RESPONSE OF POTATO GROWTH, YIELD AND QUALITY TO FARMYARD MANURE, SULPHUR AND GYPSUM LEVELS APPLICATION.

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ABSTRACT

This study was conducted during the two successive summer seasons of 2000 and 2001 at Baramoon Experimental Farm, Dakahlia Governorate, Egypt on potato cv. Spunta. This investigation aims to study the effects of farmyard manure (0 and 12.5 ton/fed.), three levels of sulphur (250, 500 and 750 kg/fed.), and/or gypsum (1.33, 2.67 and 4.0 ton/fed.) and their interactions on growth, tubers yield and their constituents of N, P, K in foliage and tuber, as well as starch and microelements (Fe, Zn, and Mn).

The results indicated that the application of FYM induced significant increases in the vegetative growth parameters (plant height, foliage fresh weight/plant and foliage dry weight %), total tuber yield, number of tubers/plant, tuber average weight, tuber dry matter (%), specific gravity and percentage of starch, the concentration of NPK in foliage and tubers, microelements in foliage (Fe, Mn and Zn) in both growing seasons.

Similarly, plant height, foliage dry weight (%), total tubers yield/fed., number of tubers/plant, tuber average weight, tuber dry matter content, specific gravity and starch content, concentrations of N, P, K in foliage and tubers, microelements concentration (Fe, Mn, and Zn) in foliage were significantly increased by increasing sulphur or gypsum levels, but not significant with number of main stems/plant and foliage fresh weight/plant in both seasons.

The interactions between FYM and sulphur and/or gypsum levels significantly increased plant height, foliage dry weight (%), total tuber yield/fed., number of tubers/plant, tuber average weight, tuber dry matter content, specific gravity and starch content, as well as, concentration of N, P, K in foliage and tubers, microelements concentration (Fe, Mn and Zn) in foliage in both seasons.

Therefore, the best results could be obtained from the application of FYM at the rate of 12.5 ton/fed before planting, in addition to 500 kg sulphur and/or 2.67 ton/fed. gypsum, where, it had gaven the highest vegetative growth, total yield and improved tuber quality parameters.

INTRODUCTION

Potato (*Solanum tuberosum* L.) as a member of the family solanaceae is one of the most important food crops all over the world. Soil reaction is one of the most important factors affecting the availability of nutrients in the soil. Changes in soil reaction caused by liming or by the use of sulphur and acid forming fertilizers may increase the supply of nutrients to plants. Potatoes classified as a very tolerant crop to soil acidity. It grows better at pH 5-6.5 (Lorenz and Maynord, 1980). When the pH is higher than 7 as in case of the most Egyptian soils, many nutrients are most likely to be deficient.

Mengel and Kirkby (1982) found that addition of sulphur to such soils may cause much better soil conditions, i.e. decreasing soil reaction (pH), may increase availability of soil micronutrients and consequently increase potato quantity and quality.

El-Afifi et al. (1990) found that application of sulphur had a positive effect on number of main stems / plant and total tuber yield. El-Etriby (1997) reported that application of sulphur increased plant height, number of secondary stems / plant, fresh weight, dry weight / plant as compared with control. Ali (2002) mentioned that application of sulphur increased vegetative growth, total yield, NPK content in leaves and tubers, starch content (%) in tuber and its specific gravity.

Abdel-Razik and Gabr (1994), Tiwari (1995), Sharma et al. (1987) reported that application of sulphur significantly increased total tuber yield. Karmarkar et al. (1991), Sing et al. (1996), Bhunia and Dandapat (1992) and Eppendrofer and Eggum (1994) found that application of sulphur increased the total dry matter in potato tuber, also, El-Gamal et al. (1990) indicated that the dry matter, starch content and NPK in tubers were increased with increasing sulphur application. Radwan (1997) found that application of sulphur increased NK content in tubers.

