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The Effect of Sulphur and Foliar Manganese Applications on Soybean (*Glycine max L.*) Yield and Its Main Component

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TWO FIELD trails were carried out at Shandaweel, Agric. Res. Station, during the growing seasons 1999 and 2000 to evaluate the effect of different applications of sulphur (0, 60, 90 and 120 kg. sulphur /fed.) and manganese foliar (0, 200 and 400 g Mn/fed.) on yield , nodulation, plant growth, nitrogen %, protein content, phosphorus%, oil % and potassium % of soybean (*Glycine max* L.). The spilt plot design with four replications were used , sulphur treatments were in the main plots and manganese foliar applications in the sub-plots. The response to treatment varies with the levels of sulphur and manganese foliar application. The interaction effect between S and Mn-foliar was significant effect on dry matter yield (g/plant), number of branches, nodules number/plant and seeds yield (kg/fed.). The highest value of N,P,K content and consequently protein content and oil percent was obtained in the treatment received the highest levels of S and Mn. On the other word, it can be recommended to add 90 kg S/fed. and 400 g Mn/fed. to produce the highest rate of soybean seeds/fed.

Soybean (*Glycine max* L.) is one of the most important pulse crops in the world. Soybeans contribution to the Egyptian agriculture , as they represent a rich source of oil and protein for human and animal consumption. Sulphur as phosphorus nutrients considered of special importance for leguminous plant due to their essentiality in amino and nucleic formation and protein metabolism (Ibrahim & Mahmoud,1989 and Mohamed *et al.*, 2001). Foliar application technique as a practical way to supply trace elements could avoid these factors and resulting in rapid micronutrients absorption. The foliar application of manganese increased the growth nodulation and NPK content in soybean and bean plants (Haroun *et al.*, 1978 and Mohamed, 1998).

The objective of this study was to examine the effect of different levels of sulphur and Mn foliar application on growth measurements, nutrients content and yield of soybean plants.

Material and Methods

Two field experiments were conducted in Shandaweel Agricultural Research Station, Sohag Governorate, Egypt, during the growing seasons of 1999 and 2000, on a sandy clayey loamy soil. The soil of site had a pH 7.7, EC=0.47 dSm-1, organic matter = 1.05 %, total N = 582 ppm, available P=7.6 ppm and available K=294 ppm. The above measurements were determined following universal methods.

A split plot design with four replications was used, sulphur application in the main plots and manganese foliar treatments in the sub-plots. Analysis of variance and comparison between means were made according to Spiegel (1961).

Levels of main and sub-treatments were as follows:

1- Sulphur application

S1	Control
S2	60 kg S/fed.
S3	90 kg S/fed.
S4	120 kg S/fed.

2- Foliar treatments of manganese.

Mn1	Control
Mn2	200 g Mn/fed.
Mn3	400 g Mn/fed.

Sulphur treatments were thoroughly mixed with the surface soil during the soil preparation. Foliar application of manganese chelate was added after 45 days of sowing and before flowering soybean seeds (*Glycine max* L.) were sown and recommended rates of phosphate and potassium fertilizers were added before sowing.

A basic rate of recommended nitrogen fertilizers dose (15 kg N/fed.) belong to legume was added to active nodulation bacteria.

Agricultural practices were made at the recommended levels. After 60 days of sowing, plant samples were collected and prepared to analysis. Data of nodulations and their dry weights were calculated as square roots before statistical analysis. All the area of each plot was harvested and seed & straw yields were recorded. Plant samples either straw or seeds were analyzed for nitrogen, phosphorus and potassium. Determination of NPK in plants was performed following the standard methods reported by Page *et al.* (1982). Total protein was calculated by multiplying the value of total nitrogen by 6.25.

