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Effect of Ammonium Sulphate and Agricultural Sulphur on the Artichoke Plant Growth, Heads Yield and its Some Physical and Chemical Properties

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Abstract: Two field experiments were carried out during the two successive seasons of 2004/2005 and 2005/2006 in the newly reclaimed soil to investigate the response of artichoke plant for different fertilization rates of ammonium sulphate 20.6% N (80, 100 and 120 N-units/fed.) and agricultural sulphur (0, 150 and 300 kgs./fed.), and the important obtained results are as following: (1) Addition of ammonium sulphate as a nitrogen source at rate within 100 – 120 N-units/fed., gained the best plant growth parameters. However, addition sulphur at rate of 150 up to 300 kgs./fed. resulted the vigor growth of artichoke plant. (2) With increasing ammonium sulphate and/or sulphur fertilizers, total and early heads yield increased, but no statistical differences were detected within the two treatments of addition 150 with 300 kg. S/fed. as well as within addition 100 with 120 N-units/fed. (3) The fertilization by ammonium sulphate caused an enhancement on the some physical properties of head yield as well as the nutritional values of the edible parts of artichoke. The sulphur fertilizer up to 300 kgs./fed. resulted an increase in artichoke head length, diameter, fresh weight, also gained a little rise in the elemental values of artichoke heads. (4) The interaction between different rates of nitrogen and sulphur fertilizers had no significant effect on plant growth measurements, total and/or early heads yield as well as its physical and chemical properties.

Key words: Artichoke, Ammonium sulphate, sulphur, growth, heads yield

INTRODUCTION

Globe artichoke (*Cynara scolymus* L.) is a large immature flower rich in nutritional and medicinal substances. It is considered one of the most important vegetable crops in the countries bordering the Mediterranean basin including Egypt. The world production of globe artichoke increased from 1.141 to 1.290 million tons from 1995 to 2000[1]. In Egypt, the cultivated area of artichoke increased from 3482 fed. in 1983, which produced 26079 tons with an average of 7.49 tons/fed. to 4686 fed. in 1995 which produced 43231 tons with an average of 9.2 tons/fed.

Globe artichoke has important nutritional values related to its high content of proteins, fibers and minerals. Artichoke is a species of great pharmacological interest because of its coleretic and hepato-regenerative action induced by the aqueous extracts of leaves[2,3].

Among the major nutrients, nitrogen is required in the largest amount by plants. It plays an essential role for plant productivity[4]. Artichoke productivity is strongly affected by the amount of nitrogen[5-8]. Sulphur deficiency is becoming a serious problem for Egyptian soil. Sulphur fertilization is a feasible technique for lowering the plant uptake of undesired or toxic elements in the polluted soils[9]. Also, sulphur is the fourth most important nutrient is required in relatively large amount for plant growth[4]. Addition sulphur with ammonium sulphate for vegetables caused better results, because the role of sulphur for lowering the pH value in soil extract and their turn on increasing the solubility and availability of many minerals[9-12].

The present investigation was conducted to study the effect of agriculture sulphur and ammonium sulphate on artichoke productivity and product quality.

MATERIALS AND METHODS

Field experiments were conducted out in newly reclaimed soil at El-Nobaria, (Behira Governorate), Northern of Egypt during the two successive seasons of 2004/2005 and 2005/2006.

Two-factorial experiment was carried out in a split plot design with three replicates. Whereas, three agricultural sulphur treatments, i.e., 0, 150 and 300 kg/fed. (Factor A) were assigned to the main-plots, while three N levels, i.e., 80, 100 and 120 kg N/fed. as ammonium sulphate contains 20.6% N (Factor B) were randomized and occupied the sub-plots. The soil texture

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is sandy with 95.3% sand, 0.4% silt and 4.3% clay. The pH was 7.9 and EC was 2.0 dS/m. The plot area was 22.5 m^2 containing 15 artichoke plants. Before planting, all sulphur treatments were soil-incorporated, but the different rates of ammonium sulphate were divided into three equal amounts and added 30, 60 and 90 days plant old. Drip irrigation system was used and other agricultural practices such as phosphorus and potassium fertilization, weed control and pest management were followed according to the recommendation of the Ministry of Agriculture, Egypt.

The French cultivar, cv. Herious, (vegetatively propagated), was grown on September 1st and 3rd for first and second seasons, respectively, with 100 cm apart between each two plants on the ridge and 150 cm between the ridges. The first harvest of heads started in January and continued until the end of May in both growing seasons.

Vegetative plant samples were taken at 150 days after planting and the following measurements were recorded: Plant length (cm), number of leaves/plant, and the following data were recorded on the fourth leaf: leaf area (cm^2), leaf fresh weight (g), leaf dry weight (g), dry matter (%) and leaf chlorophyll content (SPAD). Early yield was determined as weight and number of heads/plant from starting of harvest until the end of February, but total yield of heads was recorded as weight and number of heads per plant from the beginning of harvest until the end of growing season. The weight, length and diameter of each head as well as the weight of edible part (receptacle) were evaluated in February (main heads). In the tissues of the edible parts the following chemical analyses were determined:
1- Total nitrogen, phosphorus and potassium were determined according to the methods of Pregl[13], Troug and Mayer[14] and Brown and Lilleland[15], respectively.
2- The rate of crude protein and crude fiber were determined according to A.O.A.C[16].
3- Ca and Fe were measured according to Chapman and Pratt[17] .

