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EFFECT OF SULPHUR APPLICATION ON SOIL IMPROVEMET AND WHEAT PRODUCTION

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ABSTRACT: *A field experiment was carried out on winter season 2012 / 2013 with wheat (Bani swif 1) grown on a clayey soil at Sids Agric. Res. Station to study the effect of sulphur (S) application and micronutrients (Mi) i.e. Fe, Zn, Mn and Cu on some properties of soil and available macronutrients in soil as well as the grain and straw yields of wheat and they chemical composition. Sulphur was added at rates of 0, 250, 500 and 1000 kg /fed alone or with afore named micronutrients which sprayed at the rate of 0.1 % Fe in the form of chelated (6%), 0.05 % Zn in the form of chelated (14 %), 0.05 % Mn in the form of chelated (13 %) and $CuSO_4$ at rate of 1 g / L. The experiment was conducted in a randomized complete block design with 4 replicates.*

The obtained results showed that the values of soil moisture retention (field capacity, wilting point and available water) were increased with increasing sulphur addition. The available contents of NPK in soil were increased with S application alone , and these increases were more pronounced when micronutrients were added. The highest treatment was found to be a mixture of 1000 kg S + Mi. This treatment reflected its positive effect on the grain and straw yields of wheat, where the highest increasing percent in the grain and straw yields of wheat reached 15.02 and 20.80 %, respectively. Data also indicated that addition of S with Mi to the studied clayey soil markedly increased the contents of NPK in wheat grains and straw, particularly at the highest rate of sulphur and Mi.

On the other hand, application of S at rate of 500 kg /fed beside sprayed with Mi gave the best treatment for all the previous parameters, because there no big differenc between 1000 kg S /fed + Mi and 500 kg S /fed + Mi or not significant.

Key words *: Sulphur, Micronutrients, Wheat, Available nutrients, Soil retention, Plant content of nutrients and Clayey soil.*

INTRODUCTION

In Egypt, it is very important to increase cereal crops production espically important for both human and animal feeding to cover the gab between production and consumption. Thus, it is recognizing the importance of improving soil properties and fertility to ensure efficient crop production. Where, maximizing crop yields depend mainly on soil fertility as related to physical and chemical properties, which strongly linked with biological activity of the soil. So, application of sulphur and micronutrients to the plants are an important practice in sustaining agricultural productivity, especially in clayey soil. The effect of sulphur on some characteristics of soil as well as plant growth was discussed by many workers such as Abdel-Nasser *et al.* (2007) who concoluded that soil conditioners i.e., natural deposits significantly increased the water constants of soils (i.e., FC, WP and AW). Deshbhratar *et al.* (2010) reported that applying elemental sulphur is an important practice in sustaining soil fertility and agricultural productivity, especially in clayey soil. Also, Taha (2013) showed that the values of soil moisture retention (field capacity, wilting point and available water) were increased with application of S.

Whereas, Jat and Mehra (2007) and Hoda (2010) concluded that application of S significantly increased the NPK contents of soil. Also, NPK uptake increased significantly with S application. Yadav and Chhipa (2007) stated that gypsum 50 % GR recorded significant increases in available NPK contents of soil. Muhammad *et al.* (2007) reported that gypsum regulated soil pH, nitrogen, phosphorus and potassium in

soil. Recently, Karimi *et al.* (2012) found that application of S had the significant effect on the amount of soil pH, total nitrogen, available phosphorus and potassium in soil. Taha (2013) found that the available contents of NPK in soil was increased with S application. Also, Taha *et al.* (2010) demonstrated that gypsum added to clayey soil improve some chemical and physical properties, which enhancing nutrients uptake by the plants and positively reflected on plant growth of wheat and crop productivity.

Moreover, Ganeshamurthy and Reddy (2001) found that dry matter production of wheat and seed yield of soybean were increased significantly by the application of S as gypsum. Also, yield and yield attributes, protein content in grain and total protein products increased significantly with increasing levels of sulphur (Singh *et al.,* 2002). Muhammad *et al.* (2003) found that application of S significantly increased the dry matter yield of maize.

