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Effect of Sulphur Application and some Foliar Feeding on Productivity and Roots Quality of Sugar Beet

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ABSTRACT

A field experiment was conducted at El-Gemmeiza Agric. Res. Station, Gharbeya Governorate, Egypt during the two successive winter seasons of 2017/2018 and 2018/2019, to study the effect of sulphur (0, 40 and 80 kg/fad.) and three foliar spray treatments (mixture of $FeSO_4$ 20%+$MnSO_43H_2O$ 23%+$ZnSO_47H_2O$ 23% +B as boric acid 17%) at 1%, blue green algae extract at 1 liter /fad. and yeast extract at 100 ml/liter water on growth , yield and root quality of sugar beet (cv Oskar poly) grown in a clay soil conditions. These treatments were arranged in a split plot in a complete block design with three replications. Sulphuer levels were randomly distributed in the main plots, while foliar spray treatments were randomly arranged in the sub plots. The interaction between sulphur at 80 kg/fad. and spraying with blue green algae extract at 1 liter / fad. gave the highest values of sugar beet shoots, roots and its components. While, the interaction between sulphur at 80 kg/fad. and spraying with the mixture of Fe+Zn+Mn+B at 1 % recorded maximum values of Fe, Zn, Mn and B in leaf tissues and roots. The increases in yield of sugar were about 32.8 and 56.3 % for the interaction between 80 kg S/fad. and spraying with blue green algae, 24.9 and 42.7 % for the interaction between 80 kg S/fad. and spraying with mixture of Fe+Zn+Mn+B over the interaction between 0 S and spraying with yeast extract in the 1st and 2nd seasons, respectively.

Keywords: Sulphur , Foliar feeding , Productivity ,Quality , Suger beet

INTRODUCTION

Sugar beet growers in Egypt are paid based on the tons of recoverable sucrose that is extracted from their crop. Sugar beet profitability therefore, depends on producing a high tonnage crop with high sucrose content.

There is a great need to find out the proper technical recommendations for improving the productivity and quality of sugar beet under egyptian conditions. Because the most Egyptian soils suffer from a high pH values particularly newly reclaimed soil, the availability of P, K and micronutrients is reduced. The use of sulphur might help in decreasing soil alkalinity during sulphur biological oxidation. Sulphur can significantly increase crop yield and improve its quality. Sulphur is a constituent element of some amino acids, namely Cystein and Methionine and it is involved in synthesis of chlorophyll, certain vitamins, carbohydrates and proteins (Thomas *et al*., 2000). In this regard , treating sugar beet with sulphuer gave the highest values of dry weight , chemical composition, yield and best root quality (Ouida, 2002; Nemeat Alla, 2005 ; Shafika *et al*.,2005; Zeinab *et al*., 2006 ; Awed Allah *et al*.,2007; Ferweez *et al*., 2011; Awad *et al* , 2013 and Tawfic *et al*. 2014)

Most of egyptian soil suffered from micronutrients deficiency as a results of the intensive cropping, low organic matter content in soil and alkaline condition of soil which decreases the availability of many nutrients. Micronutrients application gave the maximum yield and quality of sugar beet crop (Nemeata Alla *et al*. 2014). The plants require micronutrients such as iron, zinc, manganese and boron in a low quantity and are present in plant tissue in amounts calculated in parts per million, but they are involved in a wide variety of metabolic processes and cellular functions within plants. They also play an essential role in improving yield and quality, and are highly needed for improving plant growth and yield of many crops (Hansch and Mendel, 2009). In this concern, spraying sugar beet with microelements gave the best results for enhancing growth , yield and root quality (Abd El-Gawad *et al*. 2004; Yarnia *et al*. 2008; Nemeat-Alla *et al*. 2009; Garib and El-Henawy, 2011 ; Amin *et al*. 2013; and Masri and Hamza, *2015*, Dewdar *et al*. 2018, and Zewail, *et al*. ,*2020).*

Algae are natural bio active materials rich in minerals, protein, lipids, carbohydrates, vitamins and microelements (B, Mo, Zn, Cu). In addition, algae fertilizer aunique combination of N, P, K, trace elements and simple sugar that are in dissolved forms that are easily absorbed through roots and leaves, besides releasing trace elements bound to the soil and it is safe to human, animals and the environment (Sathya *et al*., 2010). Growth , yield and root quality of sugar beet increased significantly with spraying plants with algae extract (Aly *et al*. 2008 on sugar beet , Alam *et al*. 2014, Taha and Abdelaziz , 2015 on carrot , Doss *et al*. 2015 on sweet potato , Enan *et al*. 2016, AL Jbawi *et al*., 2020).

Yeast is an enriched source of phytohormones especially cytokinins, vitamins, enzymes, amino acids and minerals as well as has a stimulatory effect on the cell division and enlargement, protein and nucleic acids synthesis and chlorophyll formation (Shehata *et al*.,2012). In this concern, Sharaf, (2012), Neseim, *et al*. (2014), Abdou. (2015), Nemeat Alla *et al*. (2016), Ferweez, and Abd El-Monem (2018), Thalooth, *et al*. (2019) and Sarhan *et al*. (2020). They showed that spraying sugar beet plants with yeast extract recorded the highest values of plant growth, yield and its components and best root quality than unsprayed plants.

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Therefore, this work aimed to study the response of sugar beet to sulphur application and foliar feeding with some micronutrients, blue green algae and yeast extracts productivity and root quality under the environmental conditions of clay soil in El-Gemmeiza region, El-Gharbeya Governorate, Egypt.

MATERIALS AND METHODS

A field experiment was carried out at El-Gemmeiza Agric. Res. Station, Gharbeya Governorate, Egypt (longitude 31 7º E and latitude 30 43º N) during the two successive winter seasons of 2017/2018 and 2018/2019. This investigation was aimed to study the effect of sulphuer and some foliar treatments on growth, plant chemical constituents yield and root quality of sugar beet cv Oskar grown in clay soil conditions. Particle size distribution and some chemical characteristics of the experimental determined by the standard methods according to Balck *et al.* (1981) and Jackson, 1967.

