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GROWTH, PRODUCTIVITY AND SULPHUR USE EFFICIENCY OF GARLIC PLANTS GROWN IN SANDY SOIL AS AFFECTED BY FARMYARD MANURE AND SULPHUR

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ABSTRACT

This experiment was carried out during two successive winter seasons of 2008/2009 and 2009/2010 at EL-Khattara Experimental Farm, Faculty of Agriculture, Zagazig University, Sharkia Governorate, to study the effect of farmyard manure (FYM), elemental sulphur (S) and their interactions on growth, plant chemical composition and yield and its components as well as sulphur use efficiency (SUE) of garlic plants under sandy soil conditions.

Addition of 30 m^3FYM / fed. recorded maximum values of total dry weight / plant, chlorophyll a, b and total chlorophyll (a+b) , N, P and K uptakes by different plant organs and total uptake by plant, yields of grades 1 and 2, exportable , marketable and total yield/fed. as well as average bulb weight of garlic plants.

Obtained results indicated that application of S at the rate of 200 kg /fed. recorded maximum values of dry weight of roots, bulb, leaves and total / plant, total uptake of N, P and K by plant, yields of grades1, 2 exportable , marketable and total yield/fed as well as average bulb weight of garlic plants, whereas S at 100 Kg/fed increased chlorophyll a,b and total (a+b) in leaf tissues and sulfur use efficiency.

The interaction between FYM at the rate of 30 m^3/fed. 200 kg S/fed. significantly increased total dry weight / plant , P content in roots, N and P in bulb and N,P and K contents in leaves, uptakes of N,P and K by roots, bulb and leaves as well as total uptakes of N,P and K by plant, yields of grades 1,2 and 3, exportable , marketable and total yield/fed., as well as, average bulb weight, whereas the interaction between FYM at 20 m3/ fed and S at 100 Kg /fed increased sulpher use efficiency.

Key words: Garlic, FYM, S, dry weight, leaf pigments, mineral uptake, yield, components, sulphur use efficiency.

INTRODUCTION

Garlic (*Allium sativum* L.) is one of the most important bulb vegetable crops and is next to onion in importance. It is commonly used as a spice or in

many medicinal purposes. In Egypt, it has been generally cultivated for both local consumption and export. Therefore, increasing garlic yield and improving bulb quality are essential aims for both growers and consumers, but that advances usually depends on many factors especially that influence the plant growth throughout the growth period.

Farmyard manure is one of the traditional organic manures and is most readily available to the farmers. Farmyard manure seems to act directly in increasing crop yields by supplying nitrogen, phosphorus and sulphur in available forms to the plant through biological decomposition. Moreover, it improve physical properties of soil such as aggregation, aeration, permeability and water holding capacity. Also, it helps to increase the productivity of the soil by improving chemical properties *viz*., soil organic carbon content, increase the availability of both major and minor nutrients and availability of nutrients for longer period, biological properties increased decomposition rate. The organic matter content of the Egyptian soil is usually less than 2% in cultivated area. Frequent and high applications of organic manure are necessary to maintain soil fertility. Farmyard manure is usually used as the main organic fertilizer in Egypt (Abdel -Moez *et al*., 1999).

Fertilization of garlic plants with farmyard manure increased total dry weight /plant, N and P uptakes by leaves and N, P and K uptakes by bulb (Khalaf and Taha, 1988; Ali *et al*., 2001, Shafeek *et al.* , 2003; El-Mansi *et al*., 2004a, on garlic). Increasing organic manure increased yield and its components of garlic (Seno *et al*.,1996 ; Fayed, 1998; Zhang, 1998; Ali *et al*.,2001; El-Mansi *et al*., 2004 b and El-Hifny, 2010).

The role of sulphur application as a soil amendment and as a factor of increasing fertilizer efficiency is very important. Application of sulphur to soil has several effects such as reducing pH, improving soil water relation and increasing availability of nutrients like P, Fe, Mn and Zn (Marschner, 1998). Moreover, secondary compounds (allin, cycloallin and thiopropanol) which contained sulphur are not only important for nutritive value or flavours but also for resistance against pest and diseases (Brown and Morra, 1997). Sulphur as a macronutrient has a positive effect on garlic and other crops (Bloem *et al.*, 2004).