Jamal *et al.* (2005), Farhad *et al.* (2010) and Hussian *et al.* (2011) stated that application of elemental sulphur significantly effect on yield components, seed, and oil yield of soybean cultivars. Yadav and Chhipa (2007) stated that gypsum 50 % GR recorded significant increases in grain and straw yields of wheat over control. AbdelAziz *et al.* (2013) reported that application of S to the studied clayey soil had a markedly effect on the seeds, straw and oil yields of soybean varities.

Jat and Mehra (2007) concluded that NPK uptake by plants increased significantly up to 60 kg S /ha application. Motior *et al.* (2011) found that application of S significantly increased nutrient uptake and dry matter accumulation of maize.

Therefore, the present work was carried out to study the effect of sulphur and trace elements on the productivity of wheat grown on a clayey soil in terms of a) their effects on some soil characteristics, b) the availability of N, P and K in soil, c) biological yields of wheat and d) contents of accumulated N, P and K in seeds and straw of wheat.

MATERIALS AND METHODS

A field experiment was carried out on a clayey soil at the farm of Sids Agriculture Res. Station to study the effect of sulphur (S) and micronutrients (Mi) on some properties of soil as well as wheat production. Sulphur was applied at rates of 0, 250, 500 and 1000 kg / fed before preparing the soil to cultivation. micronutrients i.e Fe, Zn, Mn and Cu were sprayed after 30 dayes from plantation at the rate of 0.1 % Fe in the form of chelated (6%), 0.05 % Zn in the form of chelated (14 %), 0.05 % Mn in the form of chelated (13 %), and 0.1% $CuSO_4$ .The experiment was conducted in a randomized complete block design with 4 replicates.

Wheat (Bani swif 1) was sowed in winter season (Nov.) 2012/ 2013 and harvested at maturity stage to determine the yields of grains and straw as well as plant nutrients content.

Soil samples were collected from the surface layer (0-30 cm) before plantation and at the end of vegetative growth (90 days after plantation), then dried, crushed and sieved through a 2 mm screen. These samples were physico - chemical analysed to measure the electrical conductivity (EC_e) and pH (Jackson, 1973). Partical size distribution and calcium carbonate were determined according to Piper (1950) . Available N, P, K were determined according to Jackson (1973). Soil organic matter was determined according to Walkley-Black method (Black et al., 1965). Cation exchange capacity was determined using method of Richards (1954). The physical and chemical analyses of the studied soil before cultivation are shown in Table (1).

Also, plant samples (grain and straw) were taken after harvesting and digested to determine the contents of N, P, K according to Chapman and Pratt (1961).

All treatments received a uniform fertiization with recommended dose of nitrogen in the form of urea (46 % N) which was applied to soil plots at the rate of 75 kg N/fed in two equal doses during the growing period, i. e., after 15 & 40 days from

plantation. superphosphate (15 % P_2O_5) was applied at the rate of 100 kg P_2O_5 / fed and potassium sulphate (48 %) was applied at rate of 50 kg K_2O /fed before plantation. The plot area was 42 m^2 (6 m width and 7 m length).

RESULTS AND DISCUSSION

1.Effect of S and micronutrients on soil moisture retentions :

Data found in Table (2) showed that the soil moisture retentions (field capacity, wilting point and available water) of clayey soil were affected by S application. Where, application of S improved soil moistur retentions. Also, application of S + Mi were more prounonced in increasing soil moisture retentions than that application of S alone. The relatively low values of field capacity, wilting point and available water were attained for the control (40.85, 20.34 and 20.51 %), and tend to increase with increasing the rates of S from 0.0 up to 1000 kg/fed. These improvements were found to be proportional to the rate of S application. However, the best treatment was 1000 kg S/fed + Mi., which gave the highest values of field capacity, wilting point and available water, as a result of the increase in soil micro-pores. These results are in harmony with those reported by Taha (2013) who showed that the values of soil moisture retention (field capacity, wilting point and available water) were increased by application of sulphur.

Table (1): Some physical and chemical characteristics of the studied clayey soil.

Soil characteristics	Value
Particle size distribution (%):	
Coarse sand	3.5
Fine sand	11.0
Silt	33.5
Clay	52.0
Textural class	Clayey
ESP	17.2
Field capacity (%)	40.65
Wilting point (%)	20.44
Available water (%)	20.21
pH (soil paste)	8.1
Calcium carbonate (%)	1.7
Organic matter %	2.05
ECe (dS / m, soil paste extract)	1.90
Cation exchange capacity (mq/100 g)	39.4
Available N (mg/kg soil)	21.6
Available P (mg/kg soil)	9.2
Available K (mg/kg soil)	285.2

Table (2): Effect of sulphur and micronutrients on soil moisture retentions (%) in the clayey soil.