Shadid and Moinuddin (2001) found that application of S (as gypsum) with muriate of potash significantly increased tuber yield. Kamar and Omar (1987) found that the gypsum additions reduced the pH value of the soil from (7.79-7.90) to (7.05-6.95), increased the availability of Zn, B and Mn to potato plants and this was reflected on plant growth, total yield, tuber weight and dry matter percentage.

Silva et al. (1991) indicated that mean tuber yields were higher with the combined application of gypsum + KCl. Simmones et al. (1988)

demonstrated that application of gypsum in the field improved grade, size and microelements (Fe, Zn and Mn) concentrations in foliage and tubers. Prakash et al. (1997) found that application of sulphur as gypsum increased the total tuber yield.

Organic fertilizers of which the farmyard manure (FYM) is the principal one, plays an extraordinary role in the cultivation of potato, not only as a source of the nutrients but also as improving agent to the physical and chemical properties of the soil (Sujatha and Krishnappa. 1995).

Several workers have been reported the effect of farmyard manure on vegetative growth characters and yield. Sahota (1983), Arisha and Bardisi (1999), El-Kader (2002) reported that plant height, foliage fresh and dry weight, NPK contents in foliage and tuber, number and weight of tubers / plant, dry weight and total tubers yield / fed., were increased due to FYM application. Also, El-Banna and Abd El-Salam (2000), and Sood et al. (1994) showed that the tubers yield and dry matter increased significantly with application of FYM.

This investigation was suggested to study the response of potato plant to FYM, sulphur and gypsum levels also their interactions on growth, yield and quality.

MATERIALS AND METHODS

This investigation was carried out during the two summer seasons of 2000 and 2001 on potato (*Solanum tuberosum* L.) cv. Spunta at Baramoon Experimental Farm, Dakahlia Governorate, Egypt.

Spunta seed pieces with an average weight of about 50 g per each were planted on rows of 70 cm apart and 25 cm within row.

Seed tubers were planted on January 24th and 29th in seasons of 2000 and 2001, and were harvested on May 24th and 29th, respectively, in both seasons.

Some physical and chemical properties of the experimental soil at the depth of 0-30 cm are shown in Table (1).

Table 1. Some physical and chemical analysis of the experimental soil.

Sand	Silt	Clay	O. M.	$CaCO_3$	pH	Available nutrients (ppm)		
(%)	(%)	(%)	(%)	(%)		N	P	K
24.4	31.2	42.5	1.8	3.5	7.9	24.3	11.5	318

Sulphur and gypsum application:

Sulphur was obtained from Kafr El-Zyat Co. The sulphur percentage in the product was about 99%. Gypsum source was obtained from Abou Zaabal Company, Egypt. The treatments of the two sulphur sources were applied at three rates of 250, 500 and 750 kg sulphur/fed. and 1.33, 2.67 and 4.0 ton gypsum/fed., the sulphur and gypsum were applied before planting at rowing preparation. Table (2) shows the properties of gypsum material.

Table 2. The gypsum material analysis

Properties	Conc.
Purity (%)	80.0
Sulphur (%)	18.60
pH	6.0
Total acidity (meq/100g)	1.70
EC (ds/m) (gypsum pds) extract	4.10
Water soluble phosphorus (%)	0.30
Water soluble Magnesium (meq/100 g)	0.40
Water soluble sodium (meq/100 g)	2.90
Fe (ppm)	0.50
Mn (ppm)	0.20
Cu (ppm)	1.00

Farmyard manure was added at rate of zero (control) and 12.5 ton/fed., before planting at rowing preparation. Table (3) shows chemical analysis of FYM.

Table 3. Chemical analysis of the FYM.

Elements Concentration	Macroelements (%)			Microelements (ppm)		
	N	P	K	Fe	Mn	Zn
Farmyard manure	0.94	0.22	0.82	6.40	3.64	1.50

Mineral fertilizers were added as follows:

1. Ammonium nitrate (33.5% N) was added as three equal sub doses after 3, 5 and 7 weeks from planting date with full dose of 180 kg/fed.
2. Superphosphate (15.5% P_2O_5) was added as only one addition during soil preparation with dose of 75 kg P_2O_5 / fed.
3. Potassium sulphate (48% K_2O) was added after 7 weeks from planting date with dose of 96 K_2O/fed.

