

Effect of Organic Manure and Sulfur Application on Maize (*Zea mays* L.)

Darwish, H. A.

Maize Research Program, Field Crops Res. Inst., A.R.C., EGYPT

ABSTRACT: A field experiment was performed in Gemmiza Agricultural Research Station in 2013 and 2014 seasons and Nubaria Agricultural Research Stations in 2014 season to study the effect of manure and sulfur applications on maize grain yield and other traits. The results showed that the differences due to manure application significantly affected grain yield, plant height and kernels weight. The effect of manure application significantly increased grain yield, where both 10 and 20 m³ of manure treatments gave the highest grain yield at Gemmiza in 2013 season (30.2, 30.5 ardab/fed.), and Nubaria in 2014 season, (31.1 and 33.3 ardab/fed), respectively. Manure application significantly affected on kernels weight, where 20 m³ manure treatment gave the highest value of 100-kernel weight (39.7 g) followed by 10 m³ manure (37.1 g) at Gemmiza in 2013 season. It was noticed that 20 m³ manure treatment gave the highest value of ear length. The application of 10 and 20 m³ manure gave significantly the tallest plants. Significant differences were detected among sulfur application for grain yield. Sulfur application of 200 kg/fed gave more significant means of grain yield. Mean grain yield at Gemmiza in 2013 season for 200 kg/fed sulfur was 32.2 ard/fed compared with 28.5 ard/fad for 100 kg/fed sulfur treatment. At 2014 season, 200 kg/fed sulfur treatment gave 26.2 and 33.6 ard/fed at Gemmiza and Nubaria, respectively. Sulfur application of 200 kg/fed increase ear length with values of 22.2 cm compared with 21.2 and 21.7 cm for the other treatments (100 kg/fed and non sulfur) at Nubaria in 2014 season. Treatment of 200 kg sulfur had the tallest plants in 2014 season with values of 225.0 and 220.2 cm at Gemmiza and Nubaria, respectively. Manure-by-sulfur interaction significantly affected 100-kernel weight at Gemmiza location in 2013 and 2014 seasons, ear length and ear height at Nubaria location in 2014 season. Generally, manure and sulfur application increased 100-kernel weight at 2013 and 2014 seasons. Also, 20 m³ manure with 200 kg sulfur treatment gave significantly the highest value of ear length at Nubaria region in 2014 season (22.7 g).

Keywords: *Zea mays*, Maize, Organic manure, Sulphur, Nubaria, Gemmiza.

INTRODUCTION

Continuous use of fertilizers creates potential polluting effect in the environment (Oad *et al.*, 2004). Synthesis of chemical fertilizers consumes a large amount of energy and money. However, an organic farming seems to be possible solution for these situations (Prabu *et al.*, 2003). Farming practices which involve heavy application of chemical fertilizers may cause depletion of certain nutrients in soil and certain others would generally accumulate in excess resulting in nutrient imbalance which affects the soil productivity. Some of these problems can be tackled by using bio-fertilizers, which are natural, beneficial and ecologically friendly. In agricultural production, organic manure and bio-fertilizer play an important role to possess many desirable soil properties and exerts beneficial effect on the soil physical, chemical and biological characteristics. Manure can substitute for inorganic N fertilizer and can mitigate potential soil deterioration under irrigated corn (*Zea mays* L.), (Ardell *et al.*, 2015). Fresh manure decreased corn emergence by 9.5% compared with the unamended, non fertilized control treatment. Applied manure increased maize grain yield and biomass at tasseling. The application of organic matter as a strategy to boost maize production can be increased up to 140% relative to treatments without organic matter application (Bernard *et al.*, 2016). These

relatively low responses to the application of organic matter are related to the low nitrogen recovery by a following crop. The combined application of organic matter and fertilizer can easily lead to 200 to 400% increases in maize grain yield relative to an unamended control and give absolute yield increases easily exceeding 2000 kg grain ha⁻¹.

The importance of sulfur in a fertilizer program for corn has been the focus of diverse research projects conducted over several years at various locations. Sulfur availability indicators are necessary for rational use of sulfur fertilizers (Agustin and Echeverria, 2011). Broadcast application of sulfur in a band near the seed at planting has proven to be satisfactory in most production situations (George and Clapp, 2008). Sulfur application significantly increased grain yield, total biomass, sulfur concentration and nitrogen concentration in total biomass. Sulfur deficiency symptoms are more often observed in crops at early stages of growth since sulfur can be easily leached from the surface soil (Kiyoko, *et al.*, 2005). Significant response to sulfur was shown by maize in all experiments. A response curve for sulfur showed that 5 to 10 kg/ha of Sulfur was optimal, with mean yield response ranging from 90 to 142 kg grain/kg sulfur (Ray and Mughogho, 2000). Sulfur application significantly increased grain yield of maize, and also increased total biomass (Agustin and Echeverria, 2011).

