعدل 0.80طن للفدان لزيادة انتاجية وجودة محصول الذرة الصفراء –وتحسين صفات التربة تحت ظروف الأراضى الملحية .