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EVALUATION EFFICIENCY OF SULPHUR FERTILIZER IN CALCAREOUS SOIL AMENDED BY COMPOST

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ABSTRACT: *A pots experiment was carried out at greenhouse of Soil Sci., Dept., Fac., of Agric., Menoufia Univ., Egypt to study the effect of individual and combined applications of compost and S as soil amendments on calcareous sandy soil properties and its content of available macro and micronutrients barley plants (Hordeum Vulgare L.) growth and its content of macro and micronutrient and agronomical efficiency (AE) of the tested soil amendments. Compost was added at rates of 0, 1 and 2 %, where S was added as elemental S at rates of 0, 200, 300 and 400 mg/kg. The dry matter yield of barley plants harvested after 70 days of planting and its content of macro and micronutrients were determined. Also, chemical properties of the tested soil and its content of available macro and micronutrients after planting harvesting were determined.*

Increasing application rates of compost and S individually and together resulted in a decrease of calcareous soil pH, EC (dS m^{-1}) and its content (%) of $CaCO_3$, while were associated by an increase soil OM (%), CEC (meq/100 g) and its content (mg/kg) of available N, P, K, Ca, Mg, S, Fe, Zn, Mn and Cu. The high relative changes “RC” (%) of the studied soil properties were associated the combined treatments of compost and S especially at high application rates. Dry matter yield of barley plants and its content of N, P, K, Ca, Mg, S, Fe, Zn, Mn and Cu were increase with the increases of added compost and S individually and together. Agronomical efficiency (AE) of both compost and S under calcareous sandy soil conditions were increased in their combined application treatments. So, these results concluded that, to improve the properties of calcareous sandy soil and increased its fertility and productivity must be treated by compost and S together.

Key words: *Calcareous sandy soil, Compost, Sulphur, Barley plant, Soil amendment, Nutrients uptake and Agronomical efficiency.*

INTRODUCTION

In Egypt desert area represents about 96% of Egypt total area, where most of desert areas are scattered in the eastern and western parts at the periphery of the Nile Valley and Delta. The reclamation of desert lands to become agriculturally productive is a first priority of the government policy. Calcareous soil is wide occurrence in these regions. Most of newly reclaimed calcareous soil is mainly found in western part of the Nile Delta. The calcareous soils are those with high content of $CaCO_3$, especially the active fraction with high specific surface area which causes some physical problem of these soil and water use for crop production. A soil is considered “calcareous” from the chemical point of view when it is in equilibrium with excess of $CaCO_3$ at the partial pressure of the atmospheric CO_2. In the context of agricultural problem soil, calcareous soils are in which a high amount of calcium carbonate dominates the problem related to agricultural soil use. The formation of crusts is a problem in the carbonate – rich soils newly put under cultivation. Crusting which takes place at the soil surface hinders seeding rate of emergence and percentage. The adverse effect of crust depends on their strength and thickness. (Imas, 2000).

Composting is useful in avoiding greenhouse gas emissions, as it is an aerobic process (Nada, 2011). Composting has been presented as an environmentally friendly alternative to manage and recycle organic wastes with the aim to produce products used as amendments in agriculture. However, the generation of polluting or odorous gases has become a serious negative environmental impact of the composting process. (Barrington *et al.,* 2002).

Sulphur deficiency in soils is widespread around the world (Mathot and Thélier-Huché, 2009) because sulphur is difficult for plants to absorb and results in sterilization and bacteriostatic. Therefore, the addition of sulphur alone may inhibit microbial activity and result in volatilization of H2S (Nasser et al., 2004). Sulphur mineralization is tied closely to C and N levels in the soil. Sulphur will become or remain immobilized if either the C:S or N:S ratios are too large and conditions conducive to S mineralization often lead to N mineralization. The N:S ratio in many soils is in the range of 8- 12:1. Carbon: sulphur ratios tend to be more variable (with respect to the C levels) they have been reported in the range from about 57-141:1 (Edwards, 1998). Stotzky and Norman (1961) proposed that C:S ratios less than 900:1 are adequate for maximum microbial activity. This means that sufficient S is present to meet microbial needs and formation of organic S may not be necessary. However, smaller optimal ratios have been suggested by Barrow (1961). Indeed, C:S ratios in the literature are almost always within the 900:1 range; so the range may be too broad and/or other factors beside the C:S ratio must be considered when interpreting microbial activity.

Barley (*Hordeum Vulgare* L.) is one of the most dependable cereal crops in harsh environment it is grown in semiarid areas as well as in cold, short season areas. Local varieties and landraces of barley occupy nearly 80% of the cultivated areas in west Asia and North Africa and these should be collected before they are losing (Qadir *et al.,* 2008).