The soil was digested as described by Jackson (1967) using a modified Kjeldahl procedure, but, the plant samples were digested using sulfuric and perchloric mixture, Jackson (1967).

Contents of Fe, Mn, Zn and Cu were determined as described in Page et al. (1982) using an atomic absorption spectrophotometer.

Total nitrogen was determined with micro-Kjeldahl method according to Chapman and Pratt (1961). Phosphorus was colorimetrically determined following Jackson (1967). Potassium was determined using a flame photometer as described by Jackson (1967).

The experimental treatments and design:

The experiment included 12 treatments, which were the combinations of three levels of sulphur and gypsum, at rate of 250, 500 and 750 kg sulphur/fed. and 1.33, 2.67 and 4.0 ton gypsum/fed.), as sulphur sources, with or without farmyard manure. Treatments were distributed in a split plot design in randomized complete blocks with 4 replicates. The farmyard manure treatments occupied the main plots, which were subdivided to 3 subplots each contained one of the sulphur and/or gypsum levels. The sub-plot area was 11.25 m^2, 3 ridges each, having 5 m long and 0.75 m width.

The other agricultural practices were applied according to the Ministry of Agriculture recommendations.

Studied characters:

Vegetative growth characters:

At 90 days after planting (DAP), a random sample of 3 plants from each plot was taken to determine plant height (cm), number of main stems / plant, foliage fresh weight (g) and foliage dry weight (%).

Yield data at harvest:

Total tuber yield (ton/fed.), number of tubers / plant and tuber weight / plant were determined.

Tuber quality:

At harvest, random samples of Tubers were dried at 70°C till constant weight for dry matter (%) determination. Specific gravity was determined according to the following equation:-

$$\text{Specific gravity} = \frac{\text{Weight in air}}{\text{Weight in air - weight in water}}$$

Chemical composition:

The mineral content of NPK, Fe, Mn and Zn were estimated by taking a sample of the foliage dry weight at 90 days after planting. NPK estimated in tubers at harvest time.

Percent of starch content in tubers was determined in dry matter according to A.O.A.C (1990).

Data were statistically analyzed and means were compared by using LSD test as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Vegetative growth parameters:

1. Effect of FYM:

Data presented in Table (4) show that application of FYM gave a significant increase in the vegetative growth parameters, i.e. plant height, foliage fresh weight / plant, foliage dry weight (%), while number of main stems / plant was not significantly affected in both seasons. This effect of FYM might be related to its contents organic materials. It may improve the physical conditions of the soil, provides energy for microorganisms activity, increases nutrient supply and improves the efficiency of macro elements as well as its ability to meet some micro nutrient requirements (Cooke, 1982; Sahota, 1983; Tisdale et al., 1985; Kolbe et al., 1995; El-Nagar, 1996; Arisha and Bardisi, 1999; and El-Kader, 2002).

2. Effect of sulphur and gypsum levels:

Data in Table (4) indicated also that plant height and foliage dry weight/plant were significantly increased by sulphur or gypsum levels, while number of main stems/plant and foliage fresh weight were not significantly affected in both growing seasons. The highest values were recorded at adding 500 kg sulphur and 2.67 ton/fed. gypsum in both seasons. These results can be discussed according to gypsum and sulphur decrease the pH of alkaline soil as in our experiment, and in turn increase the availability of minerals in the soil, also, has a beneficial effect on microorganisms in soil media in turn an affect on potato growth. These results agreed with those obtained by El-Etriby (1997) and Ali (2002).

3. The interaction effects of FYM, sulphur and gypsum levels:

The results in Table (4) show that interaction between FYM and sulphur and gypsum levels treatments had significant effects on plant height and foliage dry weight, while insignificant differences has been detected as number of main stems/plant and foliage fresh weight.