This study is carried out to determine the effect of manure and sulphur application on maize grain yield and other traits at two different environments.

MATERIALS AND METHODS

A field experiment was performed in Gemmiza Agricultural Research Station in 2013 and 2014 seasons and Nubarria Agricultural Research Station in 2014 season to study the effect of organic manure and sulfur applications on maize grain yield and other traits. Organic manure treatments were 10 and 20 m³/faddan, while the rates of sulfur were 200 and 400 kg/faddan, in addition to treatment of zero application (control). Manure and sulfur were applied during soil preparation for cultivation at the plowed layer before planting. Maize variety SC.167 was used at this study. Soil samples were collected before planting and analyzed for some physical and chemical properties (Table 1). Also, samples of organic manure were analyzed according to Black (1982) and the most important characteristics are shown in Table (2). Farmacyard organic manure was produced at Nubarria and used at both locations. The experimental design was split-plot with four replications. Manure treatments were randomly assigned to the main-plots, while sulfur treatments were randomly assigned to the sub-plots. Sowing date was in the first of June at both locations. Plot size was four rows, 6 m long and 80 cm apart and hills were spaced 20 cm along the row. Data were collected for number of days to mid-silking (silking date), plant and ear heights (cm), ear length (cm), 100-kernels weight (g) and grain yield (ardab/faddan). Ears per plot were weighed and about five kg/plot were taken for moisture percent determination. Grain yield was expressed as ardab/faddan (ard/fad⁻¹) at 15.5% moisture content. The obtained data were statistically analyzed according to Steel and Torrie (1980), using SAS software (1997).

Table (1). Physical and chemical analysis of the field experiment at Gemmiza and Nubaria, during 2014 season.

Variables	Nubaria	Gemmiza
Clay %	22.00	45.8
Silt %	28.50	21.5
Sand %	49.50	35.1
Texture	Sand clay loam	Clay
pH	8.2	8.3
Available N (mg/kg)	33.8	41.1
Available K (mg/kg)	119	198.5
Available P (mg/kg)	4.97	15.5

Table (2). Physical and chemical analysis of organic manure used in this study at Gemmiza and Nubaria.

Character		Value
Bulk density	kg/m ³	736
Moisture content	%	9.6
pH		7.4
EC (1:10 water extract)	dS/m	2.75
Organic matter	%	73.78
Organic carbon	%	43.40
C/N ratio	%	19.91
Total N	%	2.18
Total P	%	0.47
Total K	%	1.24
Available N	(mg/kg)	223
Available P	(mg/kg)	259
Available K	(mg/kg)	860

RESULTS AND DISCUSSION

1. Manure effects

The results in Table (3) showed that the application of manure fertilizer treatments were significantly affected the grain yield and plant height during 2013 and 2014 seasons at Gemmiza and Nubaria region at 2014. Significant differences were observed for ear height and kernels weight at Gemmiza 2013 season, as well as ear length and ear height at Nubaria 2014 season. Application of manure fertilizer increased plant height and grain yield. The positive effect of manure on plant growth might be attributed to its role in improving soil structure through aggregate formation, hydraulic properties and also through providing plants with some of their needs from macro and micro-elements. These results are in agreements with those obtained by Abou El-Maged *et al.*, (2008), Abd El-Wahed, (2009), Ahmed *et al.*, (2011) and El-Mekser *et al.*, (2014). The results in Table (4) showed that the manure application significantly increased grain yield, where both 10 and 20 m³ of manure treatments gave the highest mean grain yield at Gemmiza in 2013 season and Nubaria in 2014 season compared with non application of manure

(30.2, 30.5, 31.1 and 33.3 ard/fad, respectively, compared with 25.9 and 28.1 ard/fad. In Gemmiza in 2014 season, 20 m³ manure treatment gave significantly higher at value of grain yield (26.7 ard/fad) compared with the other two treatments (24.5 and 24.7 ard/fad). At Gemmiza in 2013 season, manure application had significant affect on kernels weight, where 20 m³ manure treatment gave the highest value of 100-kernel weight (39.7 g) followed by 10 m³ manure (37.1 g) compared with 35.3 g for no manure added (Table 4). Regarding ear length, at both locations in 2014 season, manure application increased ear length, where 20 m³ manure treatment gave the highest value of ear length (21.5 and 22.2 cm) compared with the other treatments. Also, the application of 10 and 20 m³ manure to maize plant gave significantly the tallest plants at Gemmiza in 2013 season (238.3 and 236.2 cm) compared with 227.9 cm with non manure added (control treatment), (Table 4). In 2014 season, at both locations, the treatment of 20 m³ manure gave significantly the tallest plants (224.6 and 221.7 cm), while, 10 m³ manure treatment was not significantly different from no application at Gemmiza and Nubaria. At Gemmiza in 2013 season and Nubaria in 2014 season, manure application of 20 m³ gave significantly increased of mean ear height (139.2 and 125.7 cm) compared with the other treatments, although 10 and 20m³ manure treatments didn't significant differe at Nubaria in 2014 season (124.7 and 125.7 cm). Results showed that manure application didn't affect number of days to mid-silking at both locations.