In this regard, Khalaf and Taha (1988), Singh *et al*. (1995), Abd El-Hameed (1997), Mee *et al.* (1997), El-Morsy (2005), Losak and Winiowska-Kielian (2006), Mansour (2006), Farooqui *et al*. (2009) and Abou El-khair (2010) found that sulphur fertilization enhanced garlic plant dry weight, N, P and K contents in different plant organs of garlic and yield and its components.

Therefore, the main objectives of present investigation to study the effect of farmyard manure under different rates of elemental sulphur to reach the best one to have the perfect beneficial towards better growth, yield and its components, of garlic bulbs (Balady cv.) under sandy soil conditions.

MATERIALS AND METHODS

This experiment was carried out during two successive winter seasons of 2008/2009and 2009/2010 at EL-Khattara Experimental Farm, Faculty of Agriculture, Zagazig University, Sharkia Governorate, to study the effect of farmyard manure, elemental sulphur and their interactions on growth , plant chemical composition and yield and its components as well as sulphur use efficiency of garlic plants under sandy soil conditions.

The physical and chemical analysis of the experimental soil and farmyard manure are presented in Tables 1a and b.

Table 1a: The physical and chemical properties of the experimental soil in 2008/2009 and 2009/2010 seasons

Soil property	1st Season	2nd Season
Physical properties		
Sand (%)	90.84	91.33
Silt (%)	5.16	2.23
Clay (%)	3.94	6.40
Organic matter (%)	0.07	0.05
Texture	Sandy	Sandy
Chemical properties		
pH	8.27	8.21
E.C. (mmhos/cm)	2.01	2.11
Available N (ppm)	4.27	3.83
Available P (ppm)	4.43	4.12
Available K (ppm)	11.32	10.46

Samples of the soil were obtained from 25 cm soil surface.

Table 1b: Analysis of farmyard manure

Properties	1st Season	2nd Season
Total N %	0.49	0.48
Total N units in m^3 (328kg)	1.607	1.574

This experiment included nine treatments, which were the combinations between three farmyard manure rates; i.e., 10, 20 and 30 m^3 /fed. and three rates of elemental sulphur ; i.e., 0, 100 and 200 kg /feddan.

These treatments were arranged in a split plots in a complete randomized block design with three replications. The FYM treatments were randomly arranged in the main plots and the rates of sulphur were randomly distributed in the sub plots.

Plot size was 12.6 m^2 .It contained three dripper lines with 7m long and 60 cm in wide. Garlic cloves of Balady *cv* were selected for uniformity

in shape and size. The cloves were sown on both sides of the dripper lines on September 20th in both seasons at 10 cm apart.

All experimental units received equal amounts of commercial fertilizers; *i.e.*, 120, 100 and 100 kg/ fed. N, P and K fertilizers in the form of ammonium sulfate (20.6%N), calcium superphosphate (15.5%P_2O_5) and potassium sulfate (48%-52% K_2O), respectively.

Total amounts of FYM, elemental sulphur and one third of the commercial fertilizers of N, P and K were added at soil preparation. The rest of commercial fertilizers (two thirds) were added monthly at three portions as soil application beginning one month after sowing. The other normal agricultural treatments for growing garlic plants were practiced.

Data Recorded

1. Growth Parameters

A random sample of ten plants was taken from each plot at 135 days after sowing in both seasons of study, for measuring the growth characters of garlic plants; i.e., plant height (cm), leaf number /plant, neck diameter (mm), bulb diameter (mm), and bulbing ratio.

The different parts of garlic plant; i. e., roots, leaves and bulb were oven dried at 70 ºC till constant weight and then the following data were recorded.

Root dry weight /plant, bulb dry weight /plant, leaf dry weight /plant, and total dry weight (roots + bulb +leaves) /plant (g).

2. Photosynthetic pigments

Chlorophyll (a & b), as well as, carotenoids in leaf tissues (mg/gm dry weight) were determined at 135 days after sowing according to the method described by Wettestein (1957).