This study was carried out to evaluate the effect of different additives of compost and sulphur individually and together on the chemical properties of calcareous sandy soil and its content of available macro and micronutrients. The effect of the studied treatments of plant growth and nutrients uptake was one of the aims of this study. Also, agronomical efficiency of both compost and sulphur was determined.

MATERIALS AND METHODS

This study was carried out as pot experiment at greenhouse experiment, Soil Sci., Dept., Faculty of Agric., Menoufia Univ., Shebin El-Kom, Egypt to study the effect of different compost and S additives on calcareous sandy soil properties and plant growth. Also, agronomical efficiency of both compost and S was determined

Soil sampling

Surface soil samples (0- 20 cm) represented newly reclaimed calcareous soils of Egypt were collected from Village 6, Abu El-Matamir, EL-Behaira Governorate, Egypt. The collected soil samples air-dried, ground, good mixed and sieved through a 2 mm sieve. Sieved fine soil (**<** 2 mm) was analyzed for its physical and chemical properties and its content of available macro- and micronutrients according to the methods described by Klute and Dirksen (1986) and Cottenie *et al.* (1982). The obtained data are recorded in Table (1). Other part of this fine soil was used in the greenhouse experiments as mentioned in the following sections.

Soil amendments

Two soil amendments.ie. compost and S were used in this study. The used compost was produced from the mixture of maize stalks and farmyard manure at mixed rate of 65:35 by weight for 60 days. Sample of produced compost was taken, air dried, ground and analyzed for its chemical composition according to the methods described by Page *et al.* (1982). The obtained data are recorded in Table (2). The used elemental sulphur taken from El Help company, Egypt. The purity of this elemental sulphur was 99% with pH value of 6.4 (in suspension of 1:5).

Table (1): Some physical and chemical properties and available nutrients content of the used calcareous soil.

Property and unit			Values
Particle size distribution (%)		Sand	78.50
		Silt	10.30
		Clay	11.20
Textural grade			Sandy
pH 1:2.5 (soil: water Susp.)			8.40
EC 1:5 (soil: water extract) dSm^{-1}			1.42
Organic matter (%)			0.55
$CaCO_3$ (%)			13.95
CEC meq/100g			10.20
Soluble ions (meq/l)	Soluble cations	Ca^{++}	3.32
		Mg^{++}	1.40
		K^{+}	0.12
		Na^{+}	9.10
	Soluble anions	CO_3^{--}	0.00
		HCO_3^{-}	3.15
		Cl^{-}	6.90
		SO_4^{--}	3.89
Available macronutrients (mg / kg)		N	45.25
		P	4.35
		K	925.00
		S	7.62
		Ca	20.28
		Mg	10.42
Available micronutrients (mg / kg)		Fe	4.90
		Zn	1.89
		Mn	6.25
		Cu	0.78

Table (2): Chemical composition of the used compost.

Property and unit		Values
pH 1:2.5 (compost: water) Susp.		6.88
EC 1:5 (compost: water extract) dSm^{-1}		2.24
Organic carbon (%)		24.74
Organic matter (%)		42.65
Total nitrogen (%)		1.60
C/N ratio		15.46
Available macronutrients (mg / kg)	N	888
	P	711
	K	2016
	S	296
	Ca	694
	Mg	5913
Available micronutrients (mg / kg)	Fe	403
	Zn	61
	Mn	518
	Cu	17

Greenhouse experiments

In this experiment, 36 plastic pots with 20 cm diameter and 25 cm depth were used. Each pot was filled with 5 kg of fine calcareous soil. The pots were divided into three main groups (12 pots/ main group) representing treatments of compost 0 (C0), 1 (C1) and 2 (C2) % which equal 0, 10 and 20 tons compost /fed, respectively. The pots of each main groups were divided into four sub groups (3 pots / sub group) representing sulphur additives treatments 0 (S0), 200 (S1), 300 (S2) and 400 (S3) kg/fed (0, 200, 300 and 400 mg S/kg). All treatments of compost and sulphur were carried out separately before planting. Also before planting super phosphate (15.5% P_2O_5) was applied at rate of 200 kg/fed (200 mg/kg). The studied were arranged in two way randomize blocks in three replicates.