Sulpher (kg /fed)	Field capacity	Wilting point	Available water
Control	40.85	20.34	20.51
250	42.64	21.20	21.44
500	48.33	21.62	26.71
1000	49.25	22.00	27.25
250 + Mi	42.75	21.50	21.25
500 + Mi	49.15	21.82	27.33
1000 + Mi	49.85	22.35	27.50
Mi			
	41..22	20.60	20.62
L.S.D.0.05	1.84	0.64	1.43

2.Effect of S and micronutrients on available macronutrients:

Data in Table (3) showed the contents of available NPK in a clayey soil treated with different rates of S and Mi. It shows that available NPK in top soil increased with S application alone. The relative increase percentegs of NPK when treated with 250 kg S /fed were 18.30, 33.00, and 7.86 for NPK, respectivily. While, the relative increase percentegs of NPK when treated with 500 kg S/fed reached 29.53, 66.46 and 32.53 % over that of control, respectively. Meanwhile, the corresponding values when the soil treated with the highest rate of S (1000 kg/ fed) were 32.25, 69.08 and 35.07 % for N, P, K, respectively. This is due to improving some charatrestics of the clayey soil, and consequantly increased available macronutrients.These results are in accordance with those obtained by AbdelAziz et al. (2013) and Taha (2013) who reported that the available contents of NPK in soil were increased with S application.

Concerning the effect of applied S and Mi, data revealed that the best treatment was 1000 kg S /fed + Mi, since their effect caused the highest values of available NPK where the relative increase percentages of these nutrients reached 37.23, 83.14 and 48.36 % over that of control, respectively. While, the relative increase percentages when the soil treated with 500 kg S/fed + Mi were 36.46, 80.60 and 45.38 % over control, respectively. This means that the big difference between 500 kg S + Mi and 1000 kg S + Mi was not found or not significant. So, it was cosidered that the best treatment was 500 kg S + Mi /fed.

3. Grain yield of wheat and its chemical composition :

Effect of different treatments of S and added micronutrients on grain yield of wheat and its increasing percent is given in Table (4). Data indicated that the application of different rates of S had a markedly effect on the grain yield of wheat. The highest yield was recorded when the soil treated with S at rate of 1000 kg/fed (about 19.82 ardab / fed). Increasing percentage at this treatment reached about 14.97 % compared with control. Also, the grain yield of wheat reached 19.77 ardab/fed when the soil treated with 500 kg S /fed. Increasing percentage at this treatment reached about 14.68 % compared with control. These results are resembled with those obtained by Ganeshamurthy and Reddy (2001) who found that dry matter production of wheat was increased significantly by the application of S as gypsum.

Table (3): Effect of sulphur and micronutrients on available macronutrients in soil (mg/kg soil) .

Sulpher (kg /fed)	N	P	K
Control	22.08	11.03	313.26
250	26.12	14.67	337.89
500	28.60	18.36	415.16
1000	29.20	18.65	423.12
250 + Mi	28.82	15.32	347.12
500 + Mi	30.13	19.92	455.42
1000 + Mi	30.30	20.20	464.75
Mi	23.13	13.68	320.15
L.S.D.0.05	1.35	1.41	26.47

Table (4): Effect of sulphur and micronutrients on grain yield of wheat.

Sulpher (kg /fed)	Grain (ardab/fed)	Increasing percent
Control	17.24	0.00
250	19.07	10.61
500	19.77	14.68
1000	19.82	14.97
250 + Mi	19.74	14.50
500 + Mi	20.96	21.58
1000 + Mi	20.98	21.69
Mi	19.19	11.31
L.S.D.0.05	0.67	

Moreover, the plants sprayed with Mi only gave about 11.31% increase in the grains of wheat, while application of S to the soil at rate of 500 kg/fed combined with Mi gave about 21.58% increase in the grain of wheat compared with that of control. However, application of S at rate of 1000 kg + Mi gave about 21.69 % increase in the grain yield. The variation between the two treatments was not biger. This means that application of S at rate of 500 kg + Mi gave the same effect of the application at the rate of 1000 kg + Mi, whearas synergistic effect of two treatments was happaned.

This is mainly ascribed to stimulated growth of shoots and roots of wheat plants and improved some properties of soil which correlated with enhanced uptake of macronutrits.

Data in Table (5) also showed that there were markedly increases in the contents of N, P, K of wheat grains which treated with S and Mi in the studied clayey soil. Application of S alone increased the N, P, K contents in grains of wheat by about 0.220, 0.102 and 0.230 unite for 250 kg S; 0.360, 0.117 and 0.240 unite for 500 kg S and 0.450, 0.119 and 0.270 unite for 1000 kg S over control treatment, respectively.

Table (5): Effect of sulphur and micronutrients on chemical composition of wheat grains.

Sulpher (kg /fed)	N %	P %	K %
Control	1.650	0.115	1.150
250	1.870	0.217	1.380
500	2.010	0.232	1.390
1000	2.100	0.234	1.420
250 + Mi	1.980	0.221	1.460
500 + Mi	2.200	0.245	1.550
1000 + Mi	2.200	0.244	1.540
Mi	1.880	0.197	1.370
L.S.D.0.05	NS	NS	NS

Results also indicated that S application combined with Mi to wheat grown in the studied clayey soil had a markedly effect on the contents of N, P, K, where the highest values were found at 500 kg S application + Mi. These increases reached 0.550, 0.130 and 0.400 unite for NPK in grain of wheat over that of control, respectively. This was due to increasing the growth of shoots and roots of wheat plants and increasing the uptake of macronutrients.

4. Yield of wheat straw and its chemical composition :

Effect of different rates of S and micronutrients on wheat straw yield and its increasing is given in Table (6). Data indicated that application of different rates of S to soil had a markedly effect on the yield of wheat straw. The highest yield was recorded with 1000 kg S /fed (about 5.69 ton / fed). Increasing percentage at this treatment reached about 14.94 % compared with control. While,treated the soil with 500 kg S /fed gave increase about 11.52 % in the wheat straw compared with control. These results are resembled with those obtained by Ganeshamurthy and Reddy (2001) who found that dry matter production of wheat was increased significantly by the application of S as gypsum.

Moreover, the plants sprayed with Mi gave increase of wheat straw about 4.44%, while S application to the soil at rate of 500 kg /fed + Mi gave the best treatment (about 20.20 %) increase in the straw of wheat compared with appliction 1000 kg /fed + Mi (about 20.80 %) increase in the straw of wheat. So, there is no big difference between them. This means that application of S at 500 kg /fed in combination with Mi gave the same effect of 1000 kg S /fed + Mi, whearas synergistic effect of two treatments was happaned.

Data in Table (7) also showed markedly increases in the contents of N, P, K of wheat straw by S addition with Mi in the studied clayey soil. Application of S alone increased the N, P, K contents in straw of wheat by about 0.060, 0.012 and 0.250 unite for 250 kg S; 0.100, 0.046 and 0.250 unite for 500 kg S and 0.110, 0.052 and 0.250 unite for 1000 kg S over control treatment, respectively.

Results also indicated that application of S combined with Mi to wheat grown in the studied clayey soil had a markedly effect on the contents of N, P, K, in the straw, where the highest values were found at application of 1000 kg S mixed with Mi. The increases reached 0.170, 0.060 and 0.380 unite for NPK in straw of wheat over that of control, respectively. On the other hand, application of S at rate of 500 kg + Mi gave about 0.150, 0.058 and 0.360 unite for N, P and K. Consequntaly, there is no big diffference between the the effects of the tow treatments. Thus, it was considred that application of S at rate of 500 kg + Mi was more effect than application of S at rate of 1000 kg + Mi. This increase in the yield of straw was due to increase of shoots and roots of wheat plants growth and increase of macronutrients uptake.

Table (6): Effect of sulphur and micronutrients on yield of wheat straw.