3. Nitrogen, Phosphorus and Potassium Contents:

They were determined in roots, bulb and leaves on the basis of dry weight according to the methods described by Bremner and Mulvaney (1982), Olsen and Sommers (1982) and Jakson (1970), respectively. N, P and K uptakes and total uptake were calculated.

4. Yield and Its Components

At proper maturity stage of bulbs (200 days after sowing), bulbs of every plot were harvested and graded into four categories according to specification laid down by the Ministry of Economic for garlic exportation (1963) as follows:

Grade 1: Bulbs with diameter above 5.5 cm,
Grade 2: Bulbs with diameter between 4.5-5.5 cm,
Grade 3: Bulbs with diameter between 3.5-4.4 cm, and
Grade 4: Bulbs with diameter less than 3.5 cm.

After that, each grade was weighed separately in the same day and the following data were recorded:

1.**Exportable yield** (grade 1+ grade 2) ton /fed,
2.**Marketable yield** (grade 1+ grade 2+grade 3) ton/fed, and
3.**Total yield** (grade 1+ grade 2 + grade 3 +grade 4) ton/fed.

4. **Average bulb fresh weight** $= \frac{\text{Yield of bulbs /plot}}{\text{Total number of bulbs/plot}}$

5.Sulphur Use Efficiency (SUE):

It was calculated according to equation of Bharathi and Poongothai (2008) as follows:

SUE = (Yield of S applied- yield of control) / S (kg/fed.) = yield (kg/kg S)

Statistical Analysis

All obtained data were subjected to the analysis of variance according to Snedecor and Cochran (1980). Mean separation was done according to LSD at 5 % level.

RESULTS AND DISCUSSION

1. Plant Growth

1.1. Effect of farmyard manure (FYM)

Fertilization of garlic plants grown in sandy soil with farmyard manure (FYM) at 30 m^3/fed. significantly increased plant height, number of leaves/ plant, neck and bulb diameter, bulbing ratio, dry weight of roots, bulb, leaves and total dry weight/ plant, except number of leaves/ plant and dry weight of leaves in the 1st season and bulbing ratio in the 2nd season (Tables 2 and 3). The increases in total dry weight were about 7.12 and 8.77 % for FYM at 20m^3/fed. and 15.22 and 26.41% for FYM at 30 m^3/fed. over the FYM at 10 m^3/fed in the 1st and 2nd seasons, respectively. Since sandy soil had low organic matter and also low mineral content (Table 1a), farmyard manure can improve its content of organic matter and this in turn led to improve soil conditions. For maximization exploitation of organic matter, mineralization of the manure by its flora needs of N-supply induced multiplication of such flora to utilize the organic manure. Therefore, application of organic and mineral nitrogen fertilizers together may increase the exchangeable NPK and the uptake of these elements as found by Cooke (1972) which consequently led to increase cell division and cell enlargement and as a result this might be reflected on the plant growth.

Table 3: Effect of farmyard manure and sulphur quantity on dry weight of different garlic organs at 135 days after planting during 2008/2009 and 2009/2010 seasons under sandy soil conditions

Treatments	Dry weight (g/organ)							
	Root		Bulb		Leaves		Total dry weight	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
	Effect of FYM (m^3/fed.)							
10	1.21	0.93	3.95	3.93	5.21	5.05	10.38	9.92
20	1.31	1.20	4.47	4.24	5.33	5.34	11.12	10.79
30	1.43	1.69	4.88	4.83	5.64	6.01	11.96	12.54
LSD at 0.05 level	**0.09**	**0.35**	**0.58**	**0.51**	**NS**	**0.73**	**0.82**	**0.66**
	Effect of sulphur (kg/fed.)							
0	1.24	1.04	4.33	3.92	5.23	5.12	10.81	10.09
100	1.32	1.26	4.36	4.34	5.43	5.46	11.11	11.07
200	1.38	1.52	4.62	4.74	5.53	5.82	11.54	12.09
LSD at 0.05 level	**NS**	**0.10**	**NS**	**0.18**	**0.14**	**0.30**	**0.47**	**0.44**

FYM: Farmyard manure, 1st and 2nd : First and second seasons, respectively

These results are in harmony with those obtained by Fayed (1998), Farrag and Hussein (2000), Ali *et al.* (2001), Shafeek *et al.* (2003), El-Mansi *et al*. (2004a) and El-Hifny (2010) all on garlic. They found that organic manure significantly increased all plant growth parameters; *i.e*., plant height, number of leaves/plant, fresh and dry weights of bulb, as well as, bulb and neck diameter and bulbing ratio.