Each pot was sown by 10 grains of barley plant (*Hordeum vulgar* L.) Variety Giza 123 at 2 cm depth in 20 November 2014. The pots were irrigated with tap water at 60 % of WHC for each treatment. After complete germination, the plants in each pot were thinned at 5 plants. Irrigation water was added every 5 days to keep the moisture content at 60% WHC. After 20 days of planting each pots were fertilized by ammonium nitrate (33.5 % N) at rate of 100 kg/fed (100 mg/kg). At the same time, each pot was received potassium chloride (48% K_2O) at rate of 100 kg/fed (100 mg/kg). Another and equal dose of ammonium nitrate and potassium chloride was added after 42 days of planting. All N and K applications were carried out with irrigation water. At the end of the experiment (70 days from sowing), the plants of each pot were harvested. The harvested plants were washed by tap water to remove any soil particles. Then the harvested plants were separated to roots and shoots. After that the plants (roots and shoots) air-dried. Then divided into two parts the first was dried at 105 °C to determine the dry weight and the second parts were dried at 70 °C to determine some of mineral composition content, after that ground and kept for chemical analysis according by Page et al. 1982. The data of obtained dry matter yield for both roots and shoots of barley was statistically analyzed according to Snedecor and Cochran (1980). In addition, relative changes "RC" (%) of the data of obtained dry matter yield for both roots and shoots were calculated using (Eq. 1)

$$\boldsymbol{RC}\ (\%) = \frac{DT-DC}{DC} \times 100 \qquad \text{(Eq.1)}$$

Where the *DT* and *DC* represent dry weights of treated and untreated plants, respectively.

Also the agronomic efficiency *"AE"* (g plant/ g soil amendment) of S or compost additives of both shoots and roots of the plants were calculated using (Eq. 2).

$$\boldsymbol{AE} = \frac{DT-DC}{P} \qquad \text{(Eq. 2)}$$

Where the *DT* and *DC* represent the data of treated and untreated plants, respectively and *P* represent the application rate S (g/pot) or compost (g/pot). Soil sample of each pot was taken air-dried, ground, good mixed, sieved through a 2 mm sieve and kept for some chemical determinations and its content of available macro and micronutrients, according to Cottenie *et al.* (1982).

Plants Analysis

Sample of 0.5 gm of oven dried plant material was digested with a mixture of 10ml concentrated sulphuric acid and 1 to 5 drops perchloric acid on the sandy hot plate at 250°C until the flask content become colorless according to Chapman and Partt (1961). Then, the digest was diluted with distilled water to a volume of 100 ml. Aliquots from this digest was analyzed for the content of macro and micronutrients, according to Cottenie *et al.* (1982).

RESULTS AND DISCUSSION

Soil properties

The presented data in Table (3) show that, calcareous soil pH, EC (dS m^{-1}) and $CaCO_3$ (%) were decreased with the increase rates of added S and compost individually and together. Individual applications of S were associated by more decrease of soil pH and EC compared with that associated the individual applications of compost. On the other hand, the found decrease of soil content (%) of $CaCO_3$ associated the individual application of compost was higher than that resulted from the individual S applications. More decreases of calcareous soil pH, EC and $CaCO_3$ were found with S and compost applications together. These findings may be cleared by relative changes (RC) values (%) of soil pH, EC and $CaCO_3$ affected by individual and combined applications of S and compost, where these values were negative with wide variations depending on the studied soil properties and the treatments of added soil amendment .

Other studies attributed the decrease effect of S and compost on soil pH, EC and $CaCO_3$ to their reactions and reactions products which characterized by acidic effect (El-Maddah *et al.,* 2012; Hashemimajd *et al.,* 2012; Ahmed, 2013; Mutowal *et al.,* 2013 and El-Gamal, 2015).

Also, data in Table (3) show an increase effect of compost applications individually on soil content (%) of OM, where the individual applications of S resulted in a decrease of this content. Combined applications of compost and S resulted a little increase of soil content of OM compared with that found with the individual applications of compost. So, RC (%) values of soil content of OM were positive in both individual applications of compost and combined treatments of compost and S, while these values were negative with the individual treatments of S.

The decrease effect of S on soil content of OM may be resulted from oxidation reactions associated S applications which resulted more oxidation of soil organic matter (Pandey and Shukla, 2006). In this respect, Aiad (2010) and Gohar (2011) obtained on similar results.

Data of CEC (meq/100 g) of calcareous sandy soil presented in Table (3) show that, increasing application rates of added S and compost individually and together resulted in an increase of soil CEC. According to the found increases of soil CEC, the studied treatments takes the order combined applications of S and compost **>** individual applications of compost **>** individual applications of S. Mahmoud *et al.* (2001) and El-Gamal (2015) showed that applications of gypsum and sulphur alone or combination with different resources of organic matter improved soil properties and its fertility.i.e. pH, EC, ESP, CEC and availability macro and micronutrients. In this respect, Wang *et al.* (2009); Aiad (2010); Gohar (2011) and El-Maddah *et al.* (2012) obtained on similar results.

Table (3): Effect of sulphur and compost additives on pH, EC, OM, CEC and $CaCO_3$ in calcareous soil and its relative change "RC" (%) as affected by sulphur additives.

The studied treatments		**pH** 1:2.5(compost : water) susp.		**EC 1:5**(dSm^{-1}) (compost : water) extract		**OM** %		**CEC** meq/100g		**$CaCO_3$ (%)**	
Compost	**Sulphur**	value	RC %	value	RC %	value	RC %	value	RC %	value	RC %
C0	**S0**	8.20	0	1.36	0	0.60	0	10.50	0	13.84	0
	S1	8.18	-0.24	1.32	-2.94	0.57	-5	10.65	1.43	13.15	-4.99
	S2	8.12	-0.98	1.30	-4.41	0.52	-13.3	10.90	3.81	12.25	-11.5
	S3	7.95	-3.05	1.20	-11.8	0.50	-16.7	11.10	5.71	11.65	-15.8
Mean		**8.61**		**1.30**		**0.55**		**10.79**		**12.72**	
C1	**S0**	8.17	0	1.34	0	0.79	0	11.80	0	13.11	0
	S1	8.12	-0.61	1.31	-2.24	0.74	-6.33	11.98	1.53	12.75	-4.99
	S2	8.05	-1.47	1.25	-6.72	0.71	-10.1	12.23	3.64	11.95	-11.5
	S3	7.88	-3.55	1.13	-15.7	0.69	-12.7	12.80	8.47	11.05	-15.8
Mean		**8.06**		**1.26**		**0.73**		**12.20**		**12.22**	
C2	**S0**	7.98	0	1.28	0	0.92	0	13.50	0	12.50	0
	S1	7.88	-1.25	1.26	-1.56	0.85	-7.61	13.70	1.48	11.90	-4.8
	S2	7.79	-2.38	1.15	-10.2	0.78	-15.2	13.98	3.56	11.10	-11.2
	S3	7.68	-3.76	0.95	-25.8	0.75	-18.5	14.15	4.81	10.78	-13.8
Mean		**7.83**		**1.16**		**0.83**		**13.83**		**11.57**	

C0, C1 and **2. 0, 1** and **2 %** compost and **S0, S1, S2** and **S3 = 0, 200, 300, 400** kg S/ fed of sulphur respectively.

Available macronutrients

The presented data in Table (4) show that, calcareous sandy soil contents (mg/kg) of available N, P, K, Ca, Mg and S increased with the increase rates of added compost and S alone or in together. The found content of available macronutrients varied widely from nutrient to another, where the highest content was found with available K followed by available N, while the lowest one was found with available P followed by that found with the sandy soil content of available S. The found wide variations in calcareous sandy soil content of available macronutrients depending on the initial contents of these nutrients in the soil and the used soil amendments and also on the effect of these amendments on soil properties. Except the soil content of available S, the increase of soil content available macronutrients resulted from the individual applications of compost were higher than these resulted from the individual applications of S. Combined applications of S and compost were associated by high content of the determined available macronutrients compared with those resulted from their individual applications.

So, all RC (%) values of calcareous sandy soil content of available macronutrients affected by S and compost applications compared with the control treatments were positive and increased with the increase rates of S and compost alone or together. With all macronutrients, the highest RC (%) values were found in the soil treated by S and compost together, but the lowest values were found in the soil treated by S alone (Table,). At the same treatment of the tested soil amendments, RC (%) values varied from nutrient to another, where the highest value was recorded with N followed with S and the lowest one found with Ca. Similar increase effect of S and compost or other organic matter resources were reported by Abdel Dayem *et al.* (2008); Aiad (2010); Gohar (2011); El-Maddah *et al.* (2012) and El-Gamal (2015).

Table (4): Effect of sulphur and compost additives on concentration (mg/kg) of N, P, K, Ca, Mg and S in calcareous soil and its relative change "RC" (%) as affected by sulphur additives.