Yield parameters:

1. Effect of FYM:

Data in Table (5) show that application of FYM caused a significant increase in total tuber yield/fed., number of tubers/plant, tuber average weight and tuber dry weight (%) in both seasons. The average increase in

total tuber yield/fed., was 26.45 and 22.76% due to FYM application in the first and second season, respectively. These results may be attributed to the role of organic manure in increasing the availability of certain elements and their supply to plant. These results are in correspondence with those obtained by Sood et al. (1994); Kolbe et al., 1995; El-Nagar (1996); Sing et al., 1996; Arisha and Bardisi (1999) and El-Kader (2002).

Table 4. Effect of farmyard manure, sulphur and gypsum and their interactions on vegetative growth during the two summer seasons of 2000 and 2001.

Characters	Plant Height (cm)		No. of main stems / plant		Foliage fresh weight/plant (g)		Foliage dry weight (%)	
Treatments	2000	2001	2000	2001	2000	2001	2000	2001
FYM treatment:								
With	59.67	56.11	2.00	1.83	350.7	338.5	13.26	13.09
Without	48.78	46.06	1.86	1.59	276.4	267.3	12.13	12.02
F-test	*	*	NS	NS	*	*	*	*
Amendments:								
Sulphur levels (kg/fed):								
S_1 : 250	53.33	50.13	1.83	1.67	318.1	307.8	12.16	12.03
S_2 : 500	60.67	57.50	2.22	2.00	324.2	310.3	13.33	13.15
S_3 : 750	54.83	52.00	1.80	1.83	316.0	305.8	12.26	12.11
Gypsum levels (ton/fed):								
G_1 : 1.33	49.17	46.00	1.61	1.33	310.3	295.7	12.75	12.66
G_2 : 2.67	56.50	53.57	1.89	1.83	320.1	299.8	13.10	13.00
G_3: 4.00	51.83	48.10	1.78	1.61	300.8	298.0	12.94	12.85
LSD at 5%	3.95	4.64	NS	NS	NS	NS	0.44	0.41
Interactions:								
With FYM:								
S_1 : 250	61.67	57.33	1.89	1.69	360.0	352.0	12.45	12.24
S_2 : 500	68.67	66.00	2.67	2.33	373.0	358.0	13.95	13.87
S_3 : 750	59.33	57.00	1.89	2.00	360.7	347.0	12.68	12.42
G_1 : 1.33	51.00	47.00	1.56	1.33	332.7	311.7	13.40	13.21
G_2 : 2.67	63.15	58.00	2.11	2.00	346.3	335.0	14.41	14.25
G_3: 4.00	54.10	49.67	1.89	1.67	331.7	327.3	12.75	12.54
Without FYM:								
S_1 : 250	49.00	46.33	1.78	1.67	276.3	263.7	11.87	11.82
S_2 : 500	52.67	49.00	1.78	1.64	275.3	262.6	12.04	12.05
S_3 : 750	50.33	47.00	1.69	1.66	271.3	264.4	11.85	11.80
G_1 : 1.33	47.33	45.00	1.67	1.33	288.0	279.7	12.09	12.11
G_2 : 2.67	49.33	46.67	1.66	1.67	277.7	264.7	12.25	12.25
G_3: 4.00	44.00	42.33	1.65	1.65	270.0	260.8	12.69	12.93
LSD at 5%	5.58	6.56	NS	NS	NS	NS	0.62	0.59

FYM = Farmyard manure. S = Sulphur. G = Gypsum.

2. Effect of sulphur and gypsum levels:

Data presented in Table (5) reveal that total tuber yield/fed, number of tubers/plant, tuber average weight and tuber dry matter (%) were significantly increased with increasing sulphur and gypsum levels until a certain limit was reached. The maximum total yield, tuber average weight/plant and tuber dry weight, were obtained from treatments received 2.67 ton gypsum and 500 kg/fed. sulphur, while the highest number of tubers/plant was obtained with 4.0 tons gypsum and 750 kg/fed sulphur. These results were true in both seasons.

Table 5. Effect of farmyard manure, sulphur and gypsum and their interactions on total tuber yield, number of tubers, tuber average weight and tuber dry matter (%) during the two summer seasons of 2000 and 2001.