Statistical analysis:

All data values were subjected to the analysis of variance according to Gomez and Gomez,[18].

RESULTS AND DISCUSSIONS

A. Plant growth as affected by:

1. Sulphur fertilization: The presented data in Table (1) shows clearly that, addition agricultural sulphur gained an enhancement in plant growth parameter of artichoke plant if compared with those plants which no received sulphur. Moreover, more addition of sulphur, i.e. 300 kgs./fed., resulted the highest plant length, number, fresh and dry weight of 4th leaf as well as its area and its total pigments. These findings are in good similar in two experimental seasons, with some slow exceptions. However, in most cases, the statistical analysis of the resulted data reveals no significant difference within the two rates, i.e. 150 and/or 300 kgs./fed. of sulphur treatments. It means, that from the economic view the addition of 150 kgs./sulphur per fed. may be gained a good plant growth of artichoke plant. Also, in the two seasons of experiments, addition of sulphur at any rate resulted a significant improvement of the plant growth characters compared to the no sulphur treatments. These were true in both experiments for all plant growth parameter, except the area of 4th leaf and the percentage of dry matter, which recorded no significant responses.

It could be concluded that, under the condition of this investigation, sulphur is important for improving plant growth of artichoke plant. These results are in good accordance with those which reported by other investigators such as Abd El-Moez *et al*.,[11] on onion, Shafeek *et al*.,[12] on Japanese radish and Saleh *et al*.,[8] on artichoke.

2. Ammonium sulphate: Fertilizing artichoke plant with ammonium sulphate (20.6% N) as a source of nitrogen at rates of 80 up to 120 kgs. N/fed. had a significant effect on the plant growth characters as shown in Table (1). This findings were true in 1st and 2nd experiments for all plant growth parameters except, the values of dry matter percentage in both experiments and the dry weight of 4th leaf in 1st season only. Generally the statistical analysis of the obtained data reveals that, the differences between treating artichoke plants with ammonium sulphate at rate of 100 and/or 120 kgs.N/fed, failed to reach the 5% level of significant in most criteria's of plant growth. It means that, addition of 100 kg.N/fed. might be gained the best benefits at least from the economic view.

It could be concluded that, the ammonium sulphate fertilization of artichoke plant enhanced plant growth characters if that added at rates of 100-120 kg.N/fed. Nitrogen is present in the chlorophyll molecule and it is a main component of protein synthesis. Moreover, the advancing effect of nitrogen might be attribute to its role in enhancing plant capacity in protein synthesis, leading to an increase in building up carbohydrates, and this in turn resulted in increases the plant growth characters.

It is noteworthy to mentioned that, nitrogen is essential for plant growth as its a constituent of all proteins of all protoplasm. As the level of nitrogen supply increases compared with other nutrients, the extra protein produced allows the plants leaves to grow larger and hence to have a larger surface available for photosynthesis proportional to the amount of nitrogen supplied.

Table 1: Effect of different levels of agricultural sulfur and chemical nitrogen as ammonium sulfate on vegetative growth of artichoke plants in 1st season 2004/2005 and 2nd season 2005/2006:

Treatments	(A) 0 kg Sulfur				150 kg Sulfur				300 kg Sulfur				Mean				*LSD at 5%*		
Characters (B)	80 kgN	100 kgN	120 kgN	*Mean*	80 kgN	100 kgN	120 kgN	*Mean*	80 kgN	100 kgN	120 kgN	*Mean*	80 kgN	100 kgN	120 kgN	*A*	*B*	*AxB*
								1st season 2004/2005										
Plant cm	66.7	69.7	70.3	68.9	69.3	74.0	74.3	*72.5*	71.3	75.3	73.7	*73.4*	69.1	73.0	72.8	*1.5*	*2.3*	*ns* length,
Leaves	56.7	58.0	61.7	*58.8*	59.3	62.7	64.3	*62.1*	59.7	62.0	61.7	*61.1*	58.6	60.9	62.6	*2.5*	*1.6*	*ns* number
Leaf W., g	98.3	106.7	107.7	*104.2*	104.7	114.3	110.0	109.7	108.3	115.3	112.7	*112.1*	103.8	112.1	110.1	*5.4*	*2.2*	*ns* fresh
Leaf dry g	13.7	15.6	15.9	*15.1*	15.0	17.8	17.0	*16.6*	15.8	17.1	16.2	*16.4*	14.8	16.8	16.4	*0.9*	*ns*	*ns* weight,
Dry %	13.9	14.6	14.8	*14.4*	14.3	15.6	15.5	*15.1*	14.6	14.8	14.4	*14.6*	14.3	15.0	14.9	*ns*	*ns*	*ns* matter,
Leaf area, cm^2	493.0	497.3	514.3	*501.5*	499.0	503.7	519.7	*507.5*	513.3	517.3	525.3	*518.6*	501.8	506.1	519.8	*ns*	*13.3*	*ns*
Chloro-phyll, Spad	49.6	49.4	52.1	*50.4*	51.9	54.0	54.5	*53.5*	52.2	54.4	53.2	*53.3*	51.2	52.6	53.3	*2.1*	*1.4*	*ns*
								2nd season 2005/2006.										
Plant cm	67.3	68.7	71.3	*69.1*	69.0	73.3	74.7	72.3	71.0	73.7	74.3	73.0	69.1	71.9	73.4	*1.0*	*0.7*	*12* length,
Leaves	53.7	55.7	56.3	*55.2*	55.0	59.3	58.7	*57.7*	56.7	58.0	59.7	*58.1*	55.1	57.7	58.2	*2.2*	*1.9*	*ns* number
Leaf fresh W., g	97.3	102.0	104.3	*103.7*	103.7	107.0	106.3	*105.7*	106.3	110.0	111.7	109.3	102.4	106.3	107.4	*1.5*	*1.4*	*ns*
Leaf weight, g	14.0	14.7	15.2	*14.6*	15.0	15.4	15.2	*15.2*	15.3	15.7	16.1	*15.7*	14.8	15.3	15.5	*0.2*	*0.2*	*0.4* dry
Dry %	14.4	14.4	14.6	*14.5*	14.5	14.4	14.3	*14.4*	14.4	14.3	14.4	*14.4*	14.4	14.4	14.4	*ns*	*ns*	*ns* matter,
Leaf cm^2	494.0	497.3	506.7	*499.3*	495.3	509.3	506.0	503.5	501.7	507.3	513.3	507.4	497.0	504.6	508.7	*ns*	*6.8*	*ns* area,
Chloro-phyll, Spad	48.8	50.0	51.7	*50.2*	52.5	51.6	53.7	*52.6*	51.7	52.9	53.1	52.6	51.0	51.5	52.8	*1.1*	*0.5*	*0.9*