1.2. Effect of sulphur (S)

The obtained results in Tables 2 and 3 show that fertilization of garlic plants with sulphur (S) at 200 kg/fed. significantly increased plant height, number of leaves/ plant, neck and bulb diameter, dry weight of roots, bulb, leaves and total dry weight/ plant, but had insignificant effect on number of leaves/ plant and dry weight of roots in the 1st season and bulbing ratio in both seasons. The increases in total dry weight were about 2.97 and 9.7 % for S at 100 kg/fed. and 6.75 and 19.02 % for S at 200kg/fed. over the control (without S) in the 1st and 2nd seasons, respectively.

Overall increases in growth attributes may be due to that sulphur increased root system growth which in turn enhanced nutrients uptake and the other dependent physiological processes like photosynthesis (Jaggi, 2004).

These results coincided with those reported by Khalaf and Taha (1988) , Singh *et al*. (1995) , Mee *et al.* (1997), El-Morsy (2005), Losak and Winiowska-Kielian (2006) and Farooqui *et al*. (2009) and Abou El-Khair (2010). They found that sulphur fertilization enhanced growth of garlic*; i.e.,* vegetative growth and dry weight / plant.

1.3. Effect of the interaction between FYM and S

It is clear from data in Tables 4 and 5 that the interaction between fertilization with FYM at 20 m^3/fed. and S at 200 kg/fed. and the interaction between FYM at 30 m3/fed. and S at 200 kg/fed. recorded the tallest plants in both seasons, whereas the interactions between FYM at 30 m^3/fed. and S at 100 or 200 kg/fed recorded the maximum values of neck diameter in both seasons.

The interaction between FYM at 30 m^3/fed. and S at 200 kg/fed. gave the highest values of number of leaves/ plant, bulb diameter, dry weight of root, bulb, leaves and total dry weight/ plant, followed by the interaction between FYM at 30 m^3/fed and S at 100 kg/fed., except number of leaves and root dry weight in the 1st season and bulbing ratio in both seasons. The increases in total dry weight were about 15.81 and 32.69 % for the interaction between FYM at 30 m^3/fed. and S at 100 kg/fed. , 26.38 and 50.03 % for the interaction between FYM at 30 m^3/fed. and S at 200kg/fed. over the interaction between FYM at 10 m^3/fed. and control (without S) in the 1st and 2nd seasons, respectively.

2. Photosynthetic pigments:

2.1. Effect of FYM

Presented data in Table 6 show that the concentration of chlorophyll a, b and total (a+b) as well as carotenoides in leaf tissues of garlic significantly increased with increasing FYM up to 30 m^3/fed. with no significant differences with FYM at 20 m^3/fed. with respect to chlorophyll b and total (a+b) in the 2^{nd} season only. Application of FYM led to increase soil acidity, organic matter, available P, exchangeable Mn, and Zn and this in turn may affect leaf pigments (Hsieh and Hsu ,1993).

Results are in harmony with those obtained by El-Mansi *et al.* (2004a) they indicated that addition of 45 m3FYM/fed. recorded maximum concentration of all leaf pigments in leaf tissues of garlic.

2.2. Effect of sulphur

The obtained results in Table 6 show that fertilization of garlic with S at 100 or 200 kg/fed. significantly increased chlorophyll a, b and total (a+b) in the 1st season and carotenoides in the 2^{nd} season, whereas S at 100 kg /fed. significantly increased total chlorophyll (a+b) in the 2nd season only.