Table (3). Mean square for grain yield and other traits of three manure and three sulfur treatments at Gemmiza during 2013 and 2014 and Nubaria during 2014.

S.O.V.	df	Grain yield	100-Kernel weight	Ear length	Silking date	Plant height	Ear height
Gemmiza-2013							
Replications(Rep)	3	10.96	0.32	1.62	0.37	19.44	3.56
Manure (Man)	2	77.45**	57.03**	3.73	1.03	364.58*	136.11*
Rep x Man	6	0.56	2.88	1.75	0.40	36.80	16.67
Sulfur (Sul)	2	1118.19**	15.53**	0.27	0.19	14.58	21.53
Man x Sul	4	5.82	7.48**	0.54	0.07	47.92	17.36
Error	18	2.85	1.61	1.12	0.33	19.21	17.82
Gemmiza-2014							
Replications(Rep)	3	1.18	3.95	0.17	0.62	90.47	86.11
Manure (Man)	2	17.48*	9.48	2.46	0.08	118.75**	71.53
Rep x Man	6	2.15	6.82	0.53	0.23	20.60	68.75
Sulfur (Sul)	2	12.51*	12.46	0.01	0.08	133.33**	96.53
Man x Sul	4	0.78	35.68*	0.48	0.29	42.71	10.07
Error	18	2.18	9.61	1.07	0.22	21.06	34.26
Nubaria-2014							
Replications(Rep)	3	10.35	12.47	0.08	0.63	21.63	5.70
Manure (Man)	2	79.27**	7.88	2.07*	3.69	499.53*	93.25*
Rep x Man	6	7.52	5.72	0.33	1.55	87.71	9.40
Sulfur (Sul)	2	26.72*	32.47*	2.54*	1.03	197.44	93.00*
Man x Sul	4	2.88	19.27	2.44*	0.94	46.36	106.75**
Error	18	7.47	7.41	0.47	0.60	61.13	19.16

2. Sulfur effect

Significant and highly significant differences were detected among sulfur application treatments for grain yield at both seasons in Gemmiza and Nubaria locations (Table 3). Also, plant height was affected by sulfur application at Gemmiza location in 2014 season. Significant differences were observed at Nubaria location on 2014 season for ear height, ear length and 100-kernel weight. Manure-by-sulfur interaction was significant on 100-kernel weight at Gemmiza location in 2014 season, ear height and ear length at Nubaria in 2014 season.

Table (4). Averages of grain yield and other traits for manure and sulfur treatments at Gemmiza during 2013 and 2014 and Nubaria during 2014.

Treatment	GrainYield (Ardab/fed.)	100- Kernel weight(g)	Ear Length (cm)	Silking date(day)	Plant height (cm)	Ear Height (cm)
Gemmiza-2013						
Manure (m³/fed.)						
0	25.9b	35.3c	20.8	60.2	227.9b	133.3b
10	30.2a	37.1b	21.6	60.5	238.3a	133.3b
20	30.5a	39.7a	21.8	59.9	236.2a	139.2a
LSD_{0.05}	0.7	1.7	Ns	Ns	6.0	4.1
Sulfur (kg/fed.)						
0	25.9c	36.3b	21.3	60.1	233.3	133.7
100	28.5b	37.2b	21.6	60.2	233.7	136.2
200	32.2a	38.6a	21.4	60.3	235.4	135.8
LSD_{0.05}	1.4	1.1	Ns	Ns	Ns	ns
Gemmiza-2014						
Manure (m³/fed.)						
0	24.5b	42.0	20.6b	62.3	218.3b	137.1
10	24.7b	43.4	21.0ab	62.4	221.1ab	136.3
20	26.7a	43.7	21.5a	62.5	224.6a	140.8
LSD_{0.05}	1.5	Ns	0.7	Ns	4.5	ns
Sulfur (kg/fed.)						
0	24.2b	42.5	21.1	62.4	218.3b	135.8b
100	25.5a	42.3	21.0	62.5	221.7ab	137.1ab
200	26.2a	44.2	21.1	62.3	225.0a	141.3a
LSD_{0.05}	1.2	Ns	Ns	Ns	3.9	5.0
Nubaria-2014						
Manure (m³/fed.)						
0	28.1b	34.6	21.4b	62.1	209.3b	120.5b
10	31.1a	37.1	21.5b	62.0	218.6ab	124.7a
20	33.3a	38.1	22.2a	61.1	221.7 a	125.7a
LSD_{0.05}	2.7	Ns	0.6	Ns	9.3	3.1
Sulfur (kg/fed)						
0	28.2b	35.5b	21.2b	61.7	212.2b	121.2b
100	30.8ab	37.5ab	21.7b	62.0	217.3ab	123.1ab
200	33.6a	38.7a	22.2a	61.4	220.2a	126.7a
LSD_{0.05}	4.1	2.3	0.6	Ns	6.7	3.7