Characters	Total tuber yield (ton/fed)		No. of Tubers/plant		Tuber average weight (g)		Tuber dry matter (%)	
Treatments	2000	2001	2000	2001	2000	2001	2000	2001
FYM treatment:								
With	14.15	13.32	4.10	4.00	110.0	115.3	21.21	21.48
Without	11.19	10.85	3.10	3.00	104.3	109.2	20.08	20.49
F-test	*	*	*	*	*	*	*	*
Amendments:								
Sulphur levels (kg/fed):								
S_1 : 250	11.90	10.91	3.30	3.20	96.0	103.3	18.19	18.47
S_2 : 500	12.99	12.44	3.40	3.30	112.0	116.0	21.81	21.90
S_3 : 750	12.29	11.31	3.50	3.40	106.0	108.2	20.34	20.93
Gypsum levels (ton/fed)								
G_1 : 1.33	12.81	12.10	3.80	3.60	103.2	107.3	21.17	21.83
G_2 : 2.67	13.57	12.91	3.90	3.80	116.7	120.7	23.05	23.08
G_3: 4.00	12.91	12.15	4.10	4.00	106.3	105.6	19.35	19.52
LSD at 5%	0.71	0.73	0.59	0.55	2.48	1.85	0.63	0.67
Interactions:								
With FYM:								
S_1 : 250	12.94	11.89	3.50	3.40	96.0	104.0	18.48	18.73
S_2 : 500	14.91	14.04	3.70	3.60	117.0	122.0	22.52	22.75
S_3 : 750	13.46	12.54	3.80	3.70	108.7	112.3	20.79	21.14
G_1 : 1.33	14.52	13.63	4.20	4.10	113.3	121.3	21.73	22.02
G_2 : 2.67	15.41	15.05	4.80	4.60	122.7	126.0	24.09	23.39
G_3: 4.00	13.61	13.44	5.00	4.80	115.3	114.0	20.66	21.75
Without FYM:								
S_1 : 250	10.87	9.93	3.00	3.10	96.0	100.7	17.90	18.22
S_2 : 500	11.14	10.14	2.90	2.90	98.0	104.0	20.60	21.71
S_3 : 750	11.12	10.07	3.20	3.10	103.0	108.0	19.88	19.28
G_1 : 1.33	11.35	10.57	3.10	3.00	109.0	113.3	19.51	22.04
G_2 : 2.67	11.74	10.78	3.20	3.00	110.7	115.3	22.02	20.76
G_3: 4.00	10.92	10.26	3.20	3.30	108.7	114.0	20.95	20.95
LSD at 5%	1.00	1.03	0.84	0.78	3.51	2.61	0.89	0.94

Similar results were obtained by Kamar and Omar (1987), Sharma et al. (1987), Abdel-Razik and Gabr (1994), Nogueria et al. (1996) and Ali (2002), who found that the addition of sulphur and or gypsum, reduced the pH value of the soil that made many elements such as Zn, B, P and Mn more available to potato plants and reflected as total yield, tuber weight and dry matter percentage.

3. The interaction effects of FYM, sulphur and gypsum levels:

Data indicated that total tuber yield, number of tubers/plant, tuber average weight and tuber dry matter were significantly affected with the interactions between FYM, sulphur and gypsum levels in both growing seasons as shown in Table (5).

Generally, these results might be due to the increase in the vegetative growth and dry matter (Table 4), as well as, the mean tuber weight (Table 5) which consequently increased the total tubers yield of potato crop.

NPK contents:

1. Effect of FYM:

Data in Table (6) indicate that application of FYM resulted in significant increase in the percentage of N, P and K in foliage and tubers in both seasons. This may be attributed to the effect of FYM as a source of essential nutrients beside improving the physical and chemical properties of soil. Similar results were obtained by Sharma and Grewal (1986), Kuszelewski and Labetowicz (1994) and Arisha and Bardisi (1999).