Table 5: Effect of the interaction between farmyard manure and sulphur quantity on dry weight of different garlic organs at 135 days after planting during 2008/2009 and 2009/2010 seasons under sandy soil conditions

Treatments		Dry weight (g/organ)							
		Root		Bulb		Leaves		Total dry weight	
FYM	Suphur	1st	2nd	1st	2nd	1st	2nd	1st	2nd
10	0	1.18	0.72	3.70	3.65	5.05	4.83	9.93	9.20
	100	1.20	1.02	4.04	3.85	5.28	5.05	10.53	9.92
	200	1.25	1.07	4.12	4.30	5.31	5.27	10.69	10.64
20	0	1.24	1.00	4.28	3.73	5.13	4.87	10.66	9.61
	100	1.31	1.23	4.57	4.35	5.41	5.41	11.30	11.00
	200	1.37	1.37	4.55	4.65	5.46	5.75	11.39	11.78
30	0	1.31	1.40	5.00	4.39	5.52	5.68	11.85	11.48
	100	1.44	1.53	4.46	4.83	5.58	5.94	11.50	12.30
	200	1.53	2.14	5.19	5.27	5.82	6.43	12.55	13.84
LSD at 0.05 level		NS	0.18	0.73	0.30	0.24	0.52	0.82	0.77

FYM: Farmyard manure, 1st and 2nd : First and second seasons, respectively.

Table 6: Effect of farmyard manure and sulphur quantity on leaf pigments of garlic leaves at 135 days after planting, during 2008/2009 and 2009/2010 seasons under sandy soil conditions

Treatments	Leaf pigments (mg/ gm DW)							
	Chlorophyll (a)		Chlorophyll (b)		Total chlorophyll (a+b)		Carotenoides	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
	Effect of FYM (m^3/fed.)							
10	2.40	2.43	1.17	1.24	3.58	3.68	2.29	2.30
20	2.55	2.70	1.44	1.27	4.00	3.97	2.49	2.51
30	2.96	2.91	1.71	1.58	4.68	4.50	2.70	2.83
LSD at 0.05 level	0.11	NS	0.23	0.33	0.31	0.74	0.03	0.23
	Effect of sulphur (kg/fed.)							
0	2.52	2.51	1.24	1.18	3.76	3.70	2.17	2.28
100	2.65	2.71	1.52	1.37	4.18	4.09	2.50	2.60
200	2.74	2.82	1.57	1.53	4.31	4.35	2.81	2.76
LSD at 0.05 level	0.12	0.14	0.13	0.14	0.18	0.17	NS	0.19

FYM: Farmyard manure, 1st and 2nd : First and second seasons, respectively

Results are in harmony with those obtained by Mahmoud (1999) on onion and Mansour (2006) on garlic who found that elemental sulphur recorded maximum concentration of chlorophyll a, b, total (a+b) as well as carotenoids in leaf tissues of garlic.

2.3. Effect of interaction between FYM and S

The obtained results in Table 7 indicate that the interaction between FYM at 30 m^3/fed. and S at 100 or 200 kg/fed. recorded the maximum values of chlorophyll a, b and total (a+b) in both seasons as well as carotenoides in the 2nd season.

3. N,P and K contents and uptake

3.1. Effect of FYM

The obtained results in Tables 8 and 9 show that fertilization of garlic plants with FYM at 30 m^3/fed significantly increased N and P contents in bulb and leaves as well as N,P and K uptakes by roots, bulb and leaves and total uptake of N,P and K by plant, followed by FYM at 20 m^3/fed. with no significant differences between 20 and 30 m^3 FYM/fed. with respect to P content in leaves. FYM contains microorganisms as *Azotobacter*, *Azospirillum***,**…etc. which fix N and release phytohormones as GA, IAA,CYT, etc. necessary for stimulating plant growth and dry matter content. These observations may indicate that micro-organisms have the ability to supply growing plants with N, P, K and photohormones which in turn may increase N, P and K concentrations in soil solution and their uptakes by plant (Reynders and Vlassak,1982).