Results in Table (4) showed that sulfur application of 200 kg/fad gave more significant means of grain yield than the other treatments at Gemmiza and Nubaria in 2013 and 2014 seasons. Mean grain yield at Gemmiza in 2013 season of 200 kg/fed sulfur was 32.2 ard/fad compared with 28.5 ardab/fed for 100 kg/fed sulfur treatments which were significantly higher than no application of sulfur (25.9 ard/fed). In 2014 season, 200 kg/fed sulfur treatment gave 26.2 and 33.6 ard/fed at Gemmiza and Nubaria, respectively, which was not significantly different from 100 kg/fad sulfur treatment (25.5 and 30.8 ardab/fed) at Gemmiza and Nubaria, respectively.

Also, 200 kg sulfur application had significantly heavier 100-kernel weight mean than the other treatments at Gemmiza in 2013 and Nubaria in 2014 seasons (38.6 and 38.7 g), while the treatment of 100kg sulfur didn't significantly differ from no application of sulfur (Table 4). Sulfur application of 200 kg/fad increase ear length with values of 22.2 cm compared with 21.2 and 21.7 cm under the other treatments (100 kg/fad and no sulfur) at Nubaria in 2014 season (Table 4). The same trend was observed for plant and ear heights due to sulfur application at Gemmiza and Nubaria in 2013 and 2014 seasons. Treatment of 200 kg sulfur gave the tallest plants in 2014 season with values of 225.0 and 220.2 cm at Gemmiza and Nubaria, respectively. Also, higher values of ear height were detected due to 200 kg sulfur in 2014 season with values of 141.3 and 126.7 cm at Gemmiza and Nubaria, respectively (Table 4). As shown in Table (3), It was noticed that sulfur application didn't affect number of days to mid-silking date at both tested locations, Gemmiza and Nubaria in 2013 and 2014 seasons.

Significant response of maize to sulfur was shown in all experiments. A response curve for sulfur showed that 5 to 10 kg/ha of Sulfur was optimal, with mean yield response ranging from 90 to 142 kg grain/kg sulfur (Ray and Mughogho, 2000). Sulfur application significantly increased grain yield of maize, and also increased total biomass (Agustin and Echeverria, 2011).

Manure-by-sulfur interaction significantly affected 100-kernel weight at Gemmiza location in 2013 and 2014 seasons, ear length and ear height at Nubaria location in 2014 season. Generally, manure and sulfur application increase 100-kernel weight in both seasons. Treatment of 20 m³ of manure and 200 kg sulfur significantly increased 100-kernel weight more than the other treatments in both seasons, and gave values of 100-kernel weight of about 40.7 and 45.8 g in 2013 and 2014 seasons, respectively (Table 5), while the other treatments gave significantly the lowest values of 100-kernel weight. Also, 20 m³ manure with 200 kg sulfur treatment gave significantly the highest value of ear length at Nubaria (22.7 g) as compared with the other treatments (Table 5). Treatment of 20 m³ manure with 200 kg sulfur gave significantly the highest mean of ear height at Nubaria (134.2 cm) as compared with the other treatments (Table 5).

Table (5). Effect of interaction between manure and sulfur application on some traits at Gemmiza during 2013 and 2014 and Nubaria during 2014.