Results and Discussion

1. Growth measurements

Data of dry matter/plant, plant height, number of branches and number of pods as influenced by both factors sulphur and manganese applications are presented in Table 1. Data reveal that in the absence of Mn-foliar applications,

dry matter yield /plant, plant height, number of branches and number of pods/plant raised by about 39%, 28%, 39% and 56% respectively, due to increasing S rate up to 90 kg/fed. over the control in both seasons. The rate of increment was significant in all growth measurements, which reflect the high response of sulphur level. Data also show that sprayed Soybean plant with manganese had a significant effect on growth measurements. The rate of increase in dry matter yield /plant, plant height number of branches and number of pods/plant due to the increase of Mn-foliar applications from o to 400 g / fed were 8%, 16%, 10% and 25%, respectively. On the other hand, the increase of growth measurements due to the interaction between both studied factors (S rates and Mn-folair applications) was significant effect on both dry matter & number of branches and non significant on numbers of pods and plant height. The results obtained from this study indicated a clear positive effect of S and Mn-foliar levels on Soybean plant growth. This finding is in agreement with Gendy *et al.* (1997), Mohamed (1998) and Mohamed *et al.* (2001).

TABLE 1. Effect of sulphur and manganese foliar applications on growth measurement of soybean plants.

Treat.	1999				2000			
g	0	60	90	120	0	60	90	120
Mn/	S/fed.							
Fed.	Dry matter (g/plant)							
0	8.90	11.1	14.58	12.38	8.98	10.68	14.48	12.30
200	9.63	12.78	16.25	13.58	9.73	12.13	15.78	13.48
400	9.65	14.85	17.73	14.4	10.08	13.78	17.33	14.28
L.S.D	S = 0.4437		Mn = 0.3843		S = 0.2168		Mn = 0.1877	
5%	S x Mn = 0.7686				S x Mn = 0.3754			
	Plant height (cm)							
0	58.75	67.25	85.00	87.25	61.50	66.25	82.50	81.0
200	63.50	70.50	91.50	96.00	64.50	71.25	88.75	91.00
400	69.50	81.75	89.75	10.20	69.50	76.25	92.00	98.75
L.S.D	S = 3.453		Mn = 2.991		S = 1.802		Mn = 1.561	
5%	S x Mn = N.S				S x Mn = 3.121			
	No. of branches							
0	1.10	1.43	1.86	1.95	1.13	1.38	1.78	1.93
200	1.16	1.50	1.91	2.15	1.20	1.50	1.87	2.10
400	1.22	1.65	1.96	2.35	1.23	1.55	1.98	2.30
L.S.D	S = 0.0498		Mn = 0.0341		S = 0.0389		Mn = 0.0337	
5%	S x Mn = 0.0863				S x Mn = 0.0674			
	No. of pods							
0	12.98	16.78	30.95	28.85	13.35	16.38	29.25	23.65
200	14.93	17.83	35.73	26.08	14.38	18.00	31.21	27.83
400	17.15	19.60	37.50	29.75	16.10	19.55	32.70	29.03
L.S.D	S = 2.168		Mn = 1.877		S = 1.277		Mn = 1.106	
5%	S x Mn = N.S				S x Mn = N.S			

2. Nodulation

Data presented in Fig. (1 and 2) reveal that a significant relation existed between sulphur levels and number of nodules and their weight formed on the roots of soybean plants. The increase in number of nodules and their weight was associated with the increase S level up to 90 kg/fed. in both seasons. The data also reveal that foliar application of manganese has markedly affected the nodulation development on soybean roots in a direct correlation. The rate of increase in nodulation due to increase Mn foliar levels were significant in both seasons. Concerning the interaction between S and Mn rates, data in Fig.(1) show that the increase in number of nodules was significant. Values of dry weight of nodules /plant followed the same trend of the nodules numbers, for all experimental variables . No worthy alterations could be mentioned which indicate that nodules dry weight directly reflected their numbers without any specific role of the introduced treatments in either parameter apart. These results are in agreement with Abo El-Zahab *et al.* (1981), El-Essawi & Abadi (1983) and Mohamed *et al.* (1999 & 2001).