Results agree with Fayed (1998) and El-Mansi *et al*., (2004a) on garlic. They found that addition of 45 m^3FYM / *fed* recorded maximum values of total N, P and K uptake / plant.

3.2. Effect of sulphur

It is clear, from data in Tables 8 and 9 that S at 200 kg/fed. increased N and P contents in roots and bulbs, the contents of N,P and K in leaves, the uptakes of N, P and K by roots, bulb and leaves as well as their total uptake by plant, followed by S at 100 kg /fed. with no significant differences between 100 and 200 kg/fed. with respect to N and P contents in roots and N,P and K contents in leaves. The increments in nutrients uptake under sulphur treatments might be resulted from sulphur role in adjusting sandy soil pH which increased nutrients availability and in turn reflected as more nutrients uptake and plant growth (Mehana, 1994).

Table 7: Effect of the interaction between farmyard manure and sulphur quantity on leaf pigments of garlic leaves at 135 days after planting during 2008/2009 and 2009/2010 seasons under sandy soil conditions

Treatments		Leaf pigments (mg/ gm DW)							
		Chlorophyll (a)		Chlorophyll (b)		Total chlorophyll (a+b)		Carotenoides	
FYM	Suphur	1st	2nd	1st	2nd	1st	2nd	1st	2nd
10	0	2.29	2.19	1.08	1.13	3.38	3.32	2.14	2.09
	100	2.46	2.54	1.19	1.23	3.65	3.78	2.31	2.35
	200	2.46	2.57	1.25	1.36	3.71	3.93	2.42	2.46
20	0	2.50	2.48	1.24	1.16	3.74	3.65	2.06	2.28
	100	2.52	2.76	1.49	1.29	4.02	4.05	2.54	2.61
	200	2.64	2.87	1.58	1.34	4.23	4.21	2.88	2.65
30	0	2.78	2.87	1.40	1.27	4.18	4.14	2.32	2.47
	100	2.98	2.84	1.87	1.60	4.86	4.44	2.67	2.85
	200	3.13	3.02	1.87	1.88	5.00	4.91	3.13	3.17
LSD at 0.05 level		**0.24**	**0.25**	**0.23**	**0.25**	**0.30**	**0.30**	**NS**	**0.32**

Farmyard manure, 1st and 2nd : First and second seasons, respectively

Table 8: Effect of farmyard manure and sulphur quantity on minerals content of different garlic organs at 135 days after planting during 2009/2010 season under sandy soil conditions

Treatments	Minerals content (%)								
	Root			Bulb			Leaves		
	N	P	K	N	P	K	N	P	K
	Effect of FYM (m^3/fed.)								
10	1.39	0.275	1.26	1.92	0.399	1.80	3.12	0.331	2.83
20	1.57	0.291	1.25	2.32	0.485	1.81	3.49	0.361	3.00
30	1.58	0.285	1.34	2.18	0.472	1.96	3.67	0.355	2.97
LSD at 0.05 level	**NS**	**NS**	**NS**	**0.07**	**0.011**	**NS**	**0.13**	**0.011**	**NS**
	Effect of sulphur (kg/fed.)								
0	1.34	0.272	1.28	1.73	0.438	1.79	3.21	0.329	2.84
100	1.57	0.285	1.28	2.11	0.449	1.89	3.55	0.357	2.92
200	1.63	0.294	1.29	2.58	0.468	1.89	3.52	0.361	3.03
LSD at 0.05 level	**0.09**	**0.010**	**NS**	**0.08**	**0.012**	**NS**	**0.05**	**0.009**	**0.14**

FYM: Farmyard manure

Similar results were agree with those obtained by Singh *et al*. (1995) and Abd El-Hameed (1997), Fayed (1998) and El-Morsy (2005) , Mansour (2006) and Abou El-Khair (2010) on garlic.

3.3. Effect of the interaction between FYM and S

The obtained results in Tables 10 and 11 illustrate that , in general, the interaction between FYM at 30 m^3/fed. and S at 200 kg/fed. increased P content in roots, N and P in bulb and N,P and K contents in leaves, the uptakes of N,P and K by roots, bulb and leaves and N,P and K total uptake by plant, followed by the interactions between FYM at 30 m^3/fed and S at 100 kg /fed. and the interaction between FYM at 20 m^3/fed. and S at 100 kg/fed as well as the interaction between FYM at 20 m^3/fed. and S at 200 kg/fed.