Many investigators studied the response of many vegetable plants to nitrogen fertilization and had results supported that which obtained in this in script (El-Fatth, *et al*.,[19]; Rosati, *et al*.,[20]; Saleh *et al*.,[7]; Rodrigo, *et al*.,[21] and Saleh *et al*.,[8].

3. The interaction of sulphur X ammonium sulphate: The supplying of sulphur at rates of 0, 150 and 300 kgs./fed. with ammonium sulphate at rate of 80, 100 and 120 N-unit,/fed. as interaction treatments for artichoke plant had a little effect on the parameters of plant growth as shown in Table (1). Whereas, the statistical analysis of the obtained data shows that, no significant variation recorded for all measurements of plant growth. These results were true in both experiments with some exception of the plant length, dry weight of 4th leaf, and chlorophyll content in 2nd experiment which responded significantly at 5% level.

Generally, it could be summarized that, the interaction treatment of sulphur and ammonium sulphate addition at different rates caused a little effect on the plant growth character of artichoke plant. It means that, each factor of the interaction treatments act independently.

Table 2: Effect of different levels of agricultural sulfur and chemical nitrogen as ammonium sulfate on artichoke head characters in 1st *season 2004/2005 and 2nd season 2005/2006:*

Treatments (A)	0 kg Sulfur				150 kg Sulfur				300 kg Sulfur				Mean			LSD at 5%		
Characters (B)	80 kgN	100 kgN	120 kgN	*Mean*	80 kgN	100 kgN	120 kgN	*Mean*	80 kgN	100 kgN	120 kgN	*Mean*	80 kgN	100 kgN	120 kgN	*A*	*B*	*AxB*
1st season 2004/2005																		
Head weight, g	198.3	204.6	203.4	202.1	204.7	207.7	205.6	206.0	200.5	205.6	207.8	204.6	201.2	206.0	205.6	*ns*	*4.1*	*ns* fresh
Head mm	83.0	85.0	85.7	84.6	85.3	87.7	87.3	*86.8*	86.0	87.3	88.0	*87.1*	84.8	86.7	87.0	*1.4*	*1.6*	*ns* length,
Head diameter, mm	78.3	80.0	80.0	79.4	79.0	81.3	81.0	*80.4*	81.3	82.3	82.0	*81.9*	79.5	81.2	81.0	*1.8*	*1.3*	*n s*
Edible F.W., g	38.6	40.5	40.3	39.8	40.1	41.2	40.5	*40.6*	39.5	40.5	41.0	*40.3*	39.4	40.7	40.6	*ns*	*1.0*	*ns* part
Edible part g	5.7	6.3	6.3	*6.1*	6.2	6.4	6.4	*6.3*	6.2	6.4	6.5	*6.4*	6.0	6.4	6.4	*ns*	*0.2*	*ns* D.W.,
Dry %	14.8	15.6	15.6	*15.3*	15.5	15.5	15.8	*15.6*	15.7	15.8	15.9	*15.8*	15.3	15.6	15.8	ns	0.3	*ns* matter,
2nd season 2005/2006																		
Head weight, g	183.9	187.4	186.7	186.0	189.2	197.8	195.2	194.1	187.1	196.6	198.7	194.1	186.7	193.9	193.5	*6.2*	*5.2*	*ns* fresh
Head mm	83.3	84.7	85.7	84.6	83.3	88.7	88.0	*86.7*	86.0	88.7	87.0	*87.2*	84.2	87.4	86.9	*1.3*	*1.2*	*2.1* length,
Head diameter, mm	76.0	78.0	80.3	*78.1*	79.3	82.0	80.3	*80.5*	79.7	81.3	81.0	*80.7*	78.3	80.4	80.5	1.6	1.2	*ns*
Edible F.W., g	38.7	39.6	39.5	39.3	40.0	41.7	41.3	*41.0*	39.6	41.4	41.8	*40.9*	39.4	40.9	40.9	*1.3*	*1.0*	*ns* part
Edible D.W., g	5.8	6.4	6.3	*6.2*	6.4	6.5	6.6	*6.5*	6.4	6.7	6.6	*6.6*	6.2	6.5	6.5	*0.3*	*0.2*	*ns* part
Dry %	15.0	16.2	15.9	*15.7*	16.0	15.6	16.0	*15.9*	16.2	16.2	15.8	*16.0*	15.7	16.0	15.9	*ns*	*ns*	*ns* matter,

