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Effect of Different Sulphur Rates, Organic and Inorganic Nitrogen Fertilizers on Pea Plants

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ABSTRACT

Two field experiments were carried out in the Research and Production Station, National Research Centre, Nubaria Site during the seasons of 2021 and 2022 to study the response of pea plants to sulphur addition (0, 200, and 400 Kg S/fed.) with organic (Nile compost) and/or inorganic (chemical) nitrogen fertilizers. The important results are as follows: The characteristics of pea plant growth as expressed by length, average leaf and stem numbers, as well as the fresh and dry weights of the plant, all of them had their peaks with the addition of sulphur at 400 kg/fed. The response of pigment content to the sulphur addition followed the same pattern of change as the plant growth. When comparing the chemical nitrogen fertilizer to the organic nitrogen source, all plant growth parameters as well as chlorophyll (a), (b), and carotenoids content recorded the highest significant values. The interaction treatments within sulphur and nitrogen sources showed that the most vigorous growth of plants and their highest pigment content resulted when plants received 400 kg of sulphur with mineral nitrogen fertilizer. With increasing sulphur addition rates, the highest weight of pods yield and green seeds of pea significantly increased. Mineral nitrogen sources caused an enhancement in total pod yield as compared to organic nitrogen. The elemental nutrition values (N, P, and K) exhibited higher values with mineral nitrogen fertilizer, but Fe, Mn, Zn, and Cu had no significant increase with organic nitrogen. The effect of sulphur as an individual and/or combined with nitrogen sources had a fluctuating effect on element concentrations.

Keywords: pea (*Pisum sativum* L.) sulphur, Organic and Inorganic, yield

1. Introduction

In general, soils rarely contain enough nutrients for crops to produce their maximum yield. To improve soil fertility and improve crop yield, farmers usually apply soil amendments (organic or synthetic amendments) that are high in nutrients like N, P, and K (Ahmad *et al.,* 2009). With increasing use of mineral fertilizers and questions as to their future availability, there is renewed interest in organic fertilizers, especially organic recycling, to improve soil fertility and productivity (Parr and Hornick, 1990).

All living organisms, including plants, require sulphur as one of their essential elements. In addition, sulphur is a component of a number of secondary metabolites (SMs) that are essential for the growth, development, and physiological processes of plants. Sulfur is a component of proteinogenic amino acids such as methionine, cysteine, glutathione, vitamins (biotin and thiamine), phytocalin, chlorophyll, coenzyme A and S-adenosyl-methionine. Also, sulphur deficiency has become a limiting factor for crop yield and its quality (Mc Grath *et al.,* 1996; Pacyna *et al.,* 2008; Leustek and Saito, 1999; Li *et al.,* 2020; Nakai and Maruyama-Nakashita, 2020; Aarabi *et al.,* 2020). Plant sulphur requirements and metabolism are closely related to nitrogen nutrition (Reuveny and Trinity, 1980), whereas N metabolism is also strongly influenced by the plant's S status (Duke and Reisenauer, 1986).

The sulphur element plays a great role in plant metabolism and supplying it to the soil caused a reduction in soil extract pH, consequently enhancing the solubility and availability of many other elements. Many investigators indicated that sulphur addition improved vegetable plant growth and yields (Schung 1990; Patel *et al.,* 1992; Sharma and Room, 1993; El Sawy and Hassan 1994; and Saleep

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and Abd El- Ghani, 2000). . Moreover, the conventional nitrogen fertilizer ammonium sulphate it's rapidly lost by either evaporation or by leaching in the drainage water. The problem does not only stop at losing big amounts of nitrogen, but it extends to other dangerous accumulations of nitrate in groundwater. Legume crops obtain N mainly from symbiotic N2- fixation, whether this is due to a direct effect on the symbiotic N2- fixation or an effect on the host plants is not very clear (Robson, 1983).