2. Effect of sulphur and gypsum levels:

Data in Table (6) show that N, P and K content in foliage and tubers significantly increased with increasing sulphur and/or gypsum levels in both growing seasons. The highest percentage of NPK were obtained by application of sulphur and gypsum at rate of 750 kg and 4.0 ton/fed., respectively. The higher percentage of NPK in foliage and tubers could be due to the positive effect of sulphur and gypsum in reducing the pH value of the soil, which lead potato plant to more absorption of nutrients. These results are in line with those obtained by Kamar and Omar (1987), El-Gamal et al. (1990) and Ali (2002).

3. The interaction effects of FYM, sulphur and gypsum levels:

Data in Table (6) show also significant effects of the interactions between FYM, sulphur and gypsum levels on the percentage of N, P and K in foliage and tubers in both seasons.

Table 6. Effect of farmyard manure, sulphur and gypsum and their interactions on N, P and K percentage in foliage and tubers during the two summer seasons of 2000 and 2001.

Characters	N (%)				P (%)				K (%)			
	Foliage		Tuber		Foliage		Tuber		Foliage		Tuber	
Treatments	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
FYM treatment:												
With	2.73	2.68	1.74	1.65	0.288	0.275	0.231	0.221	3.25	3.17	2.17	2.12
Without	2.36	2.32	1.55	1.45	0.226	0.221	0.201	0.197	2.87	2.81	1.97	1.92
F-test	*	*	*	*	*	*	*	*	*	*	*	*
Amendments:												
Sulphur levels (kg/fed):												
S_1 : 250	2.44	2.39	1.48	1.50	0.237	0.228	0.195	0.190	2.89	2.81	1.96	1.88
S_2 : 500	2.47	2.40	1.46	1.49	0.250	0.230	0.198	0.193	2.95	2.91	2.03	1.96
S_3 : 750	2.51	2.45	1.57	1.53	0.243	0.242	0.203	0.197	2.92	2.86	1.94	1.90
Gypsum levels (ton/fed):												
G_1 : 1.33	2.58	2.53	1.74	1.52	0.260	0.257	0.230	0.218	3.04	2.98	2.11	2.08
G_2 : 2.67	2.48	2.43	1.66	1.58	0.267	0.250	0.221	0.215	3.14	3.06	2.10	2.13
G_3 : 4.00	2.69	2.64	1.86	1.74	0.287	0.275	0.250	0.234	3.29	3.22	2.26	2.20
LSD at 5%	0.07	0.08	0.08	0.06	0.014	0.015	0.012	0.013	0.17	0.18	0.14	0.16
Interactions:												
With FYM:												
S_1 : 250	2.49	2.44	1.69	1.62	0.243	0.230	0.180	0.173	3.02	2.92	1.98	1.92
S_2 : 500	2.56	2.48	1.63	1.56	0.277	0.250	0.200	0.197	3.13	3.11	2.11	2.06
S_3 : 750	2.71	2.66	1.50	1.43	0.277	0.263	0.220	0.200	2.99	2.93	1.99	1.95
G_1 : 1.33	2.76	2.71	1.83	1.74	0.300	0.293	0.257	0.243	3.32	3.24	2.22	2.17
G_2 : 2.67	2.85	2.82	1.75	1.71	0.303	0.293	0.243	0.233	3.18	3.11	2.27	2.23
G_3 : 4.00	2.99	2.92	2.02	1.89	0.330	0.320	0.289	0.277	3.84	3.56	2.59	2.39
Without FYM:												
S_1 : 250	2.33	2.25	1.45	1.38	0.230	0.227	0.210	0.207	2.76	2.71	1.94	1.85
S_2 : 500	2.37	2.32	1.46	1.37	0.223	0.210	0.197	0.190	2.77	2.72	1.96	1.86
S_3 : 750	2.39	2.35	1.52	1.41	0.210	0.220	0.187	0.193	2.85	2.77	1.89	1.85
G_1 : 1.33	2.31	2.30	1.57	1.43	0.220	0.220	0.203	0.193	2.75	2.72	2.00	1.99
G_2 : 2.67	2.38	2.33	1.64	1.50	0.230	0.219	0.213	0.202	3.03	2.93	1.93	1.94
G_3 : 4.00	2.40	2.35	1.65	1.59	0.243	0.228	0.197	0.206	3.04	3.00	2.11	2.09
LSD at 5%	0.10	0.11	0.12	0.09	0.021	0.021	0.017	0.019	0.25	0.26	0.19	0.22