4. Yield and its components

4.1. Effect of FYM

Fertilization of garlic plants with FYM at 30 m^3/fed. significantly increased yields of grades 1, 2 and 3, exportable, marketable and total yield/fed as well as average bulb weight, followed by FYM at 20 m^3/fed., whereas FYM at 10 m^3/fed. significantly increased yield of grade 4 in both seasons (Table 12).

Obtained results can be explained in the light of the facts that using FYM increases organic matter, availability of nutrients, nitrogen fixation, rizosphere microorganisms that release phyotohrmones and substances which led to increase growth and dry matter accumulation and this in turn might increase average bulb weight, hence increase the total yield.

These results are agree with those reported with Fayed (1998), Zhang *et al*. (1998), El-Mansi *et al*. (2004b) and El-Hifny (2010). They found that application of FYM to garlic plants were increased yield and its components.

4.2. Effect of sulphur

Fertilization of garlic plants with S at 200 kg/fed. significantly increased yields of grades 1, 2 and 3, exportable , marketable and total yield/fed. as well as average bulb weight, followed by S at 100 kg/fed. whereas the control (without S) increased yield of grade 4 in both seasons (Table 12).

The influence of S on the yield of garlic could be attributed to the important role of sulphur in protein and some hormones formation in plant,

also sulphur is necessary for enzymatic action, chlorophyll formation, synthesis of certain amino acids and vitamins and consequently it helps to have a good vegetative growth leading to get high yield (Tisdale and Nelson, 1985).

These results are in accordance with these obtained by Abd El-Hameed (1997) and Mee *et al*. (1997), El-Morsy (2005) and Farooqui *et al*. (2009). Application of 200 kg S/fed. as 50 % at soil preparation + 50% at 30 days after planting gave the highest values of bulb yield of grades 1, 2, exportable, marketable, and total yield /fed., as well as, average bulb weight (Abou El-Khair ,2010).

4.3. Effect of the interaction between FYM and S

The interaction between FYM at 30 m^3/fed. and S at 200 kg/fed. significantly increased yields of grades 1, 2 and 3, exportable , marketable and total yield/fed as well as average bulb weight, followed by the interaction between FYM at 30 m^3/fed. and S at 100 kg/fed. in both seasons. The interaction between FYM and S at different rates had no significant effect on yield of grade 4 (Table 13).

These results are in harmony with those obtained with Khalaf and Taha (1988) on garlic.

5. Sulphur use efficiency (SUE)

Presented data in Table 14, show that FYM at 20 m^3/fed. recorded maximum value of SUE as kg bulb/ kg S (7.98 and 4.32 kg bulb/1kg S) in the 1^{st} and 2^{nd} seasons, respectively.

Also, from the same Table, data reflect that S at 100 kg/fed. gave the highest values of SUE as kg bulb/kg S (10.10 and 6.17 kg bulb/kg S in the 1^{st} and 2^{nd} seasons, respectively. The interaction between FYM at 20 m^3/fed and S at 100 kg /fed. was the best interaction treatments for enhancing SUE (14.19 and 6.69 kg bulb/1kg S in the 1^{st} and 2^{nd} seasons, respectively) followed by the interaction between FYM at 30 m3/fed and S at 100 Kg/fed. Under FYM at 10 m^3/fed. , SUE increased with increasing S., whereas under 20 and 30 m^3/fed. SUE decreased with increasing S up to 200 kg/fed.

These results are in harmony with those obtained by Abou El-Khair (2010) on garlic.