The studied treatments		N		P		K		Ca		Mg		S	
Compost	**Sulphur**	**mg/kg**	**RC %**	**mg/kg**	**RC %**	**mg/kg**	**RC %**	**mg/kg**	**RC %**	**mg/kg**	**RC %**	**mg/kg**	**RC %**
C0	**S0**	44.10	0	4.15	0	908	0	20.10	0	10.30	0	7.50	0
	S1	46.50	5.44	4.70	13.25	928	2.20	20.88	3.88	10.48	1.75	7.95	6.00
	S2	49.80	12.93	4.92	18.55	963	6.06	21.62	7.56	10.81	4.95	8.75	16.67
	S3	54.65	23.92	5.05	21.69	995	9.58	22.10	9.95	11.25	9.22	9.50	26.67
Mean		**48.76**		**4.71**		**948.5**		**21.18**		**10.71**		**8.43**	
C1	**S0**	48.50	0	4.41	0	932	0	21.50	0	10.55	0	7.65	0
	S1	55.30	14.02	4.95	12.24	950	1.93	21.95	2.09	10.75	1.90	8.15	6.54
	S2	60.80	25.36	5.23	18.59	985	5.69	22.70	5.58	11.25	6.64	8.92	16.60
	S3	65.12	34.27	5.44	23.36	1042	11.80	23.45	9.07	11.60	9.95	9.90	29.41
Mean		**57.43**		**5.01**		**977.25**		**22.4**		**11.04**		**8.66**	
C2	**S0**	51.30	0	5.10	0	945	0	21.85	0	10.72	0	7.91	0
	S1	61.70	20.27	5.61	10.00	970	2.65	22.40	2.52	10.98	2.43	8.70	9.99
	S2	68.70	33.92	5.98	17.25	1010	6.88	23.15	5.95	11.63	8.49	9.45	19.47
	S3	72.50	41.33	6.18	21.18	1090	15.34	24.10	10.30	11.98	11.75	10.65	34.64
Mean		**63.55**		**5.72**		**1003.8**		**22.88**		**11.33**		**9.18**	

C0, **C1** and **C2. 0, 1** and **2** % compost and **S0, S1, S2** and **S3= 0, 200, 300, 400** kg S/fed of sulphur respectively.

Available Micronutrients

The presented data in Table (5) show that, calcareous sandy soil content (mg/kg) of available micronutrients.i.e. Fe, Zn, Mn and Cu were increased with the increase added rates of S and compost individually and in together. The found increases in the sandy soil content of available micronutrients resulted from the individual applications of S were higher than that resulted from the individual treatments of compost. More increase of soil content of available micronutrients was resulted from combined applications of S and compost especially at high their application rates. So, with all treatments of S and compost, RC (%) values of the soil content of available micronutrients were positive (Table, 5). The highest values of RC were associated the combined treatment of S and compost followed by those associated the individual applications of S. Generally, the tested sandy soil characterized by low content of available micronutrients. The highest content of available micronutrients was found with Mn followed Fe and the lowest one was found with Cu. This trend was found with all treatments under study. The found increases in calcareous sandy soil content of available Fe, Zn, Mn and Cu due to S and compost applications may be explained based on the transformations and reactions of the added amendments in the soil and their effect of the different soil properties (El-Gamal, 2015). In this respect, Abdel Hafez (2008); Ahmed (2013) and Chen *et al.* (2013), obtained on similar results.

Table (5): Effect of sulphur and compost additives on concentration (mg/kg) of micronutrients in calcareous soil and its relative change "RC" (%) as affected by sulphur additives.

The studied treatments		Fe		Zn		Mn		Cu	
Compost	**Sulphur**	**mg/kg**	**RC %**	**mg/kg**	**RC %**	**mg/kg**	**RC %**	**mg/kg**	**RC %**
C0	**S0**	4.85	0	1.80	0	6.11	0	0.75	0
	S1	4.98	2.68	1.93	7.22	6.35	3.93	0.83	10.67
	S2	5.22	7.63	2.12	17.78	6.65	8.84	0.93	24.00
	S3	5.50	13.40	2.40	33.33	7.05	15.38	1.15	53.33
Mean		**5.14**		**2.06**		**6.54**		**0.92**	
C1	**S0**	5.10	0	1.95	0	6.50	0	0.88	0
	S1	5.35	4.90	2.15	10.26	6.82	4.92	1.03	17.05
	S2	5.75	12.75	2.50	28.21	7.41	14.00	1.22	38.64
	S3	6.12	20.00	3.10	58.97	7.95	22.31	1.50	70.45
Mean		**5.58**		**2.43**		**7.17**		**1.16**	
C2	**S0**	5.40	0	2.11	0	6.88	0	0.98	0
	S1	5.82	7.78	2.40	13.74	7.30	6.10	1.12	14.29
	S2	6.30	16.67	2.95	39.81	7.90	14.83	1.40	42.86
	S3	6.78	25.56	3.63	72.04	8.62	25.29	1.78	81.63
Mean		**6.08**		**2.77**		**7.68**		**1.32**	

C0, C1 and **C2. 0, 1** and **2** % compost and **S0**, **S1**, **S2** and **S3= 0, 200, 300, 400** kg S/fed of sulphur respectively.

