THE ROLE OF SOIL AMENDMENTS ON SOIL FERTILITY AND THE RESPONSE OF WHEAT GROWN IN SALINE SODIC SOIIL

T.A.ABOU EL-DEFAN, A.S.A. ABDEL-MAWGOUD, S.A. EL-GINDI AND H.E.M. EL-KHOLI

Soil, water and Environment Research Institute, Agricaltural Research Centre, Giza, Egypt.

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Abstract

Addition of sulfur or gypsum amendments and their effect on nitrogen, phosphours and potassium availability in saline-sodic soil as well as their contents in wheat grain were studied in Koam-Oshem area, El-Fayoum Governorate. The obtained results revealed that the availability of N, P and K in soil and their content in wheat grain increased by increasing the application rates of the studied amendments. However, increasing the application rates more than 1.5 kg sulfur/plot or 7.5kg gypsum/plot decreased the relative increment of nutrient availability and content in both soil and grains. Relative wheat grain yield increased by 151% and 119% kg compared to control treatment at the application rates of 2.0 kg sulfur / plot and 10 kg gypsum/plot respectively. These results might be due to the effect of soil amendments on some factors affecting the nutrient availability in the soil.

INTRODUCTION

In view of the great awareness generated in the recent years in the different countries of the world for the utilization of salt-affected soils for crop production to meet the various escalating needs of fast expanding population, the development of proper methods for soil reclamation and management have become extremely essential. However, different countries have different needs for reclamation and utilization of the salt-affected soils depending upon the population pressure and socio-economic conditions.

Amendments which are commonly used in this respect include the gypsum ($CaSO4.\ 2H_2O$) and the elemental sulfur which is oxidized biologically in the soil to produce H_2SO4 which reacts with native CaCO3 to form CaSO4 (Jones, 1979; Curtin et al., 1993). The addition of acid form amendments such as elemental sulphur, lowers the soil pH, with well-known effects upon the availability of some nutrients in the soil (Khater, 1981; Hilal and Abdel-Fattah, 1987). Regarding the effect of

these amendments on the quality and nutrient content in some crops, Gupta and Mehla (1980) reported that sulfur amendment increased some nutrients in wheat, barley and clover plants. In addition, Many research workers reported that gypsum and sulfur amendments had favorable effects on growth and yield of some crops (Olsen and Watanab, 1979; Kumar and Singh, 1980; Ismail *et al.*, 1993).

This study aims to asses the effect of applied soil amendments (sulphur and gypsum) at different rates to a saline-sodic soil on the availability of N,P and K in soil as well as on yield and yield quality of wheat.

MATERIALS AND METHODS

A field experiment was carried out at Koam-Oshem Experimental Station (El-Fayoum Governorate). Two types of soil amendments (sulfur and gypsum) were applied at different doses. Each dose of sulphur amendment has 0.2 equivalent quantity from corresponding relative quantity of gypsum (FAO, 1988). The application rates of sulphur were 0,0.5, 1.0, 1.5 and 2.0 kg/plot. While the gypsum application rates were 0, 2.5, 5.0, 7.5 and 10.0 kg/plot. Four replications were used in a complete randomized block design. Each plot has an area of 21 m^2 (6 m length by 3.5 m width). Each plot was cultivated by wheat crop (Triticum estivum). At harvesting grain yield was determined for each treatment. Grain samples were collected at random from each treatment, dried and ground for chemical analyses then 0.5 gm of these ground grains were wet ashed as outlined by Jackson (1958). The wet ashed solutions were analyzed for N,P and K using semi-Kjeldahl, spectrophotometer, and flame photometer apparatus, respectively. Surface soil samples (0-15 cm) were taken from each treatments air dried grounded and passed through a 2 mm. sieve. The routine analyses indicated in Table 1 were carried out according to the conventional methods outlined by Black, (1965)

Available N was extracted from 10g. soil with 100ml of a 2 N. K Cl solution after shaking for one hour. NH4 HCO3 (one mole) solution was used to extract available K and P in soil as described by Soltanpour and Schwab, (1977).

The obtained data were statistically analyzed using Minitab program and the least significant difference among the different treatments was calculated according to Gomez and Gomez, (1984).

Table 1. Some physical and chemical properties of the soil.