Treatment		100-kernel weight (g)		Ear length (cm)	Ear height (cm)
		Gemmiza		Nubaria	Nubaria
Manure (m ³ /fed.)	Sulfur (kg/fed.)	2013	2014	2014	2014
0	0	32.7	42.6	21.1	116.2
	100	36.0	40.8	21.1	121.2
	200	37.2	42.6	22.1	124.0
10	0	36.2	39.1	20.3	121.7
	100	37.2	43.9	21.6	126.2
	200	37.7	47.1	22.5	126.2
20	0	38.2	42.3	21.6	121.0
	100	40.0	42.8	22.1	122.0
	200	40.7	45.8	22.7	134.2
LSD_{0.05}		0.6	1.5	0.3	2.1

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الملخص العربي

تأثير اضافة السماد العضوى والكبريت على الذره الشاميه

هاني عبدالعاطي درويش

برنامج بحوث الذرة الشامية - معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية - مصر

أجريت تجربته حقلية في كلا من محطتى البحوث الزراعيه بالجميزه موسمى ٢٠١٣ و ٢٠١٤ والنوباريه موسم ٢٠١٤ وذلك لدراسة تأثير اضافة السماد العضوى والكبريت على محصول حبوب الذره الشاميه وبعض الصفات الأخرى. أجريت التجارب فى تصميم القطع المنشقه فى أربع مكررات وتم قياس صفات محصول الحبوب وعدد الأيام من الزراعة حتى ظهور ٥٠% من الحراير وارتفاعى النبات والكوز ومتوسط طول الكوز بالاضافه الى وزن ١٠٠ حبه .

أوضحت النتائج ما يلى:

- وجود فروق معنوية راجعه الى اضافة السماد العضوى لصفتى محصول الحبوب وارتفاع النبات ووزن ١٠٠ حبه. وقد أدت اضافة كلا من ١٠ و ٢٠ م^٣ للفدان من السماد العضوى الى زياده محصول الحبوب فى الجميزه حوالى ٣٠.٢ ، ٣٠.٥ موسم ٢٠١٣ بينما كان محصول الحبوب حوالى ٢٤.٧ و ٢٦.٧ أردب للفدان موسم ٢٠١٤ ، بينما بلغ محصول الحبوب حوالى ٣٠.٨ و ٣٣.٦ أردب للفدان فى النوباريه موسم ٢٠١٤ .
- أيضا أدت اضافة السماد العضوى بمقدار ٢٠ م^٣ الى زياده وزن ١٠٠ حبه حيث بلغت ٣٩.٧ جم مقابل ٣٧.١ جم لاضافة ١٠ م^٣ من ماده العضويه للفدان.
- أدت اضافة السماد العضوى الى زياده معنويه فى ارتفاع النبات وطول الكوز .
- كما تلاحظ وجود فروق معنويه فى محصول الحبوب راجعه الى اضافة الكبريت.

- أدت إضافة ٢٠٠ كجم للقدان من الكبريت الى زياده معنويه فى محصول الحبوب حيث بلغت حوالى ٣٢.٢ أردب للقدان فى الجميزه موسم ٢٠١٣ بينما كانت حوالى ٢٦.٢ أردب للقدان موسم ٢٠١٤ فى حين بلغ متوسط محصول الحبوب حوالى ٣٣.٦ أردب للقدان فى النوباريه موسم ٢٠١٤.
- أعطت اضافته ٢٠٠ كجم كبريت موسم ٢٠١٤ متوسط محصول حبوب يقدر بحوالى ٢٦.٢ و ٣٣.٦ أردب للقدان فى الجميزه والنوباريه على التوالى.
- أيضا ادت اضافته ٢٠٠ كجم كبريت الى زياده فى طول الكوز حيث بلغ متوسط طول الكوز حوالى ٢٢.٢ سم مقارنة بمتوسط حوالى ٢١.٢ و ٢١.٧ عند اضافته ١٠٠ كجم وعدم اضافته الكبريت على التوالى فى النوباريه موسم ٢٠١٤.
- أدت إضافة ٢٠٠ كجم من الكبريت الى زياده فى ارتفاع النباتات حيث بلغ متوسط ارتفاع النبات حوالى ٢٢٥ سم موسم ٢٠١٤ بالجميزه وحوالى ٢٢٠.٢ سم فى النوباريه.
- كان لتفاعل السماد العضوى مع الكبريت تأثيرا معنويا على زياده وزن ١٠٠ حبه فى الجميزه موسمى ٢٠١٣ و ٢٠١٤ بالاضافه الى صفات طول الكوز وارتفاع النبات فى النوباريه موسم ٢٠١٤.
- عموما أدت إضافة السماد العضوى والكبريت الى زياده معنويه فى وزن ١٠٠ حبه فى النوباريه خلال موسمى التقييم حيث أدت إضافة ٢٠ م^٣ من السماد العضوى مع ٢٠٠ كجم من الكبريت الى زياده معنويه فى طول الكوز فى موقع النوباريه.