Sulpher (kg /fed)	Straw (Ton/fed)	Increasing percent
Control	4.95	0
250	5.32	7.47
500	5.52	11.52
1000	5.69	14.94
250 + Mi	5.61	13.33
500 + Mi	5.95	20.20
1000 + Mi	5.98	20.80
Mi	5.17	4.44
L.S.D.0.05	NS	

Table (7): Effect of sulphur and micronutrients on chemical composition of wheat straw.

Sulpher (kg /fed)	N %	P %	K %
Control	0.550	0.222	1.060
250	0.610	0.234	1.310
500	0.650	0.268	1.310
1000	0.660	0.270	1.310
250 + Mi	0.640	0.235	1.360
500 + Mi	0.700	0.280	1.420
1000 + Mi	0.720	0.282	1.440
Mi	0.570	0.230	1.110
L.S.D.0.05	NS	NS	NS

From the above mentioned results, it was concivied that treated the clayey soil with S at rate of 500 kg/fed associated with foliar applications of micronutrients (Fe, Zn, Mn and Cu) have positive effects on some characteristics of soil as well as available macronutrients in soil which increasing the growth of shoots and roots of wheat plants and enhanced uptake of macronutrients through increase cell membrane permeability and increasing biological proccess.

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تاثير اضافة الكبريت على تحسين التربة وانتاجية القمح

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الملخص العربى

اجريت تجربة حقلية على ارض طينية بمحطة البحوث الزراعية بسدس خلال الموسم الشتوى 2013/2012 لدراسة تاثير الكبريت المعدنى بصورة منفردة او مشتركة مع العناصر الصغرى على بعض الخواص المائية (السعة الحقلية، معامل الذبول والماء الميسر) وكذلك محتوى التربة من العناصر الغذائية الميسرة لنبات القمح (بنى سويف 1) ومحصول الحبوب والقش للقمح ، وقد اضيف الكبريت بمعدلات صفر ،250 ، 500 ، 1000 كجم/ فدان، بينما اضيفت العناصر الصغرى (حديد ، زنك ، منجنيز ، نحاس) بالمعدلات الاتية: 0.1 % حديد فى صورة مخلبية (6 %) ، 0.05 % زنك فى صورة مخلبية (14 %) ، 0.05 % منجنيز فى صورة مخلبية (13 %) ، بينما اضيف الناس فى صورة كبريتات نحاس 1 جم /لتر وصممت التجربة فى قطاعات تامة العشوائية .

وتشيرالنتائج المتحصل عليها الى زيادة قيم ثوابت الرطوبة الارضية لكل من السعة الحقلية ، معامل الذبول والماء الميسر بزيادة كل من الكبريت والعناصر الصغرى وكانت افضل المعاملات هى 1000 كجم كبريت/فدان مع العناصر الصغرى.

كما تشير ايضا الى حدوث زيادة فى محتوى التربة من العناصر الميسرة لكل من النيتروجين والفوسفوروالبوتاسيوم باضافة الكبريت منفرد ، وقد ازدادت كمياتها بدرجة واضحة باضافة العناصر الصغرى ، حيث تعاظمت قيم عناصر النيتروجين والفوسفور والبوتاسيوم الميسرة للنبات فى حالة الاضافة المشتركة .

وقد اوضحت النتائج ايضا ان اضافة الكبريت والعناصر الصغرى منفردين او معا قد اثرت تاثيرا ملحوظا على محصول القمح من الحبوب والقش ، وان الزيادة العظمى لمحصول الحبوب والقش والتى قد تحصل عليها من المعاملة المشتركة (الكبريت بمعدل 1000 كجم / فدان + العناصر الصغرى) قد وصلت الى21.69% ، 20.80 % على التوالى ، كما دلت النتائج ايضا على ان الاضافة المشتركة للكبريت مع العناصر الصغرى قد ادت الى زيادة محتوى الحبوب والقش من النيتروجين والفوسفور والبوتاسيوم ، وصلت الى اعلى قيمها عند اضافة الكبريت بمعدل 1000 كجم / فدان + العناصر الصغرى .

من ناحية اخرى فأن اضافة الكبريت بمعدل 500 كجم / فدان بالاضافة الى الرش با لعناصر الصغرى اعطى احسن معاملة لجميع القياسات السابقة لان الفرق بين 1000 كجم كبريت / فدان مع العناصر الصغرى و 500 كجم كبريت / فدان مع العناصر الصغرى ليس معنويا .