Property	Value
CaCO3 %	2.30
O.M %	1.89
Clay %	10.10
Silt %	17.32
Sand %	72.58
Texture class	Sandy Loam
pH in soil (1:1)	8.20
EC (ds/m) in soil extract (1:5)	1.19
Soluble ions (meq/100 g soil)	
CO_3	0.00
HCO_3	2.76
Cl	6.49
SO_4	3.77
Ca	2.92
Mg	4.09
Na	5.77
K	0.24
SAR	3.08
CEC (meq/100 g soil)	12.29
Exchangeable cations meq/100 g soil)	
Ca	6.37
Mg	3.26
Na	3.13
K	0.68
Available elements (ppm.):-	
N	7.68
P	4.40
K	63.00

RESULTS AND DISCUSSION

Effect of soil amendments on nutrients availability in the tested soil

The data presented in Table 2 show that available nitrogen significantly increased with gypsum treatments compared to sulfur treatments, while an opposite trend was found for available phosphorus. Moreover, there were no significant differences between the effect of sulfur and gypsum amendments on available potassium in the tested soils.

Table 2. Effect of soil amendments on the availability of N, P and K in the soil.

Treatments (kg/plot)	Available N (mg/kg. soil)	Available P (mg/kg. soil)	Available K (mg/kg. soil)
Control (0.0)	7.68	4.40	63
Sulfur (0.5)	8.44	5.60	165
Sulfur (1.0)	10.00	7.20	285
Sulfur (1.5)	16.92	7.20	510
Sulfur (2.0)	15.36	7.60	425
Control (0.0)	7.68	4.40	63
Gypsum (2.5)	7.68	5.60	150
Gypsum (5.0)	15.36	6.00	165
Gypsum (7.5)	16.92	6.00	555
Gypsum (10.)	16.92	7.20	468
L.S.D. (5%)			
Types (T)	0.387	0.305	n.s.
Rates (R)	0.611	0.482	24
T*R	0.864	0.682	34

Regarding the effect of application rates, in general data show that available N, P and K significantly increased with increasing the application rates of both soil amendments compared to control treatment. Where available nitrogen increased by 9.9, 30, 120 and 100% at application rates of 0.5, 1.0, 1.5 and 2 kg sulfur/plot, respectively. Also, it increased by 0,100,120 and 170% at the application rates of 2.5, 5.0, 7.5 and 10.0 kg gypsum/plot, respectively. The decreasing in the relative increments percent of available N by increasing the application rates of sulfur more than 1.5 kg/plot is in agreement with results obtained by Ali *et al.* (1933) who stated that sulfur is known to interact with nitrogen since both are anions.

As regards to P, available phosphorus increased by 27, 64, 66 and 37% when sulfur was applied at rates of 0.5, 1.0, 1.5 and 2.0 kg/plot, respectively. Also, it increased by 27, 36, 63 and 64% at rate of 2.5, 5.0, 7.5 and 10.0 kg gypsum/plot, respectively. The favorable effect of adding soil amendments might be due to either increasing the availability of P in soil as a result of reducing soil pH value of the amended soil (Whadan *et al.*, 1997) or release of phosphate ions from soil colloids by sulfate ions. Such results were in a good agreement with those obtained by El-Shall *et al.*, (1986). Mahrous *et al.* (1983) concluded that available P increases due to an increase in solubility of calcium phosphate under high carbon dioxide partial pressure and the lowering of soil pH by flooding.

Also data in Table 2 show that, available K increased as the application rate of both amendments increased up to 1.5 kg sulfur/plot or 7.5 kg gypsum/plot. Further addition from either amendment more than these rates decreased the available K, however its value is still higher than the control. This may be due to reducing soil pH which causes a reduction in the amount of available K by precipitation or fixation (El-Shall *et al.*, 1986). It is worthy to mention that decreasing the soil pH will lead to the dissolution of Fe-oxides and calcium carbonate which occured as a coating and/or cementing agent of soil. Consequently new retention sites will take place into the solid solution reaction and more K will be retained (Saleh and Khalied, 1993).

Data in Fig. 1 reveal that the correlation coefficients among sulfur or gypsum application rates and available N,P and K in soil are positive and highly significant. In sulphur treatments the values of correlation coefficients are + 0.888**, +0.897** and + 0.919** for available N,P and K in soil, respectively. The corresponding values of gypsum rates are + 0.907** +0.903** and 0.883** for available N,P and K in soil respectively. In this manner, six linear regression equations were calculated and shown in the same figure.

Effect of soil amendments on N,P and K contents of wheat grain.