B. Head yield as affected by:

1. Sulphur fertilization: Table (2) shows that, the total and early heads yield of artichoke plant (weights and/or numbers) as affected by the rates of sulphur addition in two experiments of 2004/2005 and 2005/2006. Whereas, the obtained results indicate that, supplying sulphur gained an increase in the total and early heads yield comparing to that plants no sulphur supplied. Moreover, with increasing agricultural sulphur up to 300 kgs./fed. obtained more total and early heads yield, but the statistical analysis of the collected data reveals that, no great difference within applying 150 and 300 kgs./fed. to be significantly at 5% level. Generally, the increments in total heads weight and early weights which obtained when 300 kgs. sulphur added per fed. over that treatment which no supplied sulphur amounted by 16.2 and 19.3% in 1st experiment and by 17.1 and 12.4% in 2nd experiment.

It could be abstracted that the sulphur addition within range of 150 up to 300 kgs./fed. caused an encourage in yield of artichoke plant. These were similar in both seasons. The response of total, early yields as number and average head weight followed the same pattern of change like that mentioned above for two experiments.

The higher total and early artichoke heads yield obtained from using the different rates of sulphur may be due to the increase in one or more of the estimated attributes either in plant length or leaf weight and/or leaf area. However, the picture reflected some significant increases in leaves number, area, fresh and dry weight and total chlorophyll. So, these increments in our opinion led to the favourable jump in the production of artichoke plant in this experiment. Moreover, the use sulphur in the examined level may increase the other nutrition elements from soil extracts,

Table 3: Effect of different levels of agricultural sulfur and chemical nitrogen as ammonium sulfate on artichoke yield and ist components in 1st season 2004/2005 and 2nd season 2005/2006:

Treatments (A)	0 kg Sulfur				150 kg Sulfur				300 kg Sulfur				Mean			*LSD at 5%*		
Characters (B)	80 kgN	100 kgN	120 kgN	*Mean*	80 kgN	100 kgN	120 kgN	*Mean*	80 kgN	100 kgN	120 kgN	*Mean*	80 kgN	100 kgN	120 kgN	*A*	*B*	*AxB*
								1st season 2004/2005										
Early yield, g/plant	536.7	691.7	628.3	*618.9*	641.7	565.0	721.7	642.8	786.7	791.7	636.7	738.4	655.0	682.8	662.2	*ns*	*ns*	*ns*
Total yield, g/plant	2515.0	2658.3	2878.3	2683.9	2915.0	3151.7	3283.3	3116.7	3018.3	3196.7	3140.0	3118.3	2816.1	3002.2	3100.5	255.5	195.6	ns
Earlyl yield No./plant	2.33	3.00	2.67	*2.67*	2.67	2.33	3.00	*2.67*	3.33	3.33	2.67	*3.11*	2.78	2.89	2.78	*ns*	*ns*	*ns*
Total yield No./plant	12.00	12.67	13.67	12.78	13.67	14.67	15.33	14.56	14.33	15.00	14.67	14.67	13.33	14.11	14.56	*0.70*	*0.90*	*ns*
Mean head weight, g	209.6	209.8	210.6	210.0	213.2	214.8	214.2	214.1	210.6	213.1	214.0	212.6	211.2	212.6	212.9	*ns*	*ns*	*ns*
								2nd season 2005/2006										
Early yield, g/plant	531.7	627.7	720.7	626.7	622.3	807.0	648.7	692.7	730.0	735.0	648.0	704.3	628.0	723.2	672.5	*ns*	*ns*	*ns*
Total yield, g/plant	2150.0	2451.0	2604.0	2401.7	2597.3	2952.0	2940.3	2829.9	2550.0	2911.7	2974.7	2812.1	2432.4	2771.6	2839.7	153.7	141.7	ns
Earlyl yield No./plant	2.33	2.67	3.00	*2.67*	2.67	3.33	2.67	*2.89*	3.00	3.00	2.67	*2.89*	2.67	3.00	2.78	*ns*	*ns*	*ns*
Total yield No./plant	11.00	12.33	13.00	*12.11*	13.00	14.00	14.33	13.78	12.67	14.00	14.33	13.67	12.22	13.44	13.89	0.90	0.70	ns
Mean head weight, g	195.5	198.8	200.3	198.2	199.8	210.9	205.2	205.3	201.3	208.0	207.6	205.6	198.8	205.9	204.4	*4.4*	*5.1*	*ns*

where the addition S caused lowering the alkalinity of soil media and this reflected on the solubility and availability of the minerals in root zone.