Dry matter yield of barley plants

The presented data in Table (6) show the dry matter yield (g/pot) of barley plants affected by individual and combined treatments of S and compost. Increasing rates of added S and compost resulted in an increase of dry matter yield of barley plants (roots and shoots). With roots and shoots, the highest dry matter yields and its RC (%) values were associated the combined applications of S and compost and the lowest values were resulted from individual applications of S. These increases of barley plants dry matter yields (roots and shoots) may be attributed to the enhancing effect of the tested soil amendments on plant growth as a result of improving soil properties and increased its content of available nutrients (Aiad, 2010 and El-Gamal, 2015). Abou Hussien (1999) and El-Sharawy (2008) found that, S additions in different sources resulted in an increase of dry matter yield of corn plants. Improving growth media, rhizosphere area and soil chemical properties and also increasing the soil content of available nutrients resulted from compost applications were the main reasons for the found increases od dry matter yield of barley plants (Gohar, 2011 and Nada, 2011).

Table (6): Dry matter yield (g/pot) of barley plants (roots and shoots) and its relative changes "RC" (%) affected by compost and sulphur applications and agronomical efficiency "AE" (g plant/g S or Compost) of compost and sulphur additions under calcareous soil conditions.

The studied treatments		Dry matter yield				Agronomical Efficiency			
		Roots		Shoots		compost		sulphur	
compost	Sulphur	mg/pot	RC %	mg/pot	RC %	Roots	Shoots	Roots	Shoots
C0	S0	5.21^{j}	0	16.60^{j}	0	-	-	-	-
	S1	5.63^{ij}	8.06	17.26^{i}	3.98	-	-	0.42	0.66
	S2	5.79^{fi}	11.13	17.72^{fi}	6.75	-	-	0.39	0.75
	S3	5.94^{fi}	14.01	18.28^{ef}	10.12	-	-	0.37	0.84
Mean		**5.64^{c}**	**-**	**17.47^{c}**	**-**	**-**	-	**0.39**	**0.75**
C1	S0	5.60^{ij}	0	17.70 ^{i}	0	0.008	0.022	-	-
	S1	6.00^{fi}	7.14	18.13^{ef}	2.43	0.007	0.017	0.40	0.43
	S2	6.70^{de}	19.64	19.22^{d}	8.59	0.018	0.030	0.73	1.01
	S3	7.30^{b}	30.36	20.98^{b}	18.53	0.027	0.054	0.85	1.64
Mean		**6.40^{b}**	**-**	**19.01^{b}**	**-**	**0.015**	**0.031**	**0.66**	**1.03**
C2	S0	5.96^{fi}	0	18.46^{e}	0	0.008	0.019	-	-
	S1	6.35^{ef}	6.54	18.70^{de}	1.30	0.007	0.014	0.39	0.24
	S2	7.19^{cd}	20.64	19.96^{c}	8.13	0.014	0.022	0.82	1.00
	S3	8.11^{a}	36.07	22.49^{a}	21.83	0.022	0.042	1.08	2.02
Mean			**6.90^{a}**		**19.90^{a}**	**0.013**	**0.024**	**0.76**	**1.09**

C0, **C1** and **C2.0, 1** and **2** % compost and **S0**, **S1**, **S2** and **S3= 0, 200, 300, 400** kg S/fed of sulphur respectively.

Agronomical efficiency of sulphur fertilizer and compost additives

The presented data in Table (6) show agronomic efficiency (AE) of both S and compost as (g plant/g soil amendment) of the obtained dry matter yield of roots and shoots of barley plants grown in calcareous soil. These data show that, AE values of both dry weights of barley plants were varied widely depending on added rates of S and compost. The highest values of AE were associated the high application rates of S and compost and decreased with the decrease of application rates. These findings mean that, the higher applications of S and compost have a high efficiency on dry matter yield of barley plants (roots and shoots) compared with these of low application rates. The same treatments of S and compost, AE values of shoots were higher than that of roots. This trend resulted from high dry matter yields of shoots than these of roots in the same plant. In addition, for dry weights of barley plants (roots and shoots) treated by S and compost together appeared high values of AE for both compost and S compared with those found with the individual treatments of S and compost. These findings mean that, efficiency of different applications of S increased in the soil treated by compost. These results are in agreement with those obtained by Nada (2011)