In general, these results might be attributed to the application of FYM, sulphur and or gypsum which increased soil aggregation which lead to a good soil properties, and also decreased the pH value of soil, which it turn reflected in vigorous plant growth parameters (Table 4). These results are in agreement with those found by Mondal et al. (1993).

Microelements, specific gravity and starch contents:

1. Effect of FYM:

Results in Table (7) demonstrated clearly that microelements (Fe, Zn and Mn), specific gravity and starch content (%) are significantly increased with FYM application in both growing seasons. These results are in agreement with Tisdale et al. (1985), Kolbe et al. (1995) and El-Nagar (1996), who reported that FYM was a source of micronutrients and improved soil properties, as well as soil fertility.

2. Effect of sulphur and gypsum levels:

Data recorded in Table (7) indicated also that micoelements (Fe, Mn and Zn), specific gravity and starch content (%) were significantly affected with sulphur and or gypsum levels in both seasons. The highest values were obtained at the rate of 500 kg sulphur or 4.0 ton gypsum/fed, while the highest specific gravity and starch content were reached at the rate of 250 kg sulphur and 2.67 ton gypsum in the two seasons. Therefore, using sulphur or gypsum increased concentrations of iron, manganese and zinc in foliage of potato plant.

Table 7. Effect of farmyard manure, sulphur and gypsum and their interactions on Fe, Mn and Zn content in foliage, as well as specific gravity and starch content in tubers during the two summer seasons of 2000 and 2001.

Characters	Fe (ppm)		Mn (ppm)		Zn (ppm)		Specific gravity		Starch content (%)	
Treatments	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
FYM treatment:										
With	110	106	58	56	32	31	1.078	1.078	15.83	15.71
Without	91	88	43	40	23	21	1.071	1.076	14.43	14.49
F-test	*	*	*	*	*	*	*	*	*	*
Amendments:										
Sulphur levels (kg/fed):										
S_1 : 250	90	87	49	46	28	26	1.077	1.081	15.71	15.69
S_2 : 500	98	95	53	51	30	28	1.074	1.080	14.83	14.65
S_3 : 750	96	94	51	48	26	24	1.073	1.078	15.07	14.95
Gypsum levels (ton/fed):										
G_1 : 1.33	104	101	52	45	26	25	1.076	1.077	15.35	15.25
G_2 : 2.67	103	100	48	46	25	26	1.078	1.079	15.49	15.54
G_3 : 4.00	110	106	53	49	29	28	1.071	1.073	15.31	15.34
LSD at 5%	3.04	3.39	2.32	2.00	1.17	2.80	0.002	0.004	0.11	0.43
Interactions:										
With FYM:										
S_1 : 250	94	94	54	52	33	30	1.074	1.079	15.84	15.59
S_2 : 500	109	105	57	58	33	31	1.078	1.083	14.93	14.88
S_3 : 750	103	100	60	61	31	29	1.076	1.080	15.24	15.16
G_1 : 1.33	114	109	60	56	30	31	1.081	1.084	16.13	16.02
G_2 : 2.67	123	117	61	59	34	32	1.082	1.088	16.55	16.42
G_3 : 4.00	114	111	56	53	30	31	1.079	1.083	16.05	16.00
Without FYM:										
S_1 : 250	84	81	43	41	24	26	1.072	1.077	14.25	14.24
S_2 : 500	91	90	46	43	27	21	1.071	1.077	14.01	13.90
S_3 : 750	86	84	42	39	21	20	1.070	1.076	14.07	14.10
G_1 : 1.33	94	92	42	41	22	20	1.072	1.075	14.57	14.49
G_2 : 2.67	98	95	43	40	24	21	1.072	1.074	14.88	14.83
G_3 : 4.00	91	90	40	37	22	19	1.071	1.075	14.82	14.40
LSD at 5%	4.31	4.80	3.29	2.83	2.50	3.97	0.003	0.002	0.16	0.61

These results are in line with those obtained by Samuel et al. (1984), Kamar and Omar (1987), Simmones et al., (1988), El-Gamal et al. (1990) and Ali (2002).