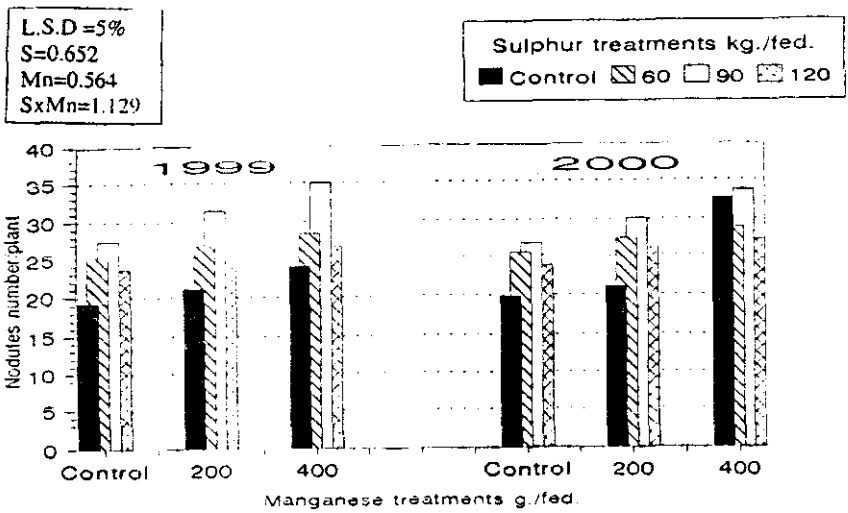

Fig. 1. Effect of sulphur and manganese foliar applications on noclules number / plant.

3. Yield and plant mineral constituents

Data on seeds and straw yields of soybean were presented in Table 2. The composition of different nutrients along with yield was shown in Tables (3, 4 and 5).

a- Yield

A significant increase in seeds and straw yield of soybean was observed with increasing application rates of sulphur and manganese up to a certain level, after which additional application increased the seed yield insignificantly in both

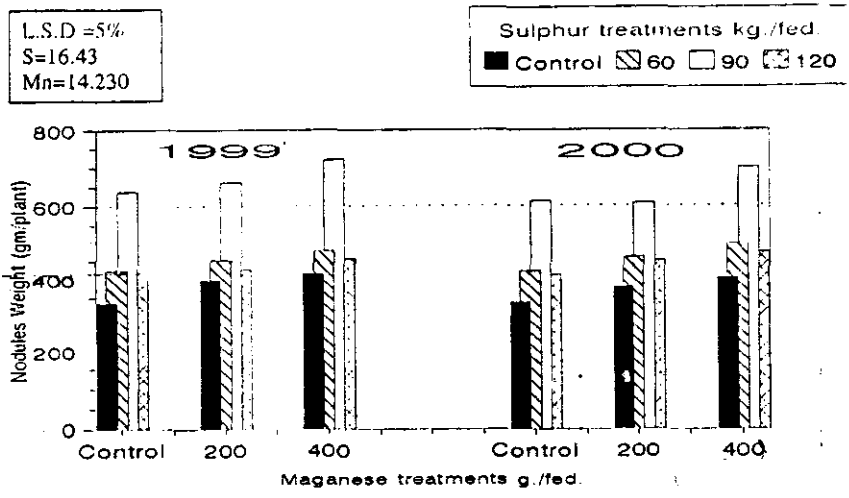

Fig. 2. Effect of sulphur and manganese foliar applications on noclules weight (g. / plant.

seasons. The interaction between sulphur and Mn-foliar application slow significant effect on both seeds and straw yields. In the absence of Mn-folair application, the yield increased with increasing the rate of sulphur addition, the same trend was also observed when Mn-foliar application applied the level of manganese (400 g/fed.) was sufficient to produce the best level of both seed and straw yield/fed. The highest seeds yield was produced at 90 kg sulphur/fed. and 400 g Mn/fed. (1359 and 1254 kg/fed. in the two seasons respectively). The highest straw yield was observes at the levels of, 120 kg sulphur /fed. and 400 g Mn/fed. (Table 2). This finding is in agreement with those of Singh & Ram (1989) and Mohamed *et al.* (2001).

TABLE 2. Effect of sulphur and manganese foliar applications on straw and seeds yield (kg/fed.).

Treat.	1999				2000			
g Mn/ Fed.	0	60	90	120	0	60	90	120
	S/fed.							
	Straw yield (kg/fed.)							
0	1292.8	1443.0	1593.2	1701.0	1258.0	1417.7	1591.2	1672.2
200	1305.8	1501.0	1665.7	1799.2	1318.0	1498.7	1627.2	1711.3
400	1391.2	1570.8	1713.5	1941.8	1359.0	1563.7	1689.7	1809.2
L.S.D 5%	S = 25.74 Mn = 22.29 S x Mn = 44.58				S = 15.45 Mn = 13.39 S x Mn = 26.78			
	Seeds yield (kg/fed.)							
0	727.3	878.0	1116.0	909.5	718.2	865.0	1124.0	878.3
200	764.5	926.2	1216.7	942.7	757.5	897.7	1204.5	934.2
400	770.0	961.2	1358.8	994.5	766.3	921.7	1253.5	944.0
L.S.D 5%	S = 24.40 Mn = 21.13 S x Mn = 42.27				S = 14.37 Mn = 12.45 S x Mn = 24.89			