Plant content of macronutrients

The presented data in Table (7) show shoots of barley plants uptake (mg/kg) of the determined macronutrients (N, P, K, Ca, Mg and S) affected by different applications of compost and S under calcareous soil conditions. With all treatments of compost and S individually and in together, uptake of macronutrients increased clearly with the increase rates of added compost and S, where the highest uptake was found in the plants treated by compost and S together followed by that found in the plants treated by compost alone. So, RC (%) values of the determined macronutrients uptake were positive with all compost and S treatments, where these values become more positive at high application rates especially in the combined treatments. These findings are in agreement with the effect of the tested soil amendments on improving soil properties and increasing the soil content of available macronutrients (Nada, 2011 and El-Gamal, 2015). According to the found uptake values, the determined macronutrients takes the order N **>** Ca **>** P **>** S **>** K **>** Mg. this order depending on the tested soil content of available macronutrients and its relation with the added soil amendments and also may be related with the plant ability of these nutrients uptake. These results are in agreement with these obtained by Aiad (2010); Belal (2011); Gohar (2011); Nada (2011) and El-Gamal (2015).

Plant content of micronutrients

The data in Table (8) show that increasing application rates of compost and S alone and together were associated by clear increase of the determined micronutrient (Fe, Zn, Mn and Cu) uptake (mg/pot) by barley plants grown in calcareous sandy soil. So, the highest uptake of these micronutrients were found in the plants treated by compost and S together followed by that found in the plants treated by compost alone. With all treatments of compost and S, RC (%) values of micronutrients uptake by barley plants were positive and increased with the increase rates of added compost and S especially in their combined treatments. Absolute values of the determined micronutrients by barley plants varied from nutrient to another, where the highest uptake was found with Fe followed by Mn, but the lowest one was found with Cu. The found increases of the determined micronutrients uptake by barley plants as a result of compost and S application attributed to the improve of soil properties and increase of soil content of available micronutrients. These results are in agreement with these obtained by Belal (2011); Gohar (2011) and El-Gamal (2015).

Table (7): Macronutrients uptake (mg/pot) by barley plants and its relative changes "RC" (%) affected by different application rates of compost and sulphur under calcareous sandy soil conditions.

The studied treatments		N		P		k		Ca		Mg		S	
compost	**sulphur**	**mg/pot**	**RC %**	**mg/pot**	**RC %**	**mg/pot**	**RC %**	**mg/pot**	**RC %**	**mg/pot**	**RC %**	**mg/pot**	**RC %**
C0	**S0**	194.22	0	78.02	0	84.66	0	87.98	0	49.80	0	64.74	0
	S1	231.28	19.08	89.75	15.03	93.20	10.09	110.46	25.55	58.68	17.83	89.75	38.63
	S2	248.08	27.73	104.55	34.00	97.46	15.12	122.27	38.97	72.65	45.88	116.95	80.65
	S3	263.23	35.53	115.16	47.60	107.85	27.39	138.93	57.91	87.74	76.18	127.96	97.65
Mean		**234.20**		**96.87**		**95.79**		**114.91**		**67.22**		**99.85**	
C1	**S0**	217.71	0	100.89	0	93.81	0	113.28	0	60.18	0	76.11	0
	S1	261.07	19.92	106.97	6.03	99.72	6.30	125.10	10.43	72.52	20.51	105.15	38.16
	S2	288.30	32.42	115.32	14.30	111.48	18.84	142.23	25.56	96.10	59.69	134.54	76.77
	S3	323.09	48.40	142.66	41.40	136.37	45.37	167.84	48.16	111.19	84.76	161.55	112.26
Mean		**272.54**		**116.46**		**110.34**		**137.11**		**85.00**		**119.34**	
C2	**S0**	239.98	0	123.68	0	101.53	0	129.22	0	73.84	0	79.38	0
	S1	274.89	14.55	132.77	7.35	110.33	8.67	140.25	8.54	86.02	16.50	123.42	55.48
	S2	329.34	37.24	145.71	17.81	129.74	27.78	159.68	23.57	109.78	48.67	149.70	88.59
	S3	386.83	61.19	179.92	45.47	155.18	52.84	193.41	49.67	137.19	85.79	188.92	137.99
Mean		**307.76**		**145.52**		**122.51**		**155.64**		**101.71**		**135.35**	

C0, C1 and **C2. 0, 1** and **2** % compost and **S0, S1, S2** and **S3= 0, 200, 300, 400** kg S/fed of sulphur respectively

Table (8): Micronutrients uptake (mg/pot) by barley plants and its relative changes "RC" (%) affected by different application rates of compost and sulphur under calcareous sandy soil conditions.