Table 14. Effect of farmyard manure and sulphur quantity and their interaction on sulphur use efficiency (SUE) of garlic during 2008/2009 and 2009-2010 seasons under sandy soil conditions

FYM (m^3/fed.)	Sulphur (kg/fed)							
	0		100		200		Average	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
10	0.0	0..0	4.07	6.06	7.75	6.95	**3.94**	**4.34**
20	0.0	0.0	14.19	6.69	9.74	6.28	**7.98**	**4.32**
30	0.0	0.0	12.05	5.76	9.76	4.66	**7.27**	**3.47**
Average	**0.0**	**0.0**	**10.10**	**6.17**	**9.08**	**5.96**	--	--

FYM: Farmyard manure, 1st and 2nd : First and second seasons, respectively

Conclusively, from the foregoing results of this experiment, it could be concluded that, *the interaction between FYM at the rate of 30 m^3/fed. and 200 kg S/fed. significantly increased total dry weight / plant, uptakes of N,P and K by roots, bulb and leaves as well as total uptakes of N,P and K by plant, yields of grades 1,2 and 3, exportable , marketable and total yield/fed., as well as, average bulb weight , whereas the interaction between FYM at 20 m3/fed and S at 100 Kg/fed increased sulphur use efficiency.*

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تأثير السماد البلدى والكبريت على النمو والإنتاجية وكفاءة استخدام الكبريت لنباتات الثوم النامية فى الأرض الرملية

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أجريت هذه التجربة خلال موسمى شتاء ٢٠٠٨/٢٠٠٩ ، ٢٠٠٩/٢٠١٠ فى مزرعة التجارب الزراعية بالخطارة التابعة لكلية الزراعة – جامعة الزقازيق، بهدف دراسة تأثير كمية السماد البلدى ، الكبريت، والتفاعل بينهما على النمو ، والمحتوى الكيماوى ، والمحصول ومكوناته بجانب كفاءة استخدام نباتات الثوم للكبريت تحت ظروف الأراضى الرملية ويمكن تلخيص أهم النتائج فيمايلى:

أعطى إضافة السماد البلدى بمعدل ٣٠ م^{٣} /فدان أعلى القيم لكل من الوزن الجاف الكلى للنبات و محتوى أنسجة الأوراق من كلوروفيل أ ، ب والكلوروفيل الكلى والممتص من النيتروجين ، الفوسفور والبوتاسيوم بواسطة الجذر والبصلة والاوراق والممنص الكلى بواسطة النبات ، محصول ا بصال الدرجة الاولى والثانية والمحصول القابل للتصدير والمحصول القابل للتسوق والكلى ومتوسط وزن البصلة .

تم الحصول على أعلى القيم لكل من الوزن الجاف الكلى للنبات والممتص من النيتروجين ، الفوسفور والبوتاسيوم بواسطة الجذر والبصلة والأوراق والممنص الكلى بواسطة النبات ، محصول ا بصال الدرجة الأولى والثانية والثالثة والمحصول القابل للتصدير والمحصول القابل للتسوق والكلى ومتوسط وزن البصلة .بتسميد نباتات الثوم بالكبريت بمعدل ٢٠٠ كجم/ فدان، بينما أدَّى التسميد بمعدَّل ١٠٠ كجم كبريت للفدان إلى زيادة كل من محتوى الأوراق من الصبغات، و كفاءة استخدام النباتات للكبريت.

كانت أفضل معاملات التفاعل لزيادة كل من الوزن الجاف الكلى للنبات ، و محتوى أنسجة الأوراق من كلوروفيل أ ، ب والكلوروفيل الكلى ، والممتص من النيتروجين ، والفوسفور والبوتاسيوم بواسطة الجذر والبصلة والأوراق، والممنص الكلى بواسطة النبات ، ومحصول ا بصال الدرجة الأولى والثانية والثالثة ، والمحصول القابل للتصدير والمحصول القابل للتسوق والكلى ومتوسط وزن البصلة وكفاءة استخدام الكبريت .بتسميد نباتات الثوم بالسماد العضوى بمعدل ٣٠ م^{٣}/فدان والكبريت بمعدل ٢٠٠ كجم/ فدان، بينما أدى التسميد بمعدل ٢٠ م٣ سماد بلدي و ١٠٠ كجم كبريت إلى زيادة كفاءة استخدام النباتات للكبريت.