Table 1. Soil particle size distribution and some chemical characteristics of the experimental site 2017/ 2018 and 2018/2019 seasons

Parameter	Value	
1. Particle size distribution*	2017	2018
Corse sand (%)	1.91	1.92
Fine sand (%)	12.0	11.61
Silt (%)	40.11	41.01
Clay (%)	45.98	45.46
Textural class	clay loam	clay loam
2. Chemical analysis*		
EC dSm^{-1} (soil post extract)	2.21	2.32
pH (1: 2.5 soil : water suspension)	8.1	7.98
$CaCO_3$ (%)	2.7	2.4
Organic matter (%)	1.94	1.79
Available nitrogen (ppm)	32.0	29
Available phosphorus (ppm)	7.9	8.2
Available potassium (ppm)	411	398
Available Boron(ppm)	0.10	0.12
DTPA-extractable		
Fe (ppm)	3.55	3.70
Zn(ppm)	0.88	0.75
Mn(ppm)	1.99	1.93

This experiment was included 9 treatments which were the combinations between three levels of sulphuer (0, 40 and 80 kg/fad.) and three foliar spray treatments (mixture of $FeSO_4$20%+MnSO43H_2O23% +$ZnSO_4$7H_2O23% + B as boric acid 17%) at 1% , blue green algae 1 liter /fad. and yeast extract(soft yeast was mixed with sugar at rasio 1:1 and left 3 hours at room temperature then freezing for distruption of yeast tussio and relazing their content. Prepration of yeast solution was don according to El-Ghamriny etal(1999), at 100 ml/liter water. Foliar spray solution from the mixture of the compounds was applied at a rate of 200 L./fed. These treatments were arranged in a split plot in a complete block design with three replicat. Sulphuer levels were randomly distributed in the main plots, while foliar spray treatments were randomly arranged in the sub plots.

Seeds of sugar beet cultivars were sown on ridges 60 cm apart and 20 cm between hills to ensure 35000 plants/ fed. Each subplot included 4 ridges each was 4 m in length.

Therefore, each subplot size was 9.6 m^2. Sugar beet seeds were sown on 23rd and 25th October 2017 and 2018 seasons, respectively.

Different levels of sulphuer were mixed with soil, which were applied at soil preparation, before sowing. The plants sprayed with microelements , blue green algae and yeast extracts three times; *i. e.,* 30 and 60 and 90 days after sowing in both seasons. Each plot received 2 liter solutions of different spraying treatments using spreading agent (reflecting materials) in all treatments to improve adherence of the spray to the plant foliage for increasing absorption by the plants.

Nitrogen was added at a rate of 80 kg N/fed. (feddan=4200 m^2) in the form of urea (46% N) in three equal doses , the first was applied after thinning and the other two doses were added at the second and third irrigations. Phosphorous in the form of superphosphate (15.5%) at the rate of 30 Kg P_2O_5 /fed. was added before sowing and during soil preparation. Potassium in the form of potassium sulfate (48%) was added at the rate of 24 Kg K2O/fed. with the first dose of N.The other cultural practices were done as recommended.

Recorded data:

1. Dry weight

At harvest time (200 days from planting), three plants were randomly taken from each plot and they were divided separately into shoots and roots, then they were oven dried at 70 °C tell constant weight. Dry weight was recorded as shoot and root dry weights/ plant (g). In addition, total plant dry weight /plant (shoot +root) were calculated

2. Photosynthetic Pigments

Disk samples from the fourth upper leaf were obtained at 90 days old in both seasons to determine chlorophyll a and b as well as carotenoids according to the method described by Wettestein (1957).

3. Potassium and sodium concentration was determined using flame photometer (%). Alpha amino nitrogen concentration (%) was determined using Kjeldahl wet oxidation process as described by Blakemore *et al.* (1987).

4. Leaves and roots microelements contents

Iron, Zn, Mn and boron in leaves and roots samples in both seasons were determined using Atomic-absorption (Analyst 200, Perkin Elmer, Inc., MA, USA), described by according to the methods Chapman and Pratt (1982).

5- Purity percentage: It was estimated according to the following equation

Purity %= 99.36-{14.27(V1+V2+ V 3/ V 4)}

Where: V1=Na , V2= K, V3= ∝-amino-N, V4= sucrose %

6- Sucrose% was determined according to the procedure of Le Docte (1927).

7- Root yields (ton/fed.) was determined on the whole plot basis were harvested, topped and weighed to determine root yield.

A sample of 10 roots was randomly taken and the following traits were recorded: Root length (cm). Root diameter (cm). average root weight (g/plant).

Sugar yield (fed), which was calculated according to following equation: total sucrose yield (fed) = roots yield (fed) x Sucrose %.

Statistical analysis: The recorded data were subjected to the statistical analysis of variance according to Snedecor and Cochran (1980) at 0.05 levels and means separation were done according to Duncan (1955) at 0.05 levels of probability.

RESULTS AND DISCUSSION

1. Dry weight

Effect of sulphur

Data in Table 2 show that dry weight of shoots, roots and total dry weight of sugar beet increased with increasing sulphuer rate up to 80 kg /fad. in both seasons.

This means that sulphur application at 80 kg /fed. gave the highest values of total dry weight of sugar beet. The increases in total dry weight were about 8.1 and 10.2 % for sulphur at 40 kg/fad. and 12.2 and 14.4 % for sulphur at 80 kg/fad. over the control (untreated sulphur) in the 1st and 2nd seasons, respectively.

The favorable effect of sulphur application on growth of sugar beet might be due to its role in lowering pH of the soil, such reduction in pH lead to an increase in availability of P, Fe, Mn, Cu, Mg, SO_4 and Zn to the sugar beet plant roots. Each of these elements has distinct role in improving plant growth. Also, application of sulphur resulted in improving the movement of P from bulk soil to rhizosphere and stimulating its uptake. Moreover, sulphur plays a role in improving soil water relation, increasing root growth and regulating urea transformation in the soil, then improved growth parameters (Hilal, 1990). Similar results were obtained by Ouida, 2002; Nemeat Alla, 2005, Ferweez *et al.* (2011) , Awad *et al* (2013) on sugar beet and Mansour (2017) on sweet potato.