3. The interaction effects of FYM, sulphur and gypsum levels:

Data in Table (7) show also that interactions between FYM, sulphur and gypsum levels had a significant increase on microelements (Fe, Mn and Zn), specific gravity and starch content percentage in both seasons. This increase may be due to the favourable effect of FYM with sulphur or gypsum where organic materials such as manure may supply chelating agents that aid in maintaining the solubility of micronutrients, as well as the effect of sulphur or gypsum on the pH value of the soil (Samuel et al., 1984 and Kamar and Omar, 1987).

CONCLUSION

This investigation recommend that the application of FYM at the rate of 12.5 ton/fed. in combination with 500 kg/fed. of sulphur and or 2.67 ton/fed. of gypsum to potato plant produced the highest values of tuber yield, as well as tuber quality.

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الملخص العربى

إستجابة النمـــو والمحصـــول وجـــودة درنـــات البطـــاطس للأسمـــدة العضـــوية ومستويات مختلفة من الكبريت والجبس

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قسم بحوث البطاطس والخضر خضرية التكاثر ، معهد بحوث البساتين ، مركز البحوث الزراعية ، الجيزة
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أجريت هذه التجربة فى موسمين صيفين متتاليين ٢٠٠٠، ٢٠٠١ فى مزرعة بحوث البســـاتيـــن بالبرامون، محافظة الدقهلية استخدم فيهما محصول البطاطس صنف اسبونتـــا، وذلك لدراسة تأثير السماد العضوى (صفر، ١٢,٥ طن/فدان) ومستويات مختلفة من الكبريت (٢٥٠، ٥٠٠، ٧٥٠ كجم/فدان)، الجبس الزراعى (١,٣٣، ٢,٦٧، ٤,٠ طن/فدان) بالإضافة إلى تفاعلاتها على النمو ومحصول الدرنات ومكوناتـــه من النتروجين والفوسفور والبوتاسيوم (فى العرش والدرنـــات) بالإضافة إلى النشا وبعض العناصر الصغرى (حديـــد – زنـــك – منجنيز).

أشارت النتائج الى ان الإضـــافات الفردية من السماد العضوى او الكبريت او الجبس الزراعى أدت إلى زيادة معنوية فى معظم قياسات النمو الخضرى وكذلك المحصول الكلى للدرنات – عدد الدرنات للنبات – متوسط وزن الدرنة – والكثـــافة النوعية ومحتوى الدرنة من المادة الجافة والنشـــا وتركيزات العناصر الكبرى (NPK) فى العرش والدرنات والعناصر الصغرى فى العرش فى موسمى الزراعة.

اوضحت النتائج ان التفاعل بين السماد العضوى ومستويات كلا من الكبريت والجبس الزراعى ادى الى زيادة معنوية فى معظم قياسات النمو الخضرى وكذلك المحصول الكلى للدرنات، عدد الدرنات/نبات ، متوسط وزن الدرنة والكثافة النوعية ومحتوى الدرنة من المادة الجافة والنشا وتركيزات العناصر الكبرى (NPK) فى العرش والدرنات والعناصر الصغرى فى العرش.

وتوصى هذه الدراسة بإضافة السماد العضوى بمعدل ١٢,٥ طن/فدان قبل الزراعة بالإضافة إلى ٥٠٠ كجم كبريت أو ٢,٦٧ طن/فدان جبس زراعى. هذه المعاملات أعطت أعلى معدل للنمو الخضرى والمحصول الكلى وحسنت صفات الجودة للمحصول.