b- Nitrogen and protein contents

Total nitrogen concentration of soybean plants increased significantly with the increase of sulphur and Mn-foliar application up to 90 kg and 400 g /fed. respectively, where the maximum level of N-content was reached (Table 3). The increase in N-content may be related to better nodulation (Zaroug and Munns, 1980). The interaction between sulphur and manganese foliar applications shaved insignificant effect on N% in straw. On the contrary, increasing either sulphur or Mn-foliar rates resulted in significant increase of N% and protein content. On the other hand, values of protein content had the same trend of N% in seeds due to the interaction between S and Mn-foliar treatment.

TABLE 3. Effect of sulphur and manganese foliar applications on N% in plant, seeds and protein content.

Treat.	1999				2000			
g Mn/ Fed.	0	60	90	120	0	60	90	120
	S/fed.							
	N % in plant							
0	1.175	1.245	1.295	1.395	1.110	1.215	1.275	1.390
200	1.250	1.270	1.315	1.430	1.190	1.255	1.295	1.415
400	1.305	1.335	1.395	1.530	1.245	1.295	1.345	1.455
L.S.D 5%	S = 0.029 Mn = 0.025 S x Mn = N.S				S = 0.014 Mn = 0.012 S x Mn = 0.023			
	N % in seeds							
0	5.150	5.300	5.850	6.050	5.050	5.375	5.775	6.125
200	5.350	5.450	5.850	6.260	5.175	5.425	5.840	6.226
400	5.300	5.850	6.000	6.450	5.460	5.825	5.950	6.375
L.S.D 5%	S = 0.151 Mn = 0.1305 S x Mn = N.S				S = 0.0881 Mn = 0.0763 S x Mn = N.S			
	Protein % in seeds							
0	32.20	33.125	36.31	37.815	31.565	32.500	36.095	38.285
200	33.44	34.065	36.31	39.080	32.345	33.895	36.500	38.905
400	33.14	36.560	37.25	40.315	34.125	36.405	37.185	39.845
L.S.D 5%	S = 0.954 Mn = 0.827 S x Mn = N.S				S = 0.264 Mn = 0.228 S x Mn = 0.4564			

c- Phosphorus concentration and oil %

It is clear from the data in Table 4 that increasing sulphur levels had significantly increased P % in seeds and oil %. In contrary, increasing S application had insignificant increase of P% in straw. Increasing Mn-foliar application with no respect to sulphur rate did not exert any significant effect on total P content in straw, while it was significant increase in both P% in seeds and oil %. Concerning, the interaction effect of both S and Mn levels on P content by soybean plant. Data in Table 4 also show that increasing the two parameters had significant increase of P content and oil percent. The highest concentrations of

P in seed and oil was obtained at the highest level of S and Mn in both seasons (Morok and Dev, 1980 and Mohamed, 1998).

TABLE 4. Effect of sulphur and manganese foliar applications on P % in plant, seeds and oil %.

Treat.	1999				2000			
g Mn/ Fed.	0	60	90	120	0	60	90	120
	S/fed.							
	P % in plant							
0	0.205	0.225	0.305	0.390	0.195	0.225	0.305	0.375
200	0.215	0.235	0.365	0.450	0.215	0.221	0.335	0.405
400	0.230	0.355	0.370	0.550	0.230	0.285	0.335	0.465
L.S.D 5%	S = N.S Mn = N.S S x Mn = N.S				S = N.S Mn = N.S S x Mn = N.S			
	P % in seeds							
0	0.695	0.735	0.815	0.935	0.705	0.735	0.795	0.870
200	0.710	0.745	0.850	1.055	0.715	0.745	0.825	0.965
400	0.735	0.800	0.905	1.195	0.735	0.760	0.855	1.010
L.S.D 5%	S = 0.0207 Mn = 0.0179 S x Mn = N.S				S = 0.01001 Mn = 0.0086 S x Mn = N.S			
	Oil % in seeds							
0	15.750	16.25	18.30	19.05	15.70	16.20	18.05	19.15
200	16.050	17.10	18.65	19.80	16.10	17.15	18.35	19.85
400	16.510	17.85	19.15	20.95	16.35	17.70	19.10	20.95
L.S.D 5%	S = 0.2442 Mn = 0.2303 S x Mn = 0.461				S = 0.1093 Mn = 0.0947 S x Mn = 0.1893			