The effect of the soil amendments on nutrient concentration in wheat grain are shown in Table 3. Data show that P% in the grain significantly increased as a result of gypsum application compared to that increase by sulfur, while there was no difference between the effect of the two amendments on N% and K%.

Data also indicate that, increasing the application rates of both soil amendments significantly increased P% and K%, while N% significantly decreased in wheat grain compared to control treatment. This decreasing in N% in the grains night be

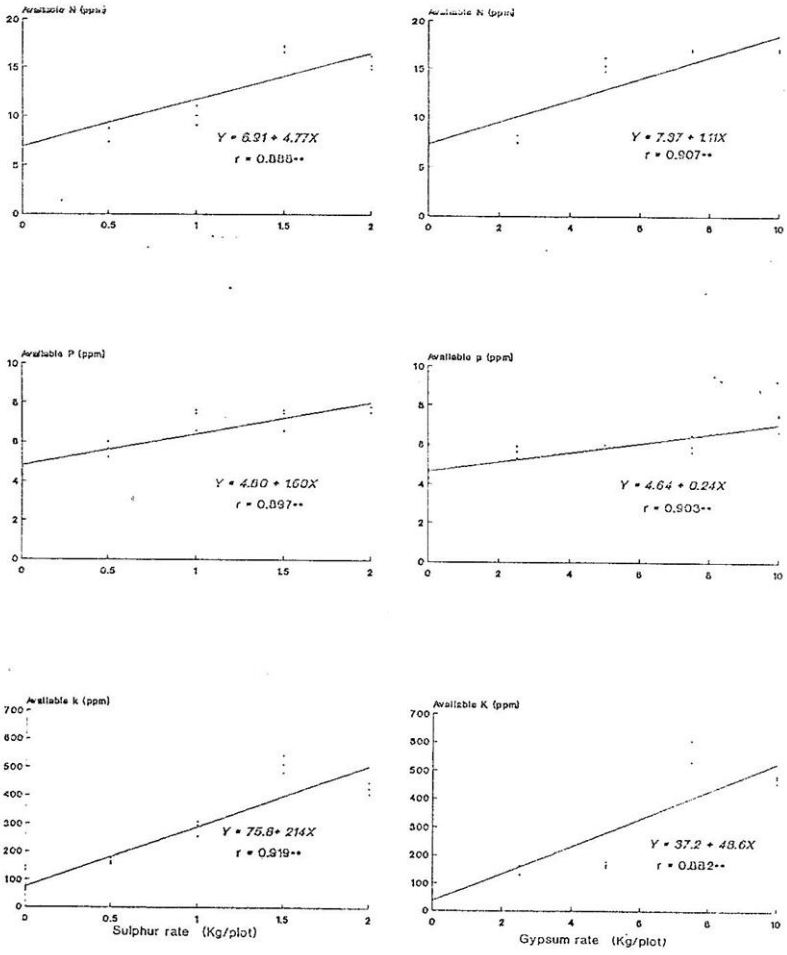

Fig. 1. The correlation coefficients and regression equations among sulphur or gypsum applications and available N, P and K in the studied soil.

due to increasing of dry matter yield as a results of increasing rates of the soil amendments, such behavior is often called dry matter dilution effect (El-Gindi, 1988).

Table 3. Grain yield componant and quality as affected by soil amendments.

Treatments (kg/plot)	Grain yield (kg/fed)	100 grains weight (g)	N		P		K	
			conc. %	content Kg/fed.	conc. %	content Kg/fed.	conc. %	content Kg/fed.
Control (0.0)	606	3.832	2.38	14.415	0.40	2.423	1.58	9.212
Sulfur (0.5)	905	4.094	2.14	19.391	0.48	4.440	2.11	19.118
Sulfur (1.0)	1116	4.375	2.10	23.429	0.52	5.801	3.24	36.148
Sulfur (1.5)	1296	5.113	2.03	26.299	0.58	7.514	3.68	47.649
Sulfur (2.0)	1520	4.990	1.51	22.951	0.43	6.536	1.72	26.128
Control (0.0)	606	3.832	2.38	14.415	0.40	2.423	1.58	9.212
Gypsum (2.5)	976	4.418	2.10	20.489	0.50	4.878	2.00	19.513
Gypsum (5.0)	1014	4.528	2.06	20.898	0.53	5.377	2.52	25.575
Gypsum (7.5)	1191	4.713	1.89	22.513	0.62	7.385	3.14	37.344
Gypsum (10.0)	1327	4.521	1.68	22.290	0.45	5.971	2.25	29.853
L.S.D. (5%)								
Types (T)	18.97	n.s	n.s	n.s	0.016	n.s	n.s	2.442
Rates (R)	30.01	0.559	0.161	2.124	0.026	0.341	0.292	3.883
T*R	24.43	n.s	n.s	n.s	ns	0.481	0.412	5.461