The role of sulphur to increase the total and early yield of vegetables are studied by many workers and their obtained reported are in good accordance with that written here (Fatma Rizk,[22]; Lancaster, *et al.*,[23]; Shafeek *et al.*,[12] and Saleh, *et al.*,[8].

2. Ammonium sulphate: Total heads yield as g./plant and/or No./plant of artichoke plant recorded its highest values with that plants which received highest rate of ammonium sulphate i.e. 120 kgs.N./fed. Whereas, that plants which supplied ammonium sulphate at rate of 100 N-units/fed. gained the heaviest early heads yield, also had the highest number of heads/plant. Concerning to the average head weight of artichoke, the presented data in table (2) clearly showed that, it responded completely like that mentioned above for early heads yield. These findings were true in the two experimental seasons.

It could be concluded that, the total and early artichoke heads yield increased with addition more ammonium sulphate, and the statistical analysis of the obtained data indicate that, the differences within the higher two rates of ammonium sulphate which applied were not great enough to reach 5% level of significant.

The yield response to adequate N fertilizer could be attributed to response of all tested growth features of artichoke plant previously discussed, whereas, yield can be affected by all physiological processes including growth and nutrient supply. By other means the favourable effect of nitrogen fertilizer in increasing yield/plant could be due to its stimulate effect on the vegetative growth which increased the photosynthetic rate and number of leaves.

The registrated data here are in good accordance with those which obtained by other workers such as El-Fattah *et al.*,[19]; Schalz and Elerbrock,[24]; Khayyo *et al.*,[25]; Pomares *et al.*,[26]; Rosati *et al.*,[20]; Foti *et al.*,[27]; Lerna *et al.*,[28].

3. The interaction of sulphur X ammonium sulphate: The total and early heads yield of artichoke as both weight or number/plant and the average head weight all of them as influenced by the interaction treatment of agricultural sulphur and ammonium sulphate at 3 levels for each are shown in Table (2) for the two experimental seasons. It evident from the obtained data that, no significant effect of the interaction treatments on all elements of artichoke yield in two experiments. This means that each factor of the interaction treatments may be act individually or independently.

C. Quality of heads yield as affected by:

1. Sulphur fertilization: Table (3) shows the response of some physical and chemical properties of artichoke yield as affected by addition sulphur at rates of 0, 150 and 300 kgs./fed. in the two experimental seasons.

Table 4: Effect of different levels of agricultural sulfur and chemical nitrogen as ammonium sulfate on leaf contents of nutrient minerals *in 1st season 2004/2005 and 2nd season 2005/2006:*

Treatments (A)	0 kg Sulfur				150 kg Sulfur				300 kg Sulfur				Mean			LSD at 5%		
Characters (B)	80 kgN	100 kgN	120 kgN	*Mean*	80 kgN	100 kgN	120 kgN	*Mean*	80 kgN	100 kgN	120 kgN	*Mean*	80 kgN	100 kgN	120 kgN	*A*	*B*	*AxB*
1st season 2004/2005																		
N, %	3.41	3.49	3.57	*3.49*	3.36	3.64	3.75	*3.58*	3.52	3.76	3.81	*3.70*	3.43	3.63	3.71	*0.06*	*0.07*	*ns*
P, %	0.42	0.47	0.42	*0.43*	0.48	0.47	0.40	*0.45*	0.38	0.33	0.45	*0.38*	0.43	0.42	0.42	*ns*	*ns*	*ns*
K, %	3.52	3.48	3.65	*3.55*	3.76	3.66	3.92	*3.78*	3.70	3.68	3.87	*3.75*	3.66	3.61	3.81	*ns*	*0.17*	*ns*
Ca, %	1.09	0.96	1.03	*1.03*	0.97	1.04	0.96	*0.99*	1.01	1.02	1.02	*1.02*	1.02	1.01	1.00	*ns*	*ns*	*0.08*
Fe, ppm	285	289	336	*303*	264	257	280	*267*	279	263	230	*257*	276	269	282	*21.3*	*ns*	*19.5*
2nd season 2005/2006																		
N, %	3.21	3.43	3.52	*3.39*	3.46	3.63	3.64	*3.58*	3.56	3.71	3.58	*3.62*	3.41	3.59	3.58	*0.05*	*0.04*	*0.08*
P, %	0.40	0.42	0.44	*0.42*	0.45	0.42	0.38	*0.42*	0.38	0.44	0.41	*0.41*	0.41	0.43	0.41	*ns*	*ns*	*ns*
K, %	3.82	3.99	3.91	*3.91*	3.80	3.68	3.99	*3.82*	3.83	3.90	3.71	*3.81*	3.82	3.86	3.87	*ns*	*ns*	*ns*
Ca, %	1.07	0.97	1.13	*1.06*	1.03	1.10	0.99	*1.04*	1.03	1.08	0.99	*1.03*	1.04	1.05	1.04	*ns*	*ns*	*0.07*
Fe, ppm	321	312	295	*309*	254	276	289	*273*	301	273	263	*279*	292	287	282	*17.3*	*ns*	*ns*