d- Potassium concentration

Potassium concentration was also significantly increased by every successive application of sulphur and Mn-foliar over control (Table 5). Regarding the effect of S rates alone, increasing S to 120 kg/fed. led to increased K% in both seed and straw. As the soil pool of sulphur became concentrated by fertilizer addition, plant uptake increased (Morok and Dev, 1980). The interaction between S and Mn-foliar was significant on K content in both seed and straw.

Conclusion

Generally, the results confirm that yield and nutrients content tended to increase by increasing rates of either sulphur or manganese foliar application. On other word, soybean grown on the alluvial soil of Egypt responded to the application sulphur and Mn-foliar fertilizers. The response is revealed in the increase of growth measurements, nodulation, yield and N, P and K content of soybean. The best rate is 90 kg sulphur/fed. applied to the land during soil

TABLE 5. Effect of sulphur and manganese foliar applications on K% in plant and seeds.

Treat.	1999				2000			
g Mn/ Fed.	0	60	90	120	0	60	90	120
	S/fed.							
	K % in plant							
0	1.445	1.530	1.710	1.920	1.395	1.515	1.705	1.910
200	1.515	1575	1.840	2.150	1.480	1.570	1.775	2.010
400	1.535	1635	1.925	2.350	1.500	1.610	1.890	2.105
L.S.D 5%	S = 0.059 Mn = 0.051 S x Mn = 0.102				S = 0.0118 Mn = 0.0102 S x Mn = 0.0204			
	K % in seeds							
0	1.375	1.440	1.560	1.805	1.345	1.425	1.525	1.695
200	1.415	1.455	1.660	1.895	1.415	1.455	1.595	1.790
400	1.485	1.520	1.670	2.010	1.450	1.495	1.630	1.870
L.S.D 5%	S = 0.0589 Mn = 0.051 S x Mn = 0.098				S = 0.0121 Mn = 0.0105 S x Mn = 0.0210			

preparation and foliation of 400 g Mn/fed. added two weeks intervals during preflowering gave the highest yield and yield components of soybean plants.

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تأثير اضافات الكبريت ورش المنجنيز على محصول فول الصويا ومكوناته الرئيسية

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أقيمت تجربتان حقليتان فى محطة البحوث الزراعية بشندويل بمحافظة سوهاج خلال موسمى ١٩٩٩، ٢٠٠٠ وذلك لدراسة تأثير الاضافات المختلفة لكل من الكبريت والمنجنيز على محصول فول الصويا والعقد البكتيرية ، ونمو النبات ، ونسبة كل من النيتروجين ، والفوسفور ، والبوتاسيوم فى القش والبذور وكذلك نسبة البروتين والزيت فى البذور لنبات فول الصويا.

واستخدم تصميم القطع المنشقة بالتجربه ، حيث كانت معاملات الكبريت فى القطع الرئيسية والمنجنيز فى القطع المنشقة . وقد أوضحت الدراسة أستجابة نبات فول الصويا لكل من اضافة الكبريت والمنجنيز ، وان التأثير المتداخل لكل من الكبريت والمنجنيز كان معنويا على المادة الجافة وعدد الافرع وعدد العقد البكتيرية ومحصول البذور بالكجم/فدان. وكانت اعلى قيم متحصل عليها بالنسبة للنتيروجين ، والفوسفور والبوتاسيوم عند أستخدام اعلى معدل من الكبريت والمنجنيز (١٢٠ كجم كبريت /فدان و ٤٠٠ جم منجنيز /فدان).

وتبين من الدراسة ان احسن معاملة يمكن التوصية بها للحصول على اعلى انتاج من بذور فول الصويا هى ٩٠ كجم كبريت للفدان مع الرش بـ ٤٠٠ جم منجنيز للفدان.