Table 2. Effect of sulphur rates and foliar spray treatments on dry weight of different parts of sugar beet plant during 2017/2018 and 2018/2019 seasons

Treatments	Dry weight of shoots (g/plant)		Dry weight of roots (g/plant)		Total dry weight (g/ plant)	
	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season
Effect of sulphur rates (kg/fad.)						
0	27.62 c	28.39 c	183.01 c	192.49 c	210.64 c	220.88 c
40	29.04 b	30.79 b	198.75 b	212.66 b	227.80 b	243.45 b
80	29.93 a	31.73 a	206.47 a	220.92 a	236.40 a	252.65 a
LSD at 0.05 level	0.41	0.37	5.24	5.60	5.19	5.73
Effect of foliar spray treatments						
Fe+ Zn +Mn+B	28.19 b	29.88 b	188.66 b	201.86 b	216.85 b	231.75 b
Blue green algae extract	30.50 a	32.33 a	212.52 a	227.39 a	243.02 a	259.73 a
Yeast extract	27.91 b	28.69 c	187.06 b	196.82 c	214.97 b	225.51 c
LSD at 0.05 level	0.36	0.44	2.20	2.36	2.12	2.28

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

Effect of some foliar spray treatments

Spraying sugar beet plants with blue green algae extract 1 L / fed. at 30, 60 and 90 days after sowing increased dry weight of shoots, roots and total dry weight at harvest in both seasons (Table 2). The increases in total dry weight were about 0.9 and 2.08 % for spraying with mixture of Fe+Zn+Mn+B and 13.0 and 15.2 % for spraying with blue green algae in the 1st and 2nd seasons, respectively.

The effect of spraying algae extracts on increasing the vegetative growth. may be due to extracts, are that the extracts contain auxins, gibberellins, and precursors of ethylene, betaine and cytokinins, which are present and potentially involved in enhancing plant growth responses (Crouch and Van Staden; 1994). Results are harmony with Aly *et al.* (2008) on sugar beet regarding algae effect and Garib and El-Henawy, (2011) regarding micronutrients effect .

Effect of the interaction

The interaction between sulphur application and spraying with some foliar spray treatments had significant effect on dry weight of shoots, roots and total dry weight in both seasons (Table 3) . The interaction between sulphur at 80 kg/fad. and spraying with blue green algae. gave the highest values of dry weight of shoots, roots and total dry weight/ plant of sugar beet at harvesting in both seasons. on the other hand spraying with yeast extract had the lowest values .

The increases in total dry weight were about 28.6 and 36.7 % for the interaction between 80 kg S/fad. and spraying blue green algae at over the interaction between 0 S and spraying with yeast extract in the 1st and 2nd seasons, respectively .

Table 3. Effect of the interaction between sulphur rates and foliar spray treatments on dry weight of different parts of sugar beet plant during 2017/2018 and 2018/2019 seasons

Treatments		Dry weight of shoots (g/plant)		Dry weight of roots (g/plant)		Total dry weight (g/ plant)	
		2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season
S rates (kg/fed.)	FST*						
0	Fe+ Zn +Mn+B	26.94 f	28.55 f	178.50 d	190.99 d	205.44 e	219.55 e
	Blue green algae extract	29.33 c	31.09 c	195.23 c	208.90 c	224.57 cd	239.99 cd
	Yeast extract	26.60 f	25.53 g	175.30 d	177.57 e	201.90 e	203.10 f
40	Fe+ Zn +Mn+B	28.41de	30.11 de	191.40 c	204.80 c	219.81 cd	234.92 cd
	Blue grean algae extract	30.63 b	32.46 b	214.18 b	229.18 b	244.81 b	261.64 b
	Yeast extract	28.10 e	29.79 e	190.67 c	204.01 c	218.77 d	233.80 d
80	Fe+ Zn +Mn+B	29.23 c	30.99 c	196.07 c	209.79 c	225.30 c	240.78 c
	Blue grean algae extract	31.54 a	33.43 a	228.13 a	244.10 a	259.68 a	277.54 a
	Yeast extract	29.03 cd	30.77 cd	195.20 c	208.86 c	224.23 cd	239.64 cd
LSD at 0.05 level		0.62	0.77	3.82	4.09	3.68	3.95

FST*= foliar spray treatments

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

2. Photosynthetic pigments

Effect of sulphur

Sulphur application at 40 and 80 kg /fed. had significant effect on the concentration of chlorophyll a, b, total (a+b) and carotenoides in leaf tissues at 90 days after sowing in both seasons (Table 4). The concentration of chlorophyll a, b, total (a+b) and carotenoides in leaf tissues increased with sulphur at 80 kg/fad. in both seasons. The increases in total chlorophyll in leaf tissues were about 17.5 and 19.0 % for sulphur at 40 kg/fad. and 31.3 and 33. % for sulphur at 80 kg/fad. over the control (untreated sulphur) in the 1st and 2nd seasons, respectively.

Sulphur plays a vital role in chlorophyll formation as its constituent of succinyl Co-A which is involved in synthesis of chlorophyll (Pirson, 1955). Results agree with

Thomas *et al*. (2000), Mansour (2017) on sweet potato and Yadav *et al.* (2019) on groundnut.

Effect of some foliar spray treatments

Data in Table 4 show that spraying sugar beet plants with mixture of Fe+Zn+Mn+B or with blue green algae. increased concentration of chlorophyll a, b, total (a+b) and carotenoides in leaf tissues compared to spraying with yeast extract (table 4). The increases in total chlorophyll in leaf tissues were about 6.9 and 8.3 % for spraying with mixture of Fe+Zn+Mn+B , 8.6 and 10.8 % for spraying with blue green algae over spraying with yeast extract in the 1st and 2nd seasons, respectively.

Algae extract may play a role through its content of cytokinins in delaying the aging of leaves by reducing the degradation of chlorophyll. In addition, algae extract as a bio-regulator affecting the balance between photosynthesis and respiration processes in plants (Yassen *et al*., 2007). Similar results were reported by Enan, *et al*. (2016). They found that foliar application of algae extract using 2.5 g/l or 3.5 g/l produced significantly higher values of photosynthetic pigments (chlorophyll a, b and carotenoides) than unsprayed.

Effect of the interaction

The interaction between sulphur at 80 kg/fad. and spraying with blue green algae gave the highest values of the concentration of chlorophyll a, b, total (a+b) and carotenoides in leaf tissues of sugar beet with no significant differences with the interaction between sulphur at 80 kg/fad. and spraying with mixture of Fe+Zn+Mn+B or /and the interaction between sulphur at 80 kg/fad. and spraying with yeast extract (Table 5).

The increases in total chlorophyll in leaf tissues were about 40.5 and 49.6 % for the interaction between 80 kg S/fed. and spraying with blue green algae , 39.0 and 47.8 % for the interaction between 80 kg S/fad. and spraying with mixture of Fe+Zn+Mn+B over the interaction between 0 S and spraying with yeast extract in the 1st and 2nd seasons, respectively.

Table 4. Effect of sulphur rates and some foliar spray treatments on leaf chlorophyll contents (mg / gm FW) at 90 days old of sugar beet during 2017/2018 and 2018/2019 seasons

Treatments	Chlorophyll a		Chlorophyll b		Total chlorophyll (a+b)		Carotenoides	
	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season
Effect of sulphur rates (kg/fed.)								
0	1.84 c	2.01 c	0.90 c	0.92 c	2.75 c	2.94 c	0.58 c	0.59 c
40	2.11 b	2.32 b	1.11 b	1.17 b	3.23 b	3.50 b	0.77 b	0.79 b
80	2.31 a	2.57 a	1.29 a	1.36 a	3.61 a	3.93 a	0.83 a	0.85 a
LSD at 0.05 level	0.08	0.11	0.03	0.02	0.10	0.27	0.04	0.05
effect of foliar spray treatments								
Fe+ Zn +Mn+B	2.11 a	2.32 a	1.13 a	1.19 a	3.25 a	3.52 a	0.72 ab	0.74 ab
Blue green algae extract	2.15 a	2.39 a	1.15 a	1.21 a	3.30 a	3.60 a	0.77 a	0.79 a
Yeast extract	2.00 b	2.19 b	1.03 b	1.06 b	3.04 b	3.25 b	0.68 b	0.70 b
LSD at 0.05 level	0.07	0.09	0.09	0.10	0.14	0.16	0.05	0.05

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

Table 5. Effect of the interaction between sulphur rates and some foliar spray treatments on leaf chlorophyll contents (mg / gm FW) at 90 days old of sugar beet during 2017/2018 and 2018/2019 seasons

Treatments		Chlorophyll a		Chlorophyll b		Total chlorophyll (a+b)		Carotenoides	
		2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season
S rates (kg/fed.)	FST*								
0	Fe+ Zn +Mn+B	1.87 ef	2.07 e	0.90 de	0.95 de	2.77 e	3.02 e	0.58 de	0.59 de
	Blue green algae extract	1.90 de	2.11 e	0.94 de	0.98 de	2.84 de	3.09 de	0.63 d	0.64 d
	Yeast extract	1.77 f	1.86 f	0.86 e	0.84 e	2.64 e	2.70 f	0.53 e	0.54 e
40	Fe+ Zn +Mn+B	2.15 c	2.32 cd	1.16 bc	1.22 bc	3.31 c	3.54 bc	0.77 bc	0.78 bc
	Blue green algae extract	2.20 bc	2.44 bc	1.17 bc	1.23 bc	3.37 c	3.68 b	0.83 ab	0.85 ab
	Yeast extract	2.00 d	2.22 de	1.01 cd	1.07 cd	3.02 d	3.29 cd	0.72 c	0.73 c
80	Fe+ Zn +Mn+B	2.33 ab	2.58 ab	1.34 a	1.41 a	3.67 ab	3.99 a	0.82 ab	0.84 ab
	Bluegreen algae extract	2.36 a	2.63 a	1.34 a	1.41 a	3.71 a	4.04 a	0.87 a	0.89 a
	Yeast extract	2.25 abc	2.49 ab	1.21 ab	1.27 ab	3.46 bc	3.77 ab	0.81 ab	0.83 ab
LSD at 0.05 level		0.12	0.16	0.17	0.18	0.24	0.28	0.08	0.08

FST*= foliar spray treatments

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

3. Iron, Zn, Mn and B in leaves

Effect of sulphur

Data in Table 6 indicate that sulphur application at 80 kg /fed. increased the contents of Fe, Zn, Mn and B in leaf tissues, followed by sulphur at 40 kg /fed. compared to the control in both seasons (Table 6).

Increasing the rates of sulphur gave a good moderation to soil solution and increased most of microelements to plants. Similar findings were found by Ouida, (2002).

Effect of some foliar spray treatments

Spraying sugar beet plants with mixture of Fe+Zn+Mn+B increased the contents of Fe, Zn, Mn and B in leaf tissues , followed by spraying with blue green algae compared to spraying with yeast extract in both seasons (Table 6). These results may be due to differential absorption of these nutrients in the presence of microelements, which enhance some elements on the account of others in the bio-accumulation. Also, very slight increases in Fe, Zn, Mn and B contents in leaves are found particularly when Fe+Zn+ Mn+ B were applied (Hellal *et al*., 2009).

This results are agree with those reported by El – Sherief *et al*. (2016). They noticed that spraying sugar beet plants with mixture of B+Zn+Mn had significant effect on B, Zn and Mn in sugar beet leaves at harvest.

Table 6. Effect of sulphur rates and some foliar spray treatments on micronutrients in leaf (ppm) of sugar beet during 2017/2018 and 2018/2019 seasons

Treatments	Fe		Zn		Mn		B	
	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season
Effect of sulphur rates (kg/fed.)								
0	34.74 c	36.80 c	17.40 c	18.08 c	21.76 c	21.96 c	32.15 c	32.40 c
40	37.93 b	40.78 b	20.34 b	21.52 b	24.31 b	25.17 b	33.98 b	34.83 b
80	40.48 a	43.51 a	22.11 a	23.39 a	26.85 a	27.79 a	35.34 a	36.22 a
LSD at 0.05 level	0.79	1.27	0.61	0.60	0.65	0.72	0.68	1.32
effect of foliar spray treatments								
Fe+ Zn +Mn+B	40.02 a	43.02 a	21.22 a	22.45 a	25.92 a	26.83 a	35.44 a	36.33 a
Blue green algae extract	36.82 b	39.58 b	19.64 b	20.78 b	23.76 b	24.59 b	33.39 b	34.22 b
Yeast extract	36.32 b	38.49 c	18.99 c	19.76 c	23.24 c	23.50 c	32.64 c	32.90 c
LSD at 0.05 level	0.51	0.68	0.39	0.35	0.32	0.55	0.40	0.63

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

Effect of the interaction

The interaction between sulphur at 80 kg/fad. and spraying with the mixture of Fe+Zn+Mn+B recorded maximum values of Fe, Zn, Mn and B in leaf tissues compared the other interaction treatments, whereas, the interaction between zero sulphur and spraying with yeast extract at 100 ml /l recorded minimum values of Fe, Zn, Mn and B in leaf tissues (Table 7).

Table 7. Effect of the interaction between sulphur rates and some foliar spray treatments on micronutrients in leaf (ppm) of sugar beet during 2017/2018 and 2018/2019 seasons

Treatments		Fe		Zn		Mn		B	
		2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season
S rates (kg/fed.)	FST*								
0	Fe+ Zn +Mn+B	36.70 d	39.45 c	18.50 e	19.57 f	22.18 ef	22.95ef	33.27 de	34.10 d
	Blue green algae extract	33.87 e	36.41 d	17.10 f	18.09 g	21.66fg	22.42f	31.94 fg	32.74 e
	Yeast extract	33.67 e	34.53 e	16.61 f	16.57 h	21.43g	20.52g	31.24 g	30.36 f
40	Fe+ Zn +Mn+B	40.26 b	43.28 b	21.50 b	22.75 bc	26.41 b	27.33 b	36.07 b	36.97 ab
	Blue green algae extract	37.06 d	39.84 c	20.20 c	21.37 d	23.57 d	24.40 d	33.26 de	34.09 de
	Yeast extract	36.48 d	39.22 c	19.34 d	20.46 e	22.97 e	23.77de	32.62 ef	33.44 de
80	Fe+ Zn +Mn+B	43.10 a	46.33 a	23.67 a	25.04 a	29.18 a	30.20 a	37.00 a	37.92 a
	Blue green algae extract	39.53 bc	42.50 b	21.63 b	22.89 b	26.04 b	26.95 bc	34.96 c	35.84 bc
	Yeast extract	38.80 c	41.72 b	21.04 b	22.26 c	25.33 c	26.22 c	34.06 d	34.91 cd
LSD at 0.05 level		0.88	1.18	0.67	0.61	0.55	0.96	0.70	1.10

FST*= foliar spray treatments

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

4. Yield and its components

Effect of sulphur

Root length, root diameter, yield of top, yield of roots /fed. and yield of sugar/fed. of sugar beet increased with increasing sulphur at 80 kg /fed. in both seasons (Table 8) The increases in yield of sugar were about 3.5 and 8.7 % for sulphur at 40 kg /fed. and 13.9 and 18.4 % for sulphur at 80 kg /fad. over the 0 S in the 1st and 2nd seasons, respectively.This may be due to the biological changes of sulphur by the soil microorganisms led to decrease soil pH which increase nutrients availability and improved the micoenvironmental around the roots which enhance plant growth and developed root formation.

Table 8. Effect of sulphur rates and some foliar spray treatments on yield and its components of sugar beet during 2017/2018 and 2018/2019 seasons

Treatments	Root length (cm)		Root diameter (cm)		Yield of top (ton/fad.)		Yield of roots (ton/fad.)		Yield of sugar (ton/fad.)	
	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season
Effect of sulphur rates (kg/fed.)										
0	36.88 c	42.36 c	26.81 c	26.67 c	8.281 c	8.320 c	23.527 c	23.596 c	4.009 b	4.195 c
40	42.83 b	44.54 b	29.21 b	30.14 b	8.964 b	9.368 b	24.656 b	25.543 b	4.150 b	4.558 b
80	45.05 a	46.85 a	30.39 a	31.36 a	9.590 a	10.022 a	25.599 a	26.520 a	4.567 a	4.966 a
LSD at 0.05 level	0.96	1.43	0.97	1.06	0.218	0.229	0.340	0.315	0.309	0.157
Effect of foliar spray treatments										
Fe+ Zn +Mn+B	41.93 a	43.61 b	28.01 b	28.91 b	8.760 b	9.1544 b	24.200 b	25.070 b	4.263 a	4.632 b
Blue green algae extract	42.59 a	48.30 a	30.41 a	31.39 a	9.538 a	9.9689 a	25.681 a	26.606 a	4.495 a	4.937 a
Yeast extract	40.24 b	41.85 c	27.99 b	27.88 c	8.536 c	8.5867 c	23.900 c	23.983 c	3.968 b	4.150 c
LSD at 0.05 level	0.76	1.12	0.76	0.83	0.082	0.086	0.227	0.309	0.242	0.171

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

The increases in root yield with increasing sulphur levels may be attributed to its role in better partitioning of the photosynthates in the shoot (Sud and Sharma, 2002). The obtained results are in harmony with those reported by Shafika *et al.* (2005), Zeinab *et al.* (2006), Awed Allah *et al.*(2007) and Tawfic *et al*. 2014. They found that treated plants with sulphur application increased yield and its components.

Effect of some foliar spray treatments

Spraying sugar beet plants grown in clay soil with blue green algae increased root length, root diameter, yield of top, yield of roots /fad. and yield of sugar/fad., followed by spraying with mixture of Fe+Zn+Mn+B compared to spraying with yeast extract in both seasons (Table 8).

The increases in yield of sugar were about 7.4 and 11.6 % for spraying with mixture of Fe+Zn+Mn+B and 13.3

and 19.0 % for spraying with blue green algae over spraying with yeast extract in the 1st and 2nd seasons, respectively.

These results could be attributed to the effect of algae extract which containing plant growth regulators on increasing the absorption of nutrients and on photosynthesis process, that led to more accumulation of metabolites in reproductive organs; which, in turn, improved the sugar beet productivity (Haider, 2012). This results are harmony with those reported by Aly *et al*. (2008), Enan *et al*. (2016) and AL Jbawi *et al*. (2020) on sugar beet with regard algae effect. Dewdar *et al*. (2018) and Zewail, *et al. (2020)* as for micronutrients effect

Effect of the interaction

The interaction between sulphur at 80 kg/fad. and spraying with blue green algae. significantly increased root length, root diameter , yield of top, yield of roots /fad. and yield of sugar/fad**.** in both seasons (Table 9). The increases in yield of sugar were about 32.8 and 56.3 % for the interaction between 80 kg S/fad. and spraying with blue green algae, 24.9 and 42.7 % for the interaction between 80 kg S/fad. and spraying with mixture of Fe+Zn+Mn+B over the interaction between 0 S and spraying with yeast extract in the 1st and 2nd seasons, respectively.

Table 9. Effect of the interaction between sulphur rates and some foliar spray treatments on yield and its components of sugar beet during 2017/2018 and 2018/2019 seasons

S rates (kg/fed.)	Treatments FST*	Root length (cm) 2017/2018 season	Root length (cm) 2018/2019 season	Root diameter (cm) 2017/2018 season	Root diameter (cm) 2018/2019 season	Yield of top (ton/fed.) 2017/2018 season	Yield of top (ton/fed.) 2018/2019 season	Yield of roots (ton/fed.) 2017/2018 season	Yield of roots (ton/fed.) 2018/2019 season	Yield of sugar (ton/fed.) 2017/2018 season	Yield of sugar (ton/fed.) 2018/2019 season
0	Fe+ Zn +Mn+B	39.44 f	41.02 ef	26.63 e	27.49 e	8.113 g	8.477 f	23.333e	24.173f	4.072 cd	4.472 cd
	Blue green algae extract	32.00 g	45.28 c	27.23 de	28.10 de	8.703 ef	9.097 de	24.380d	25.257de	4.171 cd	4.582 cd
	Yeast extract	39.22 f	40.79 f	26.59 e	24.44 f	8.027 g	7.387 g	22.867f	21.357g	3.784 d	3.532 e
40	Fe+ Zn +Mn+B	42.22 d	43.90 cd	28.88 c	29.80 c	8.800 e	9.197 d	24.133d	25.000e	3.992 cd	4.385 d
	Blue green algae extract	46.11 b	47.95 b	30.44 b	31.41 b	9.613 b	10.047 b	25.867b	26.800b	4.289 bc	4.709 c
	Yeast extract	40.18 ef	41.79 ef	28.33 cd	29.23 cd	8.480 f	8.860 e	23.967 d	24.830 e	4.170 cd	4.581 cd
80	Fe+ Zn +Mn+B	44.15 c	45.92 bc	28.54 cd	29.45 cd	9.367 c	9.790 b	25.133 c	26.037 c	4.725 ab	5.041b
	Blue green algae extract	49.68 a	51.67 a	33.58 a	34.66 a	10.300 a	10.763 a	26.797 a	27.760 a	5.027 a	5.521 a
	Yeast extract	41.33 de	42.98 de	29.06 bc	29.99 bc	9.103 d	9.513 c	24.867 c	25.763cd	3.951 cd	4.338 d
LSD at 0.05 level		1.31	1.94	1.32	1.44	0.142	0.150	0.393	0.535	0.420	0.296

FST*= foliar spray treatments

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

5. Root quality

∝N%, K%, Na%, sucrose% and purity%

Effect of sulphur

Contents of K, sucrose and purity (%) of sugar beet roots increased with increasing sulphur up to 80 kg /fed. with no significant differences with sulphur at 40 kg/fed. in both seasons with respect K (%) in both seasons and purity (%) in the 2nd season (Table 10). Sulphur at different rates had no significant effect on ∝N and Na contents in roots in both seasons. The increases in purity were about 1.0 and 1.7 % for sulphur at 40 kg /fad. and 2.8 and 3.4 % for sulphur at 80 kg /fad. over the 0 S in the 1st and 2nd seasons, respectively.

In this connection, Ferweez *et al*. (2011) indicated that sulphur application level at 200 kg/fed. had a significant increase in purity %, Na content, α- amino nitrogen, sugar recovery%, quality index and sugar yield/fed in the two growing seasons.

Table 10. Effect of sulphur rates and some foliar spray treatments on root quality of sugar beet during 2017/2018 and 2018/2019 seasons

Treatments	∝N (%) 2017/2018 season	∝N (%) 2018/2019 season	K (%) 2017/2018 season	K (%) 2018/2019 season	Na (%) 2017/2018 season	Na (%) 2018/2019 season	Sucrose % (%) 2017/2018 season	Sucrose % (%) 2018/2019 season	Purity (%) 2017/2018 season	Purity (%) 2018/2019 season
Effect of sulphur rates (kg/fed.)										
0	2.63 a	2.72 a	5.22 b	5.37 b	2.01 a	1.94 a	17.04 b	17.73 b	81.08 b	83.77 b
40	2.67 a	2.83 a	5.49 a	5.64 a	1.89 a	1.85 a	16.84 b	17.85 b	81.92 b	85.20 ab
80	2.56 a	2.78 a	5.52 a	5.68 a	1.89 a	1.86 a	17.64 a	18.70 a	83.39 a	86.61 a
LSD at 0.05 level	NS	NS	0.21	0.21	NS	NS	0.45	0.59	0.87	1.66
effect of foliar spray treatments										
Fe+ Zn +Mn+B	2.19 c	2.31 c	5.19 b	5.35 b	1.95 a	1.91 a	17.42 a	18.47 a	81.48 b	84.62 a
Blue green algae extract	2.65 b	2.82 b	5.64 a	5.81 a	1.92 a	1.88 a	17.48 a	18.53 a	82.39 a	85.46 a
Yeast extract	3.01 a	3.19 a	5.40 ab	5.54 ab	1.93 a	1.86 a	16.61 b	17.27 b	82.53 a	85.49 a
LSD at 0.05 level	0.16	0.14	0.27	0.27	NS	NS	0.80	0.85	0.68	NS

FST*= foliar spray treatments

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

Effect of some foliar spray treatments

In general**,** spraying sugar beet plants with blue green algae increased K contents , sucrose and purity (%) of sugar beet roots with no significant differences with yeast extract with respect K contents and purity and with mixture of Fe+Zn+Mn+B at 1 % with respect to sucrose (%) (Table 10). Spraying with yeast extract increased ∝N contents in roots in both seasons. Different foliar spray treatments had no significant effect on Na contents in roots in both seasons and purity (%) in the 2nd season. The increases in purity were about 1.1 and 1.0 % for spraying with blue green algae and 1.3 and 1.0 % for spraying with yeast extract over spraying with mixture of Fe+Zn+Mn+B in the 1st and 2nd seasons, respectively.

These results may be due to that alga extract is considered a source of high plant regulators content enhance directly in the metabolism. It also contains some essential macronutrients for growth and development of the plant as N, P and K. In addition, algae extract affect the nutrients uptake by plant roots (Marrez *et al*., 2014). Spraying sugar beet with 0.8%B, 1.5%Cu, %5 Fe, %3 Mn, 0.2% Mo, 4% Zn at 0.5 kg ha-1 gave the highest values of sugar contents in roots than unsprayed (Özbay and Yıldırım , 2018)

Effect of the interaction

The interaction between sulphur at 80 kg/fad. and spraying with yeast extract significantly increased ∝N, K and Na (%) in roots, whereas the interaction between sulphur at 80 kg/fed. and spraying with blue green algae significantly increased sucrose and purity (%) (Table 11). The increases in purity were about 5.2 and 5.2 % for the interaction between 80 kg S/fed. and spraying with blue green algae , 4.1 and 4.1 % for the interaction between 80 kg S/fed. and spraying with yeast extract over the interaction between any S and spraying with mixture of Fe+Zn+Mn+B in the 1st and 2nd seasons, respectively

Iron, Zn, Mn and B in roots

Effect of sulphur

Data in Table (12) indicate that sulphur application at 80 kg /fed. significantly increased Fe, Zn, Mn and B in roots , followed by sulphur at 40 kg /fad. compared to the control in both seasons .

The effect of sulphur on quality of root, with increasing the rates of sulphur to soil gave a good moderation to soil solution and increased most of micro elements to plants and decreased the impurities in roots (Tawfic *et al.* 2014).

Table 11. Effect of the interaction between sulphur rates and some foliar spray treatments on root quality of sugar beet during 2017/2018 and 2018/2019 seasons

Treatments		∝N (%)		K (%)		Na (%)		Sucrose % (%)		Purity (%)	
S rates (kg/fad.)	FST*	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season
0	Fe+ Zn +Mn+B	1.94 c	2.02 e	5.03 e	5.18 e	2.17 a	2.13 a	17.45 bc	18.50 bc	79.65 d	82.83 e
	Blue green algae extract	2.86 a	2.86 bc	5.64 abc	5.81 abc	1.99 ab	1.95 ab	17.11 bc	18.14 bcd	82.19 bc	84.81 bcd
	Yeast extract	3.10 a	3.28 a	4.99 e	5.14 e	1.88 ab	1.75 ab	16.55 cd	16.54 e	81.42 c	83.67 de
40	Fe+ Zn +Mn+B	2.25 b	2.39 d	5.42 b-e	5.59 b-e	1.78 ab	1.75 ab	16.54 cd	17.54 cde	81.34 c	84.59 cde
	Blue green algae extract	2.87 a	3.04 ab	5.77 ab	5.94 ab	2.16 a	2.12 a	16.58 cd	17.57 cde	81.16 c	84.41 cde
	Yeast extract	2.89 a	3.06 ab	5.29 c-e	5.40 cde	1.71 ab	1.68 ab	17.40 bc	18.45 bc	83.27 ab	86.60 ab
80	Fe+ Zn +Mn+B	2.40 b	2.54 cd	5.13 de	5.28 de	1.88 ab	1.84 ab	18.27 ab	19.36 ab	83.45 ab	86.45 abc
	Blue green algae extract	2.23 b	2.57 cd	5.53 a-d	5.69 a-d	1.61 b	1.57 b	18.76 a	19.89 a	83.82 a	87.17 a
	Yeast extract	3.06 a	3.24 a	5.91 a	6.09 a	2.20 a	2.16 a	15.89 d	16.84 de	82.90 ab	86.22 abc
LSD at 0.05 level		0.27	0.25	0.46	0.48	0.56	0.54	1.39	1.48	1.18	1.64

FST*= foliar spray treatments

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

Effect of some foliar spray treatments

Spraying sugar beet plants with mixture of Fe+Zn+Mn+B significantly increased Fe, Zn, Mn and B in roots, followed by spraying with blue green algae and yeast extract in both seasons (Table 12).

This results are agree with those reported with El – Sherief *et al.* (2016). They noticed that spraying sugar beet plants with mixture of B+Zn+Mn had significant effect on B, Zn and Mn in sugar beet roots at harvest.

Effect of the interaction

The interaction between sulphur at 80 kg/fed. and spraying with the mixture of Fe+Zn+Mn+B significantly increased Fe, Zn, Mn and B in roots in both seasons (Table 13).