Table 5: Effect of different levels of agricultural sulfur and chemical nitrogen as ammonium sulfate on chemical composition of head edible *in 1st season 2004/2005 and 2nd season 2005/2006:*

Treatments (A)	0 kg Sulfur				150 kg Sulfur				300 kg Sulfur				Mean			LSD at 5%		
Characters (B)	80 kgN	100 kgN	120 kgN	*Mean*	80 kgN	100 kgN	120 kgN	*Mean*	80 kgN	100 kgN	120 kgN	*Mean*	80 kgN	100 kgN	120 kgN	*A*	*B*	*AxB*
1st season 2004/2005																		
N, %	3.12	3.18	3.23	*3.18*	3.09	3.31	3.28	*3.23*	3.19	3.28	3.29	*3.25*	3.13	3.26	3.27	*ns*	*0.06*	*ns*
P, %	0.35	0.42	0.43	*0.40*	0.40	0.44	0.42	*0.42*	0.46	0.42	0.41	*0.43*	0.41	0.42	0.42	*ns*	*ns*	*ns*
K, %	3.19	3.08	2.97	*3.08*	3.03	2.83	3.07	*2.98*	3.25	3.17	3.42	*3.28*	3.16	3.03	3.15	*0.08*	*ns*	*ns*
Ca, %	0.58	0.55	0.59	*0.57*	0.55	0.52	0.49	*0.52*	0.60	0.53	0.51	*0.55*	0.58	0.53	0.53	*0.02*	*ns*	*ns*
Fe, ppm	87	108	116	*104*	90	91	104	*95*	91	84	90	*88*	89	94	103	*9.2*	*8.3*	*14.3*
Crude protein,%	19.50	19.90	20.19	*19.86*	19.31	20.69	20.52	*20.17*	19.94	20.52	20.58	*20.35*	19.58	20.37	20.43	*ns*	*0.35*	*ns*
Total fibers,%	14.04	13.95	13.81	*13.93*	13.97	14.01	13.58	*13.85*	13.95	13.63	13.45	*13.68*	13.99	13.86	13.61	*0.17*	*0.10*	*0.17*
2nd season 2005/2006																		
N, %	2.77	2.89	2.98	*2.88*	2.95	3.30	3.22	*3.16*	3.07	3.28	3.25	*3.20*	2.93	3.16	3.15	*0.10*	*0.05*	*0.09*
P, %	0.42	0.41	0.38	*0.40*	0.45	0.44	0.45	*0.45*	0.47	0.47	0.46	*0.47*	0.45	0.44	0.43	*ns*	*ns*	*ns*
K, %	3.12	2.92	2.86	*2.97*	3.14	2.86	2.96	*2.99*	2.92	2.89	2.79	*2.87*	3.06	2.89	2.87	*ns*	*0.12*	*ns*
Ca, %	0.59	0.52	0.60	*0.57*	0.60	0.56	0.53	*0.56*	0.59	0.46	0.50	*0.52*	0.59	0.51	0.54	*ns*	*0.03*	*0.04*
Fe, ppm	114	103	92	*103*	93	82	88	*87*	85	80	84	*83*	97	88	88	*14.6*	*ns*	*ns*
Crude protien, %	17.29	18.04	18.60	*17.98*	18.42	20.63	20.10	*19.72*	19.21	20.52	20.33	*20.02*	18.31	19.73	19.68	*0.60*	*0.33*	*0.58*
Total fiber, %	14.12	13.94	13.91	*13.99*	13.99	14.04	13.64	*13.89*	14.19	14.01	13.79	*14.00*	14.10	14.00	13.78	*0.26*	*0.15*	*ns*

It is reveals that, sulphur fertilizer caused an improvement in physical properties, i.e. head fresh weight, percentage of dry weight, dimension of head (length and diameter) as well as fresh and dry weight

of edible part. Whereas, the best value of the above mentioned parameters gained with supplying the highest sulphur rate, i.e. 300 kgs./fed., with no significant difference was detected with that level of 150 kgs./fed. These were similar with most heads yield parameters in the two experiments.

Concerning to the effect of sulphur addition and its influence on the some mineral content the presented data of Table (4) indicate that, addition sulphur resulted in higher mineral content, and crude protein in the edible head of artichoke yield. Moreover, with increasing the rate of sulphur supplying, the values of N, P, K, Ca and Fe increased. But the statistical analysis of the obtained data reveals that, the differences within different sulphur rates recorded no significance at 5% level. These were true for P, K and Fe in the two experiments and Ca only in 1st experiment.

In spite the no statistical response of many elements by the levels of sulphur addition, but, generally the presented data in Table (4) showed that, the addition of sulphur caused an increase in the nutritional elements in the tissues of edible parts of artichoke head. It is known that, present sulphur in the texture of soil had a reduction effect on the pH value of soil extract, thus improving the solubility and availability of many minerals in rooting zone, hence increasing their absorbing for plant feeding.

It could be summarized that, sulphur fertilization caused an enhancement in nutritional values of edible parts of artichoke yield. Many other workers obtained results which supported that written here (Abd El-Moez *et al*.,[11]; Shafeek *et al*.,[12] and Saleh, *et al*.,[8].

2. Ammonium sulphate: The nitrogen fertilization in the form of ammonium sulphate at levels ranging within 80 up to 120 N-units/fed. caused an encourage in the physical properties of artichoke heads yield as shown in Table (3).

The statistical analysis of that data indicated that, the differences recorded significant values at 5% level in both experiments, except that of the dry matter percentage in 2nd season. However, in most physical quality parameters of artichoke heads yield, the variation within addition of nitrogen at levels of 100 and/or 120 units/fed., was not great enough to reach the level of significant. It means, that from the economic view, it can recommended that, the suitable and proper rate of N fertilizing is within 100 up to 120 units/fed.

It could be concluded that, nitrogen fertilization caused an improvement in the physical quality of artichoke heads yield. This might be explained on the basis that N is an essential element for plant growth, that possibly increased the efficiency of photosynthesis which resulted in more accumulation of food that caused an increase in flower bud formation during the most favourable conditions, thus producing heads of high quality. The obtained results are in good agreement with the other reported by Pomares *et al*.,[29]; on artichoke plant; Fatma *et al*.,[30]; Salamah,[5]; El-Fatth *et al*.,[19]; Foti, *et al*.,[27] and Saleh *et al*.,[8].

Regarding the effect of nitrogen fertilization on some nutritional values, i.e. N, P, K, Ca, Fe, crude protein and total fibers during the two experimental seasons are shown in Table (4). In spite of the no significant effect of nitrogen addition at rates of 80, 100 and/or 120 units/fed. on the various nutritional values, but it is clear from the obtained data that, nitrogen fertilization for artichoke plant caused an increase in some nutritional values of heads yield.

Generally, the obtained data fluctuated within the two experiments, whereas, in 1st season its evident that increasing ammonium sulphate encouraged the nutritional values. On the contrary in 2nd season, since addition of the lower rate of N resulted in the highest of most nutritional values. In the two experiments the values of the total fibers recorded its lowest content with that plants which received the lowest nitrogen fertilizer rate. In addition, in both two experiments, nitrogen, Fe and crude protein in edible part of artichoke head were associated with the level of nitrogen fertilization.

It could be concluded that, the effect of N-level was more pronounced on the concentration of many elements similar results were reported by Salamah,[5]; El-Fattah, *et al*.,[19]; El-Abagy,[31]; Fatma Rizk,[22]; Shafeek *et al*.,[12] and Saleh *et al*.,[8].

3. The interaction of sulphur X ammonium sulphate: The interaction between agricultural sulphur and ammonium sulphate fertilization for artichoke plant and their effects on the some physical and/or chemical properties of heads yield are presented in Tables (3 and 4) for the two seasons, i.e. 2004/2005 and 2005/2006.

The fresh weight and/or dry weight percentage of artichoke head as a whole or as its edible part as well as head dimension, all these criteria's responsed no significantly at 5% level by the interaction treatments. These were true in both seasons with except, head length in 2nd season.

Concerning to the response of many elemental values, i.e. N, P, K, Ca and Fe, crude protein and total fibers to the interaction treatments, the recorded data fluctuated within the two experimental seasons. But its evident that, most the nutritional constituents had no great enough variation to be significantly at 5% level.

It could be concluded that the many physical and/or chemical properties of artichoke heads yield

were influenced no significantly by the interaction treatments. This might be explained on the basis that each factor of the interaction treatments act individually or independently.

REFERENCES

1. Behr, Hans-Christoph., 2001. ZMP-Marktbelanz, Gemüse, Deutschland Europäsche Union Weltmarkt. ZMP Zentrale Markt- und Preisberichtstelle GmbH, Bonn., pp: 233.
2. Wagenbreth, D., 1996. Evaluation of artichoke cultivars for growing and pharmaceutical use. Beitrage zur Züchtungsforschung - Bundesanstalt für Züchtungsforschung an Kulturpflanzen, 2 (1): 400-403.
3. Gebhardt, R., 1998. Inhibition of cholesterol biosynthesis in primary cultured rat hepatocytes by artichoke (*Cynara scolymus* L.) extracts. The Journal of Pharmacology and Experimental Therapeutics, 286 (3): 1122-1128.
4. Marschner, H., 1995. Mineral nutrition of higher plants. Academic press, London, 4th printing (1999): pp: 889.
5. Salamah, F.S., 1997. Effect of some agriculture treatments on productivity of globe artichoke under Ismailia conditions. M.Sc. thesis, Suez Canal University, Ismailia, Egypt.
6. Saleh, S.A., 2003. Physiological responses of artichoke plants to irrigation and fertilization under special recognition of salinity. Ph.D. Thesis, Chair of Vegetable Science, Center of Life Sciences Weihenstephan, Technische Universität München, Freising, Germany.
7. Saleh, S.A., H. Heuberger, G. Nitz and W.H. Schnitzler, 2003. Response of Globe Artichoke (*Cynara scolymus* L.) to different combination levels of N and K. 40. Gartenbauwissenschaftliche Tagung. BDGL-Schriftenreihe, Tagungband 21/2003.
8. Salah, S.A., S.M. Shehata, M. EL-Desuki and A.M. Shaheen, 2006. Response of artichoke plants to agriculture sulphur and chicken manure application. J. Agric. Sci. Mansoura Univ. Vol. 31, No. 11 (in press).
9. Schnug, E., 1990. Sulphur nutrition and quality of vege2s. Sulphur in Agric., (14): 3-7.
10. Ragab, E.A., 2000. Interactive effect of sulphur and lead on the growth of muskmelon (*Cucumis melo* L.) seedling. International Journal of Horticultural Science, 6 (1): 72-76.
11. Abdel-Moez, M.R., N.G. Shehata and S.A. Wanas, 2001. Impact of banana compost added with or without elemental sulphur on nutrients uptake, yield soil moisture depletion and water use efficiency of pepper plants. Annals of Agric. Sci. Moshtohor, 39 (2): 1355-1372.
12. Shafeek, M.R., Faten, S. Abdel-Al and Aisha, H. Ali, 2003. Effect of organic manure and sulphur application on productivity of Japanese rdish plant (*Raphanus sativus* L.). Annals Agric. Sci., Ain Shams Univ., Cairo, 48(2): 217-727.
13. Pregl, F., 1945. Quantitative organic, micro analysis, 1st Ed. J. and A. churdill. Ltd. London.
14. Troug, E. and A.H. Mayer, 1939. Improvement in the deiness calorimetric method for phosphorus and areseni Indian Engineering chemical annual Ed. 1: 136-139.
15. Browen, J.D. and O. Lillaland, 1946. Rapid determination of potassium and sodium in plant material and soil extracts by flame photometry. Amer. Soc. Hort. Sci., 38: 341-364.
16. A.O.A.C., 1975. Official Method of Analyses Chemists. 12th Ed. A.O.A.C. Washington, D.C. USA.
17. Chapman, H.D. and P.F. Pratt, 1978. Methods of Analysis for Soil, Plants and Waters. Univ. California, Div. Agric. Sci. Priced Pub., 4034.
18. Gomez, K.A. and A.A. Gomez, 1984. Statistical procedures for Agriculture Research Second Ed. Willey Inter Scince. Publ.
19. El-Fattah, M.A.A; M.E. Sorial; I.M. Ghoniem and A. A. Omer, 1998. Some attempts to change the production pattern of globe artichoke to meet the export requirement. Ann. of Agric. Sci. Moshtohor, 36 (2): 379-899
20. Rosati, A., R. Pepe, A.Senatore; L. Montic and V. Magnifico, 2004. Rationalising fertilizer use in Romenesco artichoke. Inforatore Agrario 60 (51): 63-66.
21. Rodrigo, M.C., J. Ginestar, M. Bois and C. Ramoo, 2005. Evaluation of rapid methods for mitate plant sap analysis of globe artichoke grown in sand cultyre. Acta Horticulturae (697): 393-397.
22. Fatma A. Rizk, 2001. Effect of some slow release nitrogen fertilizers on growth and yield of potato plant. J. Agric. Sci. Mansoura Univ., 25 (9): 5871–5886.
23. Lancaster, J.E., J Farrout. and. M.L. Show, 2001. Sulfur nutrition affects cellular sulfur, dry weight distribution and bulb quality in onion J. of the American Soc. for Horticultural Sci. 126 (2):164-168.

24. Schalz, V. and R. Elerbrock, 2002. The growth productivity and environmental impact of the cultivation of energy crops on sandy soil in Germany. Biomass and Bioenergy, 23 (2): 81-92.
25. Khayyo, S., J. Perez and C. Romos, 2004. Application of the N min nitrogen fertilizer recommend ation system in artichocke in the Valencia community. Acta Horticulturae (660): 261-266.
26. Pomares, F., C. Baixaull, J.M. Aguilar, A. Giner, F. Tarazone, J. Gomez and R. Albiach, 2004. Effects of water and nitrogen fertilization on seed grown globe artichocke. Acta Horticulurae (660): 303-304.
27. Foti, S., G Mauromicale and A. Lerna, 2005. Response of seed grown globe artichoke to different levels of nitrogen fertilization and water supplies, Acta Horticulturae (681): 237-242.
28. Lerna, A., G. Mauromicale and P. Licandro, 2006. Yield and harvest time of globe artichoke in relation to nitrogen and phosphorus fertilization. Acta Horticulture (700): 115-119.
29. Pomares, F., F. Tarazona, M. Estela, R. Baertual and L. Ariciniage, 1993. Response of globe artichoke to nitrogen, phosphrous and potassium fertilizer. Agrochimica 37 (1/2): 111-121.
30. Fatma A. Rizk, H.M.E. Abagy and A.M. Shaheen, 1997. Influence of hand hoeing and some herbicidal treatments on yield and quality of Artichoke and its associated weeds. Ann. of Agric. Sci. Moshtohor, 35 (3): 1697-1711.
31. El-Abagy, H.M.H., 2000. Effect of nitrogen, phosphorus and potassium fertilization levels on plant growth, chemical composition and yield of Jerusalem artichoke (*Helianthus tuberosus* L.). Ann. of Agric. Sci. Moshtohor, 40 (3): 1755-1765.