The studied treatments		Fe		Zn		Mn		Cu	
Compost	**Sulphur**	**mg/pot**	**RC %**	**mg/pot**	**RC %**	**mg/pot**	**RC %**	**mg/pot**	**RC %**
C0	**S0**	28.47	0	2.41	0	22	0	0.57	0
	S1	30.46	6.99	3.76	56.02	24.13	9.68	0.83	45.61
	S2	37.00	29.96	4.25	76.35	25.22	14.64	1.07	87.72
	S3	41.73	46.58	4.75	97.10	26.65	21.14	1.20	110.53
Mean		**34**	**-**	**4**	**-**	**25**	**-**	**1**	**-**
C1	**S0**	36.99	0	3.81	0	24.16	0	0.73	0
	S1	38.34	3.65	4.04	6.04	25.89	7.16	0.97	32.88
	S2	45.46	22.90	4.71	23.62	28.12	16.39	1.33	82.19
	S3	51.15	38.28	5.77	51.44	33.84	40.07	1.63	123.29
Mean		**43**	**-**	**5**	**-**	**28**	**-**	**1**	**-**
C2	**S0**	40.15	0	4.06	0	27.65	0	0.90	0
	S1	42.54	5.95	4.64	14.29	28.20	1.99	1.07	18.89
	S2	48.90	21.79	5.35	31.77	35.43	28.14	1.51	67.78
	S3	57.46	43.11	6.70	65.02	40.82	47.63	1.92	113.33
Mean		**47**	**-**	**5**	**--**	**33**	**-**	**1**	**-**

C0, C1 and **C2. 0, 1** and **2** % compost and **S0, S1, S2** and **S3= 0, 200, 300, 400** kg S/fed of sulphur respectively.

CONCLUSION

The data of this study may be concluded that, to improve calcareous sandy soil properties and its content of available macro- and micronutrients and also its productivity may be occurred by some soil amendments such as compost and sulphur. Also, the agronomical efficiency of S fertilization in calcareous sandy soil may be increased with compost applications.

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تقييم كفاءة التسميد بالكبريت فى الأراض الجيرية المعاملة بالكمبوست

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أجريت تجربة أصص بصوبة قسم علوم الأراضى – كلية الزراعة – جامعة المنوفية – مصر وذلك لدراسة تأثير كل من الإضافات المنفردة والمتحده للكبريت والكمبوست على خواص الأرض الرملية الجيرية وكذلك محتواها من المغذيات الكبرى والصغرى الميسرة وكذلك على نمو نبات الشعير ومحتواه من المغذيات الكبرى والضغرى. أضيف الكمبوست عند معدلات إضافة صفر و 1 و 2 % بينما أضيف الكبريت على صورة كبريت عنصرى عند معدلات إضافة صفر و 100 و 200 و 400 ملليجرام / كجم. تم قياس الوزن الجاف لنبات الشعير عند عمر 70 يوم كما قدر محتواه من المغذيات الكبرى والصغرى وكذلك تم تقدير بعض الخواص الكيميائية للأرض المستعملة بعد الحصاد كما تم تقدير محتوى الأرض من المغذيات الكبرى والصغرى الميسرة.

زيادة معدل الإضافة لكل من الكمبوست والكبريت فى صورة منفردة أو معاً كان مصحوباً بنقص فى قيم رقم حموضة الأرض وكذلك قيمة التوصيل الكهربى له بالإضافة إلى محتوى الأرض من كربونات الكالسيوم بينما أدى ذلك إلى زيادة المادة العضوية بالأرض وكذلك السعة التبادلية الكاتيونية هذا بالإضافة إلى زيادة محتواها من النيتروجين والفوسفور والبوتاسيوم والكالسيوم والمغنسيوم والكبريت والحديد والزنك والمنجنيز والنحاس الميسر وقد وجد أن أعلى قيم للتغيرات النسبية فى الخواص المقدرة للأرض ناتجاً عن المعاملة المزدوجة للكمبوست والكبريت خاصة عند معدلات الإضافة المرتفعة. كما صاحب زيادة معدلات إضافة الكمبوست والكبريت منفرداً أو معاً زيادة فى محصول المادة الجافة لنبات الشعير وكذلك محتواه من النيتروجين والفوسفور والبوتاسيوم والكالسيوم والمغنسيوم والكبريت والحديد والزنك والمنجنيز والنحاس. ولقد إزدادت الكفاءة المحصولية لكل من الكمبوست والكبريت فى معاملات الإضافة المتحده ولهذا توصى النتائج المتحصل عليها أنه لتحسين خواص الأراضى الرملية الجيرية وكذلك لزيادة خصوبتها وإنتاجيتها فإنه من الضرورى إضافة كل من الكمبوست والكبريت معاً فى إضافات مشتركة.