Generally, under the same conditions, it could be concluded that, treating sugar beet soils with sulphur at 80 kg /fed. and spraying with blue green algae were the best treatment for increasing total yield of roots and gave the best roots quality.

Table 12. Effect of sulphur rates and some foliar spray treatments on micronutrients in root (ppm) of sugar beet during 2017/2018 and 2018/2019 seasons

Treatments	Fe		Zn		B		Mn	
	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season
				Effect of sulphur rates (kg/fed.)				
0	16.27 c	16.81 c	11.86 c	12.23 c	9.57 c	9.97 c	15.09 c	15.21 c
40	18.41 b	19.51 b	13.87 b	14.56 b	11.60 b	11.95 b	16.94 b	17.70 b
80	19.59 a	20.76 a	15.88 a	16.67 a	12.78 a	13.17 a	19.28 a	20.15 a
LSD at 0.05 level	0.86	0.92	0.72	0.82	0.17	0.35	0.37	0.59
				Effect of foliar spray treatments				
Fe+ Zn +Mn+B	20.45 a	21.68 a	15.49 a	16.27 a	12.68 a	13.06 a	18.55 a	19.38 a
Blue green algae extract	17.04 b	18.07 b	13.23 b	13.89 b	10.74 b	11.07 b	16.49 b	17.23 b
Yeast extract	16.78 b	17.34 c	12.88 b	13.31 b	10.54 b	10.97 b	16.27 b	16.44 c
LSD at 0.05 level	0.49	0.58	0.60	0.60	0.53	0.51	0.35	0.56

Table 13. Effect of the interaction between sulphur rates and some foliar spray treatments on micronutrients in root (ppm) of sugar beet during 2017/2018 and 2018/2019 seasons

Treatments		Fe		Zn		Mn		B	
S rates (kg/fed.)	FST*	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season	2017/2018 season	2018/2019 season
0	Fe+ Zn +Mn+B	18.93 c	20.07 c	13.28 c	13.94 c	15.97 c	16.69 c	10.84 d	11.16 d
	Blue green algae extract	15.27 e	16.19 f	11.30 d	11.86 d	14.76 d	15.43 d	9.10 e	9.37 e
	Yeast extract	14.63 e	14.17 g	11.01 d	10.90 d	14.53 d	13.52 e	8.78 e	9.37 e
40	Fe+ Zn +Mn+B	20.50 b	21.73 b	15.50 b	16.27 b	18.50 b	19.33 b	13.03 b	13.42 b
	Blue green algae extract	17.13 d	18.16 e	13.17 c	13.83 c	16.29 c	17.02 c	10.90 d	11.23 d
	Yeast extract	17.60 d	18.65de	12.93 c	13.58 c	16.04 c	16.76 c	10.88 d	11.21 d
80	Fe+ Zn +Mn+B	21.93 a	23.25 a	17.70 a	18.58 a	21.18 a	22.13 a	14.16 a	14.59 a
	Blue green algae extract	18.73 c	19.85cd	15.23 b	15.99 b	18.43 b	19.26 b	12.23 c	12.60 c
	Yeast extract	18.11cd	19.19cde	14.71 b	15.44 b	18.24 b	19.06 b	11.96 c	12.32 c
LSD at 0.05 level		0.85	1.02	1.04	1.04	0.61	0.97	0.92	0.89

FST*= foliar spray treatments

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تاثير الاضافه الارضيه للكبريت و الرش ببعض المركبات الورقيه على انتاجيه و جوده جذور بنجر السكر

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معهد بحوث الاراضى و المياه و البيئه – مركز البحوث الزراعيه

اقيمت تجربه حقليه بمحطه البحوث الزراعيه بالجميزه , محافظه الغربيه – مصر اثناء الموسمين الشتوى 2017-2018 و 2018-2019 لدراسه تاثير الاضافه الارضيه للكبريت بمعدلات صفر و 40 و 80 كجم للفدان مع معاملات الرش الورقى خليط من كبريتات الحديد وزوكبريتات المنجنيز وكبريتات الزنك وحمض البوريك بمعدل 1 % , الرش بمستخلص الطحالب الخضراء المزرقه 1 لتر للفدان , الرش بمستخلص الخميره 100 مل للتر على النمو و المحصول و جوده الجذور لبنجر السكر صنف اوسكار فى الارض الطينيه تصميم التجربه قطع منشقه كامله العشوائيه فى 3 مكررات حيث كانت مستويات الكبريت القطع الرئيسيه بينما معاملات الرش الورقي القطع تحت الرئيسيه واوضحت النتائج ان التداخل بين الكبريت بمعدل 80 كجم و الرش بمستخلص الطحالب الخضراء المزرقه 1 لتر للفدان اعطت اعلى قيم ل الوزن الجاف للمجموع الخضرى و الجذور و الوزن الجاف الكلى لكل النبات و كلوروفيل اوكلوروفيل ب و الكلى و الكاروتينات فى نسيج الورقه و طول و قطر الجذور و محصول الجذور و محصول السكر و نسبه النقاوه لبنجر السكر فى كلا الموسمين بينما التداخل بين اضافه الكبريت بمعدل 80 كجم للفدان و الرش بمخلوط كبريتات الحديد وزو كبريتات الزنك و كبريتات المنجنيز و حمض البوريك بمعدل 1 % سجل اعلى قيم من الحديد و الزنك و المنجنيز و البورن فى الورقه و الجذر بالمقارنه بتداخل المعاملات الاخري والتداخل بين 80 كجم للفدان كبريت و الرش بمستخلص الخميره 100 مل للتر ادت الى زياده معنويه فى النسبه المئويه للنيتروجين و البوتاسيوم و الصوديوم فى الجذور , زياده محصول السكر كانت 32,8%, 56,3% للمعامله اضافه الكبريت 80 كجم للفدان مع الرش بمستخلص الطحالب الخضراء المزرقه , 24,9%, 42,7% مع اضافه 80 كجم للفدان و الرش بمخلوط العناصر الصغري مقارنه بمعامله التداخل بين الكبريت و الرش بمستخلص الخميره فى الموسم الاول و الموسم التانى على التوالى .