One of the most important winter legume vegetable crops in Egypt is the pea (*Pisum sativum* L.), which is cultivated for both local consumption and exportation. Increasing the productivity as well as the cultivated area, led to increasing the use of chemical fertilizers which increased production costs as well as environmental pollution**.**

Application of organic manure enhances the availability of organic elements in soil, improving crop nutrient use efficiency (NUE) and reducing the negative effects of climate change on crop productivity (Liang *et al.,* 2018). Organic manure contains higher levels of relatively available nutrient elements, which are essentially required for plant growth. Moreover, it plays an important role in improving soil physical properties (Awad, 2002). The supplying vegetable crops with organic and inorganic fertilizers were proved to be very essential for producing higher yields and quality (Saimbhi and Grewal, 1986; Prasad and Prasad 1999).

The aim of this work was to study the effect of sulphur addition with both organic and/or inorganic nitrogen fertilizers on the productivity of pea plants.

2. Materials and Methods

2.1. Soil analysis

Physical and chemical properties of the Nubaria soil were determined, as well as particle size distribution and soil moisture, as described by Blackmore (1972). Soil pH, EC, cations and anions, organic matter, $CaCO_3$, total nitrogen, and available P, K, Fe, Mn, ZN, and Cu were determine according to Black *et al.,* (1982). The determination of soluble, available, and total cobalt was determined according to the method described by Cottenie *et al.,* (1982). Some physical and chemical properties of Nubaria soil are shown in Table 1.

Table 1: Physical and chemical properties of Nubaria soil

Physical	**Particle size distribution (%)**			**Soil texture class**	**Saturation**	**Field capacity**	**Wilting point**	**Available water**			
	Sand	**Silt**	**Clay**	**Sandy loam**		**%**					
	82.6	14.6	2.8		20.0	14.4	3.9	10.5			
Chemical	**PH (1:2.5)**	**EC (ds/m)**	**Soluble cations (meq/l)**				**Soluble anions (meq/l)**				
			Ca^{++}	**Mg^{++}**	**K^+**	**Na^+**	**HCO_3^-**	**CO_3^-**	**Cl^-**	**$SO_4^=$**	
	8.3	1.2	9.2	1.6	3.9	3.31	--	1.18	5.68	2.4	
Total		**Available**	**Available micronutrients**				**Cobalt**			**$CaCO_3$**	**OM**
	(ppm)		**(ppm)**				**(ppm)**			**%**	
N	**P**	**K**	**Fe**	**Mn**	**Zn**	**Cu**	**Soluble**	**Available**	**Total**		
25.2	13.3	21.2	16.5	7.8	3.84	5.22	0.35	1.75	9.64	3.17	0.19

2.2. Experimental design

Two field experiments were carried out at the Research and Production Station, Nubaria site, National Research Centre, Beheara Governorate, Egypt, under the drip irrigation system during the winter 2021–2022 seasons. Seeds of pea (*Pisum sativum* L.) were inoculated prior to sowing with a specific strain of rhizobium. Seeds of peas were sown during the winter seasons of 2021, 2022 to study the effects of different agricultural sulphur addition at a rates (0, 200, and 400 kg/fed.) and nitrogen fertilizer (i.e., organic) on plant growth, pigment content, pod yield, and its physical and chemical properties. Whereas the used organic source of nitrogen was Nile compost (coming from recycling the agricultural residues), the source of inorganic nitrogen was ammonium sulphate (20.6 of N).

The rate of nitrogen which was used in both organic and inorganic sources was 41.2 units/fed. Phosphorus was applied in the form of calcium super-phosphate at a rate of 200 kg S/fed., and potassium was applied in the form of potassium sulphate at a rate of 100 kg S/fed. whereas the chemical nitrogen was added in two equal amounts, the first when the soil was prepared for seeding and the second 45 days later. Phosphorus and potassium fertilizers were added at one time, before sowing and 30 days old, respectively. Whereas the organic manure (Nile compost) was applied during preparing the soil for sowing. Table (2) shows the chemical analysis of Nile compost.

Table 2: The chemical analysis of the used Nile compost.

