

Study Influence Of Elemental Sulpher Compared with Foliar Spray Fertilizers on Productivity and Maintenance Calcareous Soil.

Azza R. Ahmed

Soils, Water and Environ. Res. Inst., Agric. Res. Center, Giza, Egypt

Abstract: A field experiment was conducted in two successive summer seasons 2009 and 2010 at the farm of Nubaria Agriculture Research Station (Calcareous soil) to study the effective role of elemental sulfur application and foliar spray fertilizers in the presence of FYM on some physical properties, productivity and maintenance of calcareous soil quality. Also, to assess and compare of farm profitability of all tested variables are considered. The obtained data indicated that the highest grain yield was obtained from the treatments of chelating foliar spraying and the application of sulfur which gave 4.95 and 4.82 ton fed⁻¹ respectively and the difference between them was not significant. On the other hand, the relative increase yield for all treatments arranged in ascending order: 28, 30, 37.7 and 41% for hormone, mineral, sulfur and chelating than the control, respectively. However, there is a positive increasing for values of growth characters of maize plant due to applied the treatments e.g. the period from planting to produce 50% silk was decreased significantly in descending order as following hormone treatment > the mineral treatment > soil application of sulfur treatment > Chelating treatment. Also, uptake of P due to the application of sulfur was enhanced by 98% than the control. While uptake of P values increased due to the application of foliar spray fertilizers treatments by 55.8%, 48% and 60% for mineral, hormone and chelate than the control, respectively. Application of elemental sulfur positively affected Zn, Fe, Mn concentration and uptake. The corresponding values were increased by about 185% for Zn, 31.7 for Fe and 30% for Mn than the control. The effect of elemental sulfur application on soil pH was positive significant and decreased by 0.44 unite than the control. On the other hand, sulfur application was significantly increased the availability of P more than all treatments and increasing P availability by 135 % than the control. Under the condition of this study, data showed a positive effect on hydro-physical properties of calcareous soil. It was considered that the aggregation stability enhanced by application of sulfur associated to FYM. As the aggregate index value for application of sulfur with FYM near to one (0.92). The application of sulfur in the presence of FYM led to an increasing hydraulic conductivity by about 58% and 126% than the control. It was obvious from the previous data that the application of foliar spray fertilizers becomes the highest costs and lower return.

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Key ward: Element S, Foliar fertilizers, aggregate size fraction, maize plant.

1. Introduction

One of the major problems of Calcareous soils in the world is low bioavailability of plant nutrients, mainly due to high pH and CaCO₃ levels which are predominantly responsible for low availability of other plant nutrients (macro and micro elements). These soils can contain from about 3% to more than 25 % CaCO₃ by weight, with pH values in the range of 7.6 to 8.3 (Thomas et al. 2012). Increasing nutritional management often is required to grow plants crops successfully on calcareous soils. The effect of soil pH on soil nutrient availability and chemical reactions affect the loss or fixation of some nutrients. The presence of CaCO₃ directly or indirectly affects, for example, on availability of phosphorus (P), manganese (Mn), zinc (Zn), and iron (Fe). A soil pH value of less than 7 is preferred to ensure that Zn and Mn are available to plants in sufficient amounts. It is worth mentioning that, Zinc (Zn) has an important role either as a metal component of enzymes or as a

functional, structural or regulatory co-factor of a large number of enzymes (Grotz and Guerinot, 2006). Also, Manganese (Mn) in turn, is regarded as an activator of many different enzymatic reactions and takes part in photosynthesis. Manganese activates decarboxylase and dehydrogenase and is a constituent of complex protein and phosphates.

Moreover, Iron (Fe) plays an essential role in the metabolism of chlorophylls. Calcareous soils may contain high levels of total Fe, but in forms unavailable to plants. Thus, this disorder on calcareous soils is not always attributable to Fe deficiency. It may be a condition known as lime-induced Fe chlorosis. Iron is considerably less soluble than Zn or Mn in soils with a pH value of 8. Thus, inorganic Fe contributes relatively little to the Fe nutrition of plants in calcareous soils (Zekri, M., and T. A. Obreza. 2003). The primary factor associated with Fe chlorosis under calcareous conditions appears to be the effect of the bicarbonate ion (HCO₃) on Fe

uptake and/or translocation in the plant. The result is Fe inactivation or immobilization in plant tissue. Chelated forms of Fe are usually more effective in reducing Fe chlorosis than are inorganic forms.

On the other hand, application of S is one of the options to solve the problems of calcareous soils. Thus, the interest has increased in using elemental S to improve the solubility of plant nutrients. The oxidation of S into H₂SO₄ is beneficial in reducing pH, supplying SO₄²⁻ to plants and making phosphorus and micronutrients more available. **Erdal et al (2006)** found that soil pH decreased by 0.11-0.37 unit but plant dry weight and phosphorus concentration and uptake were increased with the application of sulfur.

However, the effects of fertilization by carbon (C), nitrogen (N) and sulfur (S) associated with aggregates. (**Yang et al., 2007**) reported that a high level of FYM and NPKS application increased the proportion of small dry aggregates (<0.6mm) by 8%, compared with the control (without fertilizer). Although, the application of foliar spray fertilizers have a quick effect to therapy deficiency of element nutrients, the combination of organic matter (FYM) with mineral fertilizer enhance soil quality (**Azza et al 2012**).

The objective of this study aimed to identifying the effective role of application of elemental sulfur and different foliar spray fertilizers on productivity and some physical properties of calcareous soil.

On the other site, it will be ascertained from the lowest input and highest output for all treatments.

2. Materials and Methods

A field experiment was conducted in two successive summer seasons (2009 and 2010) at the farm of Nubaria Agriculture Research Station, calcareous soil, El-Behira governorate, Egypt. The current study was undertaken to assess the effect of foliar sprays of micronutrient fertilizers as well as the

treatment of S application in the presence of farmyard manure (FYM) on the maintenance of some physical properties of the calcareous soil and its productivity of corn plants (Hybrid tri 321). For this purpose, the treatments were a) foliar spray with mineral fertilizer (1g ferrous sulphate + 1g Zinc sulphate + 1g manganese sulphate/ L); b) foliar spray with chelating fertilizer (Fe+Zn+Mn, 6ml/L); c) foliar spray with hormone containing (Zn, Fe, Mn) which was added at rate of 2ml /L. d) elemental sulfur which was applied at rate of 300 Kg/Fed. e) control treatment without any addition The date of spraying was in two batches, the first one was after 35 days and the second after 50 days from planting. Also, farmyard manure (FYM) was added at rate of 20 ton /Fed for all treatments and thoroughly mixed with the surface soil during its preparing for planting, except control. This study was carried out using randomized complete block design (RCBD) with three replicates.

The grains of maize (hybrid tri 321) were planted with 15 cm distance in 5 cm of furrow deeps at the rate of 12 kg fed⁻¹ during the first week of June 2011 and 2012, respectively. The recommended doses of phosphorus and potassium were applied at rate of 45 kg P₂O₅fed⁻¹ and 24KgK₂Ofed⁻¹ in the forms of triple superphosphate (37 % P₂O₅) and potassium sulfate (48 % K₂O), respectively, which they were added on the dry soil before planting. While nitrogen fertilizer was added in the form of ammonium nitrate 33.5%N at recommended doses (120 kg Nfed⁻¹) by splitting tow equal doses. The other usual agricultural practices of growing maize plants were conducted as recommended by Ministry of Agriculture, exception of the factors under study.

Sampling procedure:

Composite surface soil samples (0-30cm) for two season 2009 and 2010 were collected before treatments application for determination of some physical and chemical analyses (Table, 1a).

Table (1a): The main initial characteristics of the experimental soil.

Experiment year	Soil depth	Soil characters									
		Ec dS/m	pH	Total N%	OM %	CaCO ₃ %	Available P ppm	DTPA- ppm			Soil Tex
								Zn	Fe	Mn	
2011	0-30	2.13	8.23	0.121	0.38	23.61	3.32	0.21	1.53	1.42	Sandy Loam
2012	0-30	2.24	8.19	0.130	0.64	22.97	2.94	2.94	1.64	1.47	Sandy loam

Also, farmyard manure was air dried, ground in a ceramic mortar and passed through 2 mm sieve and stored for chemical analyses (Table,1b).

Table (1b): Some chemical analysis of farmyard manure for two experimental summer season (2009/ 2010).

Experimental year	pH 1:10	E.C Ds ⁻¹ m	OM %	Total N %	Total P%	Total K%	Available P%	C/N ratio	Øw %
2011	7.53	2.94	66.7	1.8	0.65	0.72	82.31	21.5	19.4
2012	7.60	2.79	64.3	1.5	0.62	0.70	79.56	24.9	18.6

At harvesting time in each season the grains and shoots of maize for each plot were weighed and related to ton fed⁻¹. The following data of some parameters were recorded : such as plant height, stem circumference (cm), 100 seed weight (g), grain yield (tonfed⁻¹), ear length, number of row/ear, number of seed /row, ear circumference (cm), as well as each of, leaf area cm², ear height, the numbers of days to arrive 50% silk were determined. The plant samples were dried at 70C⁰ and ground, digested with acids mixtures (HClO₄+H₂SO₄). The available P and micronutrients (Zn,Fe,Mn) for plant were measured by **Chapman and Pratt (1961)**. Moreover, after harvesting soil samples were taken from each treatment, air dried, crushed and passed through a 2-mm sieve for estimating organic carbon according to **Jackson, 1958**. Soil pH was measured according to **Thomas (1996)**, while, Zn, Fe, Mn were determined according to **Soltanpoor (1991)**. Size distribution of water stable aggregates was determined by using wet-sieving method as described by **Yoder (1936)**. The aggregate size determined as [more than 2 mm, 1 mm, 0.5 mm, 0.25 mm, 0.125mm]. Hydraulic conductivity determined according to **Klute, 1965**. All data analysis of evaluated character were carried by statistical soft ware by using M-state soft ware before doing analysis of variance normally was assess by Minitab soft ware.

3. Results and Discussion

1- Effect of the different treatments on some physic-chemical properties of calcareous soil (average the two experimental seasons 2009/2010).

Fig. (1-a) revealed that fertilization with different foliar sprays in the presence of FYM did not significantly affect on some physical properties of calcareous soil and considered as FYM treatment alone. On the other hand, the application of elemental sulfur with FYM improved significantly some physical soil properties such as aggregate size particles, hydraulic conductivity and soil pH running on maintenance and conservation of calcareous soil. Whereas, it showed that the aggregate sizes distribution to more than 2.0, 2.0-1.0, 1.0-0.5, 0.5-.025, 0.25-0.063 and less than 0.063 mm diameter tended to increase due to the application of elemental sulfur combined with FYM towards to large aggregate size fractions by 17.3% comparing with control treatment (without any addition) which gave 17.16 %. As large aggregation fractions (macro aggregates) are composed of small aggregation fractions (micro aggregates) containing older carbon (C). The SOM (FYM) stabilizing macro aggregates which was taken to be younger and more transient. **Yang et al., (2007)** reported that both medium and high level of FYM application combined with S increased the proportion of large water and dry stable aggregates (>2mm) compared with mineral fertilizer (NPKS and NK) or control without fertilizer. Also, **Azza et.al (2011)** reported that increasing the percentage of macro-aggregate and reducing the percentage of micro-aggregate with either Blue green algae (BGA) or FYM, may be due to that, these materials play a positive role as a cementing agent through the released active organic acids and polysaccharides during the decomposition of organic residues by microbial activity.

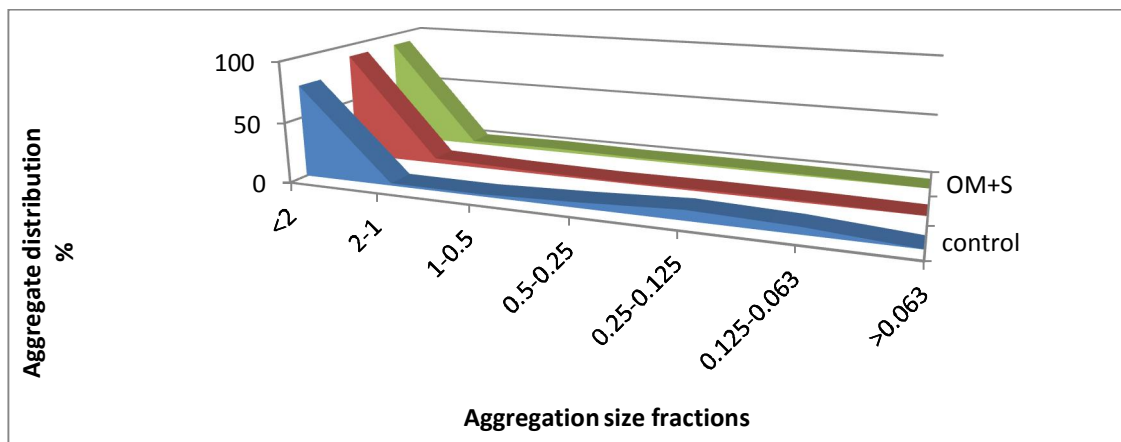


Fig. (1-a) Effect of elemental sulfur application in the presence of FYM on the aggregate size distribution of calcareous soil.

On the other hand, Fig (1-b) showed that the effect of the treatments on aggregate state and aggregate degree. It is obvious that the application of

element sulfur with FYM was ascertained an increasing the aggregation state and its degree by about 16.5 and 26.02, respectively, when comparing with that of control which gave 10.94 and 23.9, respectively. **Yang et al., (2007)** concluded that application of high amounts of FYM resulted in S

accumulation in bulk soil, and C and S accumulation in most aggregates, but that the accumulation pattern

was dependent on aggregate size and the element (C, N and S) considered.

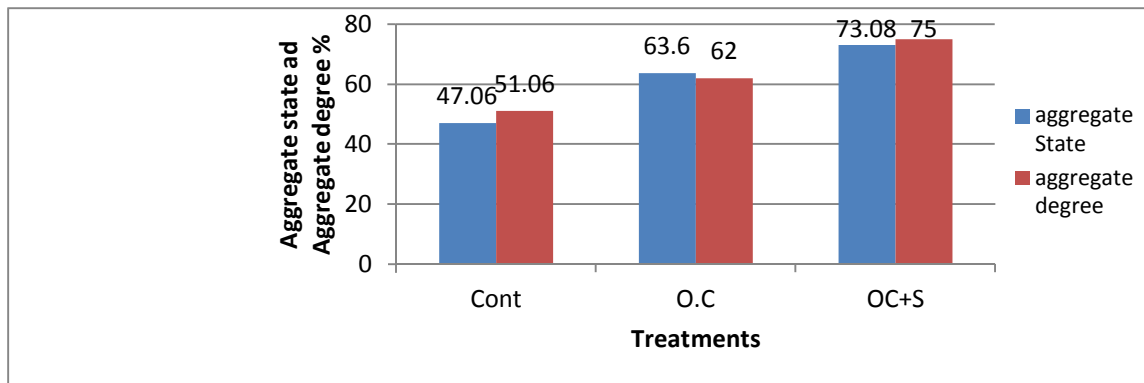


Fig. (1-b) Effect of elemental sulfur application in the presence of FYM on aggregation state and aggregation degree.

Finally, fig. (1-c) illustrated the aggregation index as a result of sulfur application with FYM. It is clear that the aggregate index value for application of sulfur with FYM near to one. It takes into consideration, good aggregation stability the aggregate index closely to one. Under the condition

of this study, it was considered that the aggregation stability enhanced by application of sulfur associated to FYM and the aggregate Index about 0.92. **Whitbread, et al (1994)** strongly sorbet polymers such as some polysaccharides and organic materials stabilized by association with metals are included.

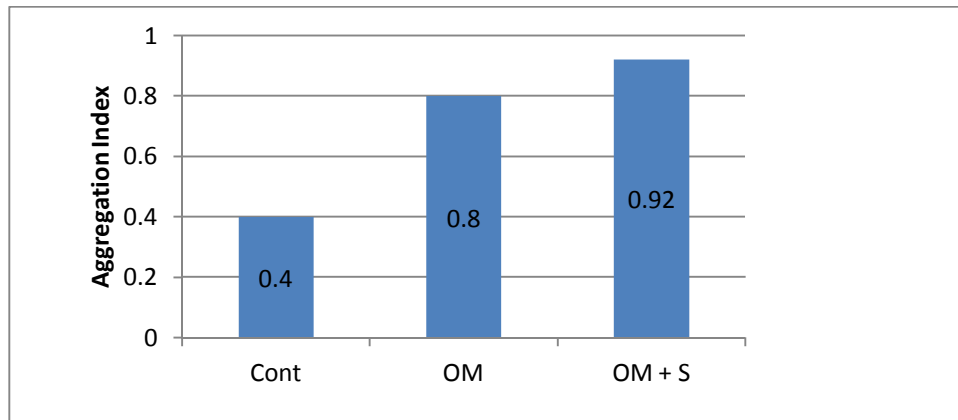


Fig. (1-c) Effect of elemental sulfur application in the presence of FYM on aggregate index.

Also, results in Fig. (2) revealed that application of sulfur combined with FYM caused a gradual significant increase in hydraulic conductivity. The application of sulfur with FYM led to an increasing of hydraulic conductivity by about 58 % than the control treatment. **Azza et al., (2012)** reported that FYM addition up to the highest rate (40 m³ Fed⁻¹) increased K_n and I.R by about 86% and 60% over the control for first season while in the

second season (the residual effect) for both hydraulic conductivity and Infiltration rate increased by about 104% and 46% over control, respectively on calcareous soil with maize plant. On the other site, the increment by application of sulfur with FYM on hydraulic conductivity value twice than that of control. These results are similar to those found by **Jose et al., (2007)**.

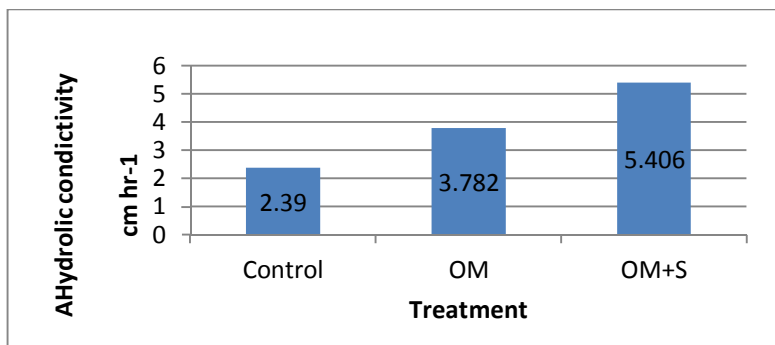


Fig. (2) Effect of elemental sulfur application in the presence of FYM on hydraulic conductivity

The effect of different sources of foliar spray fertilizers and soil application of sulfur with FYM on soil pH are presented in Fig (3). The addition of organic matter (FYM) for all treatments caused decreasing the values of soil pH. The foliar spray fertilizers with application of FYM were slightly

decreased pH values by about 0.05, 0.03, and .003unit for mineral, hormone, chalet than the control, respectively due to the addition of FYM. The effect of elemental sulfur and farmyard manure on soil pH was positive significant and decreased by 0.44 unite than the control.

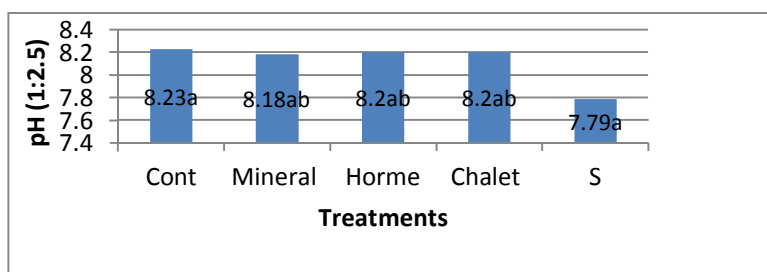


Fig (3) Effect of foliar spray fertilizers and elemental sulfur application on pH values.

Soil pH decreased in the case of sulfur application with FYM not only for decomposition of organic matter but also for biologically oxidized of sulfur element to H_2SO_4 in soil under aerobic conditions. The oxidation of S to H_2SO_4 is particularly beneficial effect in reducing pH, supply SO_4 to plants, make P and micronutrients more available, and reclaim soils. **El-Eweddy et al., (2005)** stated that in calcareous soils, sulfur reduced soil pH values by oxidation of sulfur to sulfuric acid through species of soil microorganisms.

Data in Table (2) revealed that the effect of different sources of foliar spray fertilizers and soil application of sulfur on the availability of phosphorus

at the end of experiment (the mean of two seasons). Different sources of foliar spray fertilizers have low significant effect on P availability due to the application of FYM alone. On the other hand, sulfur application was significantly increased the availability of P more than all treatments and increasing P availability by 135 % than the control. This may be due to reducing pH value as a result of the effect of sulfur application. Data in Table (2) also indicated that the availability of Fe, Mn and Zn in soil were slightly significantly increased compared to the control treatment in case of applying different sources of foliar spray fertilizers with application of FYM.

Table (2) Effect of different treatments on available phosphorus and some micronutrients (Zn, Fe, Mn) in soil.

Treatments	P ppm	Zn ppm	Fe ppm	Mn ppm
Cont	8.73b	0.469b	2.960ab	1.465ab
Mineral	10.66ab	1.484ab	3.920ab	2.436ab
Hormone	10.71ab	1.480ab	3.554ab	2.520ab
chalet	10.84ab	1.488ab	3.828ab	2.481ab
S	20.59a	3.038a	16.758a	8.439a

On the contrary, there was positive increase of the above mentioned micronutrients in the case of treated soil with sulfur such increase were significant when compared to all treatments. These results may be attributed to the biochemical oxidation of S produces H_2SO_4 which decrease soil pH in calcareous soil and make soil conditions more favorable for increasing the availability of phosphorus (**El-Tarabily et al., (2006)**). Also, soil pH affected the availability of micronutrients such as Fe, Mn and Zn which were more available at lower pH than most nutrients.

2-Effect of the different treatments on some growth parameters, yield and yield components of maize plant (average the two experimental seasons 2009/2010).

Data presented in Tables (3&4) showed that the different sources of foliar spray fertilizers and application of elemental sulfur to soil in the presence of FYM were improved some plant characters and yield as well as yield components of maize. Whereas,

stem circumference (cm), 100 seed weight (gm), grain yield (ton fed⁻¹), ear length (cm), number of row/ear, number of seed /row, ear circumference (cm) as well as relative increasing yield (RIY) were increased significantly as compared to the control treatment.

Whereas, data in Table (3) showed considerable increasing of plant height(cm), leaf area (L.A) cm², Ear height cm, and the period to produce 50 % silk (desirable phenomenon and indicate on early maturity of maize plant) for all treatments when comparing with control.

However, the positive increasing values of growth parameters of maize plant due to applied the treatments could be arranged in ascending order hormone spray < mineral spray < soil application of sulfur < chelating spray. The data also showed that, the period from planting to produce 50 % silking was decreased significantly in descending order as following hormone spray treatment > the mineral spray treatment > soil application of sulfur treatment > chelating spray treatment.

Table (3). Effect of different treatments on some growth parameters of maize plant (average the two experimental seasons 2009/2010).

Treatments	Plant height cm	L.A cm ²	Ear height cm	No. Of days to produce 50 % silking
Cont	260.13d	805.5c	123.8e	62.63a
Mineral	291.50b	890.7a	139.1c	61.38b
Hormone	281.25c	840.1b	135.2d	62.38a
Chalet	304.38a	898.5a	148.1a	60.38c
S	293.88b	906.3a	141.7b	60.88bc

Values within the same column with a common letter do not differ significantly (p=0.05).

*L.A leaf area

On the other hand, the difference between the highest values of growth parameters of maize plant due to applying chelating spray and soil application of sulfur were significantly. The corresponding values were increased by about 17% and 12.9 for height plants and 19.6% and 14.5% for ear height when applied chelating spray treatment and soil application of sulfur treatment, respectively. On the contrary, the value of leaf area of maize plant was increased by 12.5 and 11.5 for soil application of sulfur and chelating spray, respectively and the difference between them was not significant. **Patel and Singh (2010)** reported that the multi-micronutrients mixture (foliar or soil application) facilitate the application of the wide range of plant nutrients in the proportion and to suit the specific requirements of a crop in different stages of growth. Crop system and foliar application of micro nutrients enhance crop productivity and improve quality of different plant (**Hedge et al., 2007**).

Also, data in Table (4) showed that the highest grain yield was obtained with the treatments of chelating foliar spraying and the application of sulfur which gave 4.95 and 4.82 ton fed⁻¹, respectively, being the difference between them was not significant. Also, the relative increasing yield (RIY) which was obtained at the same treatments was 39.5 and 38.2 %, respectively. This is may be due to increasing the amount of nutrients (micro) from chelating spray than the other sprays and also due to sulfur application. On the other hand, both mineral spraying and hormone spraying were ascertained an increasing of RIY by about 35.6 and 35.1 % than the control, respectively. **Yassen et al., (2010)** reported that spraying wheat plants with micronutrients either as a single nutrient or as the possible combination markedly increased grain yield. **Farshad and Malakooti (2000)** reported that in Karay country the effect of K and micro-element were increasing significantly maize yield.

Table (4) Effect of different treatments on Yield and yield components of maize plant (average the two experimental seasons 2009/2010).

Treatment	Stem circu cm.	seed weigt ht	Ear lengt h Cm	No. of row / Ear	No. of seed /row	Ear circu cm	Grar n yield Ton/ food	RIY
Cont	5.89d	37.7d	19.88e	12.56c	45.38c	16.11c	3.00c	-
Mineral	7.95b	40.5c	22.25c	13.44b	48.50a	17.01b	4.56b	35.6
Hormone	7.25c	40.4c	20.88d	13.31b	47.25b	16.38c	4.51bc	35.1
Chalete	9.41a	45.3a	25.13a	14.69a	49.38a	17.66a	4.95a	39.5
S	8.94a	43.1b	23.50b	14.06ab	48.75a	17.03b	4.82a	38.2

Values within the same column with a common letter do not differ significantly (p=0.05)

3- Effect of different treatments on the concentration and uptake of phosphorus and some micronutrients (Fe, Zn, Mn) by maize plant:

Data in Table (5) revealed that the treatments of foliar spray fertilizers as well as soil application of sulfur were enhanced the concentrations and uptake of P and some micronutrients (Zn, Fe, Mn) in maize plant over the control. This result indicated an increase in the micronutrients use efficiency due to the application of foliar spray fertilizers and sulfur application. Application of sulfur and FYM gave significantly values the concentration and uptake of P in plant. **Ali, et al (2007)** reported that FYM combined with S enhanced leaf mineral content. Also, uptake of P due to the application of sulfur was enhanced by 98% than the control. While, uptake of P was increased by 55.8%, 48% and 60% for foliar spray fertilizers with mineral, hormone and chalet, respectively than the control. The highest plant P content may be due to the acidified soil caused by decomposition of FYM and S application.

On the other hand, application of foliar spray fertilizers increased significantly the uptake of Zn, Fe, Mn. Whereas, the uptake values of Zn in plant increased by about 189%, 95% and 193% for mineral, hormone and chalet than the control, respectively. While the foliar spray fertilizers treatments improved the uptake of Fe and Mn by plant, the corresponding values were 34%, 13%, 34.3% for Fe as well as the uptake of Mn increased by 14%, 6% and 21% for mineral, hormone and chalet than the control, respectively. However, application of elemental sulfur positively affected Zn, Fe, Mn concentration and uptake. Where, the values of uptake were increased by about 185% for Zn, 31.7 for Fe and 30% for Mn than the control. Whereas, the highest uptake values of plant Zn, Fe, Mn due to the application of foliar spray fertilizers treatments were not only for the action of FYM but also for immediately response to applying nutrients during the leaves.

Table (5) Effect of different treatments on the concentrations and uptake of phosphorus and some micronutrients (Fe,Zn,Mn) by maize plant.

Treatments	Concentration			
	P mgg ⁻¹	Zn μgg ⁻¹	Fe μgg ⁻¹	Mnμgg ⁻¹
Cont	2.021d	30.566d	77.81d	49.009e
Mineral	2.996c	79.891b	112.633b	82.344c
Hormone	3.005c	50.026c	91.338c	72.314d
Chalet	3.256b	89.218a	119.728	90.328a
S	3.976a	90.415a	114.201ab	85.516b
Uptake (mg/Kg)				
Treatment	P	Zn	Fe	Mn
Cont	14.990d	312.099d	2984c	1135d
Mineral	23.355b	902.773ab	4007a	1299b
Hormone	22.201c	609.314c	3382b	1204c
Chalet	23.913b	916.799a	4010a	1438a
S	29.725a	891.736b	3931a	1479a

Values within the same column with a common letter do not differ significantly (p=0.05).

4-Profitability assessment:

Data in Table (6) showed profitability calculations for the input values for different

treatments under study, considering the appraisal of all costs and gains of cultivation process.

Table (6): Input production items and output of the experimental work .

Items	Treatments Maize	Treatment Unite	Unite Price (L.E)
Inputs:			
Foliar spray fertilizers			
1-Mineral compound			
Zinc sulphate g/L	1.2	Kg ZnSO ₄ fed ⁻¹	5
Ferrous sulphate g/L	1.2	KgFeSO ₄ fed ⁻¹	5
Manganese sulphate g/L	1.2	KgMnSO ₅ fed ⁻¹	5
2-Hormone compound			
2ml/L	2.4	L(Hormone)/ fed ⁻¹	30
3- chelating compound			
Zinc sulphate 2ml/L	2.4	L ZnSO ₄ fed ⁻¹	50
Ferrous sulphate 2ml/L	2.4	LFeSO ₄ fed ⁻¹	50
Manganese sulphate 2ml/L	2.4	LMnSO ₅ fed ⁻¹	50
Mineral fertilizer			
S	300	Kg Sfed ⁻¹	0.95
N	120	KgNfed ⁻¹	8.95
P	45	KgP ₂ O ₅ fed ⁻¹	3
K	24	KgK ₂ Ofed ⁻¹	12
Farmyard manure	20	M ³ fed ⁻¹	42
Seeds	12	Kg fed ⁻¹	8.5
Land preparation*		Per fedan	180
Labour for foliar fertilizers		Per fedan	675
Labour for sulfer treatments			315
Pesticides		Per fedan	180
Other costs**			285
Outputs			
Maize grain yield		Ton	1100

*Rent of agricultural machines

** Depreciation rate of pumping machine,....et, electric consumption, irrigation and drainage systems conservation, tax transportation of seeds, fertilizers,etc.

Total input costs, outputs, net income and investments ratio (I.R) for all tested treatment /were presented in table (7).

The obtained results and their discussion will be handled as follows:

Table (7): Economical assessment for the tested variables (elemental sulfur and foliar fertilizers).

Treatment	Average yield Tonne d ⁻¹	Total Outputs L,EFed ⁻¹	Total inputs L,EFed ⁻¹	Net income L,E fed ⁻¹	IR*
Cont	3.50	3300	2274	1026	1.3
Mineral	4.56	5016	3726.2	1289.8	1.3
Hormone	4.51	4961	3780.2	1180.8	1.3
Chalet	4.95	5445	4068.2	1376.8	1.3
S	4.82	5302	3633.2	1668.8	1.5

Data presented in Table (7) showed that the highest net income was obtained when the FYM was applied at rate of 20 m³ /fed combined with elemental S. The representing net income was descending as 1668.8, 1376.8, 1289.8, 1180.8 and 1026 for application of S, chalet, mineral, hormone and control. In the same manner the IR arranged. Also, results revealed that the lowest value of the control treatment for total input was always related to the absence of foliar spray fertilizers, S and farmyard manure application.

On the other site, the application of S combined with FYM was ascertained the lowest input and highest output than the application of foliar spray fertilizers. It was obvious from the previous data that the application of foliar spray fertilizers becomes the highest costs and lower return.

Conclusion

On the basis of the presented data and under the same of experimental conditions, data revealed that the application of elemental sulfur combined with farmyard manure enhanced some growth characters

of maize plant and increased the grain yield by about 38.2% than the control. Not only that, but data indicated that the application of elemental sulfur combined with farmyard manure significantly improved some physical- chemical properties, i.e. aggregation size stability, hydraulic conductivity, decreased pH value and increased available P and microelements (Zn, Fe, Mn). The use of foliar fertilizers also gave a high productivity of grain yield but chalets are rarely economically feasible for low-value crops such as maize. These results were incorporated with the height crop yield and net income and investment ratio. Further and more detailed studies are needed for applied elemental sulfur integrated with FYM and foliar mineral fertilizers in order to formulate a better guideline for combining elemental sulfur, the farmyard manure and foliar mineral fertilizer application.

Corresponding author

Azza R. Ahmed

Soils, Water and Environ. Res. Inst., Agric. Res. Center, Giza, Egypt

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