Compared to control treatment, the nitrogen content increased by 35, 63, 82 and 59% at the application rates of 0.5, 1.0, 1.5 and 2.0kg sulfur/plot respectively. Also, it increased by 42, 45, 56 and 55% at application rates of 2.5, 5.0, 7.5 and 10.0 kg gypsum/plot, respectively. This might be due to the effect of the amendments on improving physical and chemical conditions of the tested soil. Data presented in Table 3 show that amendments increased phosphorus content of wheat grain. Compared to control treatment, phosphorus content was increased by 83, 139, 210 and 170% at the application rates of 0.5, 1.0, 1.5 and 2.0 kg sulfur/plot, respectively. Also, it increased by 101, 122, 205 and 146% at the application rates of 2.5, 5.0, 7.5 and 10.0 kg gypsum/plot, respectively. Moreover, the data indicated that increasing the application rate more than 1.5 kg sulfur/plot or 7.5 kg gypsum/plot resulted in decresing P content of the grain, however its value was still higher than the control. These results were expected because S is known to interact antagonistically with P but can be off set by a synergistic relationship between S and P (Singh, 1988). Also S and P have a synergistic relationship when S is in low concentration, but at higher concentration they act antagonistically. The antagonstic relationship between S and P might be due to their competition for root absorbtion sites or for

the same uptake pathway within the root. (Ali *et al.* 1993).

Concerning the effects of soil amendments on K-content of wheat grains, the obtained data indicated that similar trends were obtained as previously mentioned for P-content of wheat grain. Whereas, it increased by 108, 292, 417 and 184% compared to control at the corresponding rates of sulfur and by 112, 178, 305 and 224% at the corresponding levels of gypsum. In this regard, Joshi and Seth, (1975) reported that the uptake of K significantly increased by P-application with and without S. They also found that the increasing in K-uptake was low when S was applied alone, and finally concluded that K-uptake was more related to P-uptake than to S-uptake.

Effects of soil amendments on wheat grains yield and weight of 100 grain

The effect of sulfur and gypsum amendments on wheat grain yield and the weight of 100 grain are illustrated in Table 3. It is apparent that sulfur amendment significantly increased grain yield more than that obtained with gypsum amendment, while, there was non significant difference between the effect of sulfur or gypsum on the weight of 100 grain.

Regarding, the effect of application rates of both soil amendments, it is clear that increasing the application rate significantly increased wheat grain yield and weight of 100 grain.

The relative increment percent of the grain yield was 50, 84, 114 and 151% at the application rates of 0.5, 1.0, 1.5 and 2.0 kg sulfur/plot, respectively. While it was 61, 67, 97 and 119% at the application rates of 2.5, 5.0, 7.5 and 10.0 kg gypsum/plot, respectively. These findings might be due to increasing the availability of nutrients in soil reflected on contents in wheat grain.

There were highly significant positive correlation coefficients among sulfur and gypsum application rates and grain yield and its content of nitrogen phosphorus and potassium (Fig. 2). Also, eight linear regression equations were calculated and presented in the same figure.

From the above mentioned results, it can be concluded that, N, P and K availability in the soil and their contents in wheat grain were considerably increased as a result of soil amendments application. This effect seemed to be dependant on soil

properties that determine the buffering capacity and native nutrient contents. Also, the favorable effect of soil amendments were referred to their influence on reducing soil pH, improving soil structure and increasing the availability of the studied nutrients in soil.

It should also be noticed that increasing the application rate more than 1.5 kg sulfur/plot or 7.5 kg gypsum/plot has no effect on grain yield. On the other hand more over, it decreased the availability of some nutrients in soil and their content in wheat grain.

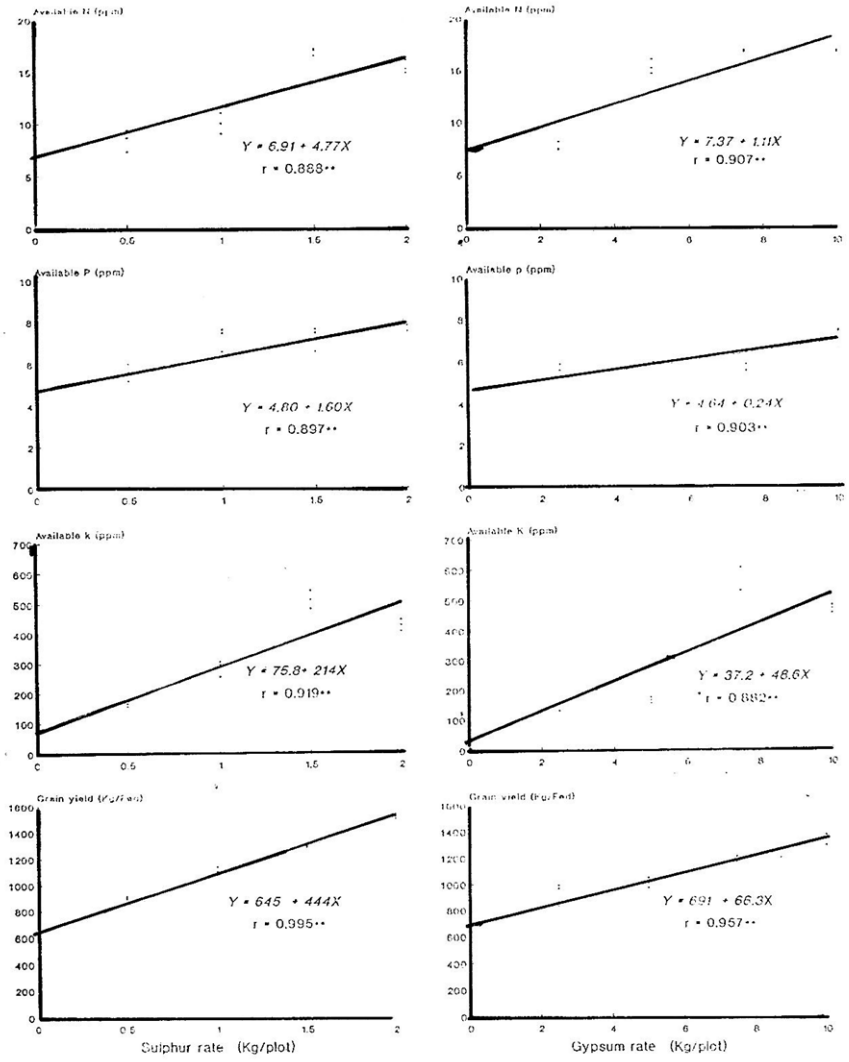

Fig. 2. The correlation coefficients and regression equations among sulphur or gypsum applications and wheat grain yield and the content of grains from N,P and K.

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دور المصلحات الكيماوية فى خصوبة التربة واستجابة محصول القمح لها فى الأراضى الملحية - القلوية

طارق عبد الرحمن أبو الضيفان، على سيد على عبد الموجود،
سمير عبد الظاهر الجندى، حسام الدين محمود الخولى

١ معهد بحوث الأراضى والمياه والبيئة - مركز البحوث الزراعية - الجيزة.
٢ قسم علوم الأراضى - كلية الزراعة جامعة الأزهر فرع اسيوط.

أجريت تجربة حقلية فى منطقة كوم أوشيم بمحافظة الفيوم لدراسة تأثير إضافة الكبريت أو الجبس كمصلحات للتربة على تيسر عناصر النتروجين والفوسفور والبوتاسيوم فى التربة ومحتوى حبوب القمح من هذه العناصر.

وقد أوضحت النتائج زيادة تيسر تلك العناصر فى التربة وكذلك محتواها فى الحبوب مع زيادة معدل الإضافة من الكبريت أو الجبس وذلك مقارنة بمعاملة الكنترول، إلا أن الزيادة النسبية فى تيسر العناصر فى التربة ومحتواها فى الحبوب قد قلت بزيادة معدل الإضافة عن ١,٥ كجم كبريت/للقطعة التجريبية أو ٧,٥ كجم جبس/للقطعة التجريبية.

وبالنسبة لمحصول الحبوب فقد كانت الزيادة بمعدل ١٥١٪ ، ١١٩٪ مقارنة بمعاملة الكنترول وذلك عند زيادة معدلات الإضافة إلى ٢ كجم كبريت/للقطعة التجريبية أو ١٠ كجم جبس/للقطعة التجريبية على التوالى، وقد يرجع ذلك الى الزيادة فى تيسر العناصر الغذائية فى التربة نتيجة لإضافة المصلحين المستخدمين.