Character	Units	Nile compost
Weight of qubic meter	Kg	400
Moisture	%	30
pH		7
EC	mmhos	5
Organic carbon	%	41
Organic Matter	%	70
Total nitrogen	%	2
C/N ratio		1:17
Total phosphorous	%	0.6
Total potassium	%	6.0
Iron	mg/ kg	7900
Manganese	mg/ kg	190
Copper	mg / kg	20
Zinc	mg / kg	4.75

Each experiment consisted of 6 treatments, which were the simple combinations of 3 rates of sulphur and the two nitrogen fertilizer sources. The factorial experiment in a split-plot design with 3 replications, where sulphur addition rates were allocated in the main plots and sources of nitrogen fertilizers were distributed randomized within the sub-plots. Each experimental sub-plot consisted of 4 ridges, 5 meters in length and 80 cm in width (plot area16 m^2).The seeds of pea cv. Little Marvel was sown on the last week of February in both 2020-2022 seasons. The seeds were sown on one side of the ridge, 20 cm apart, and the normal cultural practices commonly used in the growing and irrigation of peas were followed:

Two months after seeding time, foliage samples were collected from every experimental plot and the following vegetative growth parameters were recorded: plant length (cm). Number of leaves and stems per plant total fresh and dry weight of whole plant (g. /plant) and its different organs i.e. shoots and leaves.

Also, foliage samples were taken to the determination of total pigments, i.e. chlorophyll a, b and carotenoids as mg/100 g. fresh wt. according to the methods described by Wetstein (1957).

Pea pods were harvested weekly at 3^{th} picking 10 pods were collected and the following parameters were measured: length (cm) and weight of seeds (g. /pod) as well as the weight of green seeds.

The weight of pods for each experimental plot was recorded and the weight per feddan was accounted. Samples of green seeds were taken for the chemical determination of the elemental nutrition content, whereas N, P and K were determined according to the procedure described by Brown and Lilleland (1946), Fe, Mn, Zn, and Cu contents were determined according to the method described by Champman and Pratt (1978).

All obtained data values were subjected to the analysis of the variance according to Gomez and Gomez (1984).

3. Results and Discussion

3.1. Plant growth characteristics

3.1.1. Effect of sulphur addition

Tables (3 and 4) show clearly that pea plant growth characters were statistically significantly influenced by the different additions of the sulphur element in both seasons, except an average number of stems in 2^{nd} season. However, obtained data indicated that with increasing the agricultural sulphur addition up to 400 kg S /fed. the length of the plant, the average number of leaves and stems total fresh and dry weights of the plant and its different organs, all of which recorded their peaks. This result means that the poorest plant growth of peas resulted with plants that did not receive sulphur, but the vigor of plants resulted from plants that received the highest level (400 kg S. /fed.) of sulphur. These findings were true in the two experimental seasons.

It could be concluded that sulphur addition caused an enhancement in plant growth parameters. It may be due to the role of sulphur in reducing the pH values of soil solution and consequently the solubility of the fixed soil minerals, hence its quantity is enough in the rooting zone.

In addition, it is known that the sulphur element is one of the major necessary elements of nutrition for plants. Many investigators studied the role of sulphur in increasing the vegetative plant growth with many vegetable crops such as bean Liuch *et al.,* (1983) on bean Bakry *et al.,* (1988) on cowpea and Nour (1989) ; Omar *et al.,*(1989) and Mohammed and Kandeel (1998) on pea plants.

Table 3: Effect of sulphur addition and different nitrogen fertilizer sources on plant growth characters during 2021 and 2022 seasons.

Sulphur Kg /fed	Nitrogen source	Plant length	Number of		Fresh weight g/ plant			Dry weight g/ plant		
			leaves	Stems	Leaves	Stems	Total	leaves	Stems	Total
0	Organic	43.00	11.00	1.67	39. 33	52.60	91.93	12.91	10.23	23.14
	Mineral	48.00	13.00	2.67	47.00	55.60	102.60	15.10	16.43	31.53
Mean		45.50	12.00	2.17	43.17	54.10	97.27	14.00	13.33	27.34
200	Organic	46.67	12.00	2.67	55.67	58.73	114.40	17.07	15.83	32.90
	Mineral	58.33	14.67	3.00	90.33	71.87	162.20	29.27	22.60	51.87
Mean		52.50	13.33	2.83	73.00	65.30	138.30	23.17	19.22	42.38
400	Organic	57.33	17.00	3.33	72.00	60.07	132.07	19.83	18.47	38.30
	Mineral	69.00	18.00	3.67	108.33	87.22	195.60	37.60	27.70	65.30
Mean		63.17	17.50	3.50	90.17	73.67	163.83	28.72	23.08	51.80
Averages	Organic	49.00	13.33	2.56	55.67	57.13	112.80	16.60	14.84	31.45
	Mineral	58.44	15.22	3.11	81.89	71.58	153.47	27.32	22.24	49.57
L.S.D. at 5% level:										
Sulphur		0.63	1.69	0.46	2.51	9.84	9.46	2.10	1.81	3.18
Fertilizer source		0.79	0.19	N.S	2.73	4.74	5.40	0.99	0.43	1.14
Interaction		1.37	0.33	N.S	4.72	8.21	9.34	1.71	0.75	1.97

Table 4: Effect of Sulphur addition and different nitrogen fertilizer sources on plant growth characters during 2021 and 2022 seasons.

Suphlur Kg /fed	Nitrogen source	Plant length	Number of		Fresh weight g/ plant			Dry weight g/ plant		
			leaves	Stems	leaves	Stems	Total	leaves	Stems	Total
0	Organic	42.00	10.67	1.33	40.40	46.53	86.93	13.41	9.83	23.25
	Mineral	48.67	13.33	1.67	46.93	55.93	102.87	15.10	16.93	32.03
Mean		45.33	12.00	1.50	43.67	51.23	94.90	14.26	13.38	27.64
200	Organic	44.33	11.67	2.33	55.87	51.80	107.67	17.63	15.47	33.10
	Mineral	57.00	16.00	2.67	91.00	69.60	160.60	29.07	18.80	47.87
Mean		50.67	13.83	2.50	73.43	60.70	134.13	23.35	17.13	40.48
400	Organic	55.67	15.33	2.33	62.87	58.30	121.17	19.89	18.27	38.16
	Mineral	68.00	17.33	3.00	106.67	87.60	194.27	38.41	27.53	65.94
Mean		61.83	16.33	2.67	84.77	72.95	157.72	29.15	22.90	52.05
Averages	Organic	47.33	12.56	2.00	53.04	52.21	105.26	16.98	14.52	31.50
	Mineral	57.89	15.56	2.44	81.53	71.04	152.58	27.52	21.09	48.61
L.S.D. at 5% level:										
Sulphur		3.25	0.84	N.S	6.78	1.72	6.63	1.74	1.65	2.10
Fertilizer source		0.58	0.27	N.S	6.18	3.21	8.46	0.80	1.04	1.20
Interaction		1.00	0.47	N.S	10.71	5.56	14.66	1.38	1.81	2.08

3.2. Effect of nitrogen source

The presented data in Tables (3 and 4) clearly showed that inorganic fertilizer (Ammonium sulphate) had a superiority compared with the addition of organic nitrogen. These results were true in the two experimental seasons and for all plant growth characters. The statistical analysis of the obtained data reveals that the differences within the organic and mineral nitrogen treatments were enough to be significant at 5% level, concerning all plant growth parameters, with the exception of the average number of stems in both seasons.

It could be concluded that pea plants supplied with ammonium sulphate fertilizer (400 kg N/ fed.) were more vigor than those supplied with organic (Nile compost). This superiority might be attributed to the availability and speed of solubility of chemical nitrogen, as the rooting system of the pea plant directly absorbed it in a short time (El-Batal and Abdel and Salam, 1992).

3.3. Effect of the interaction

The interaction treatments between different sulphur addition and sources of nitrogen fertilizer (organic and /or mineral) had a statistically significant effect on pea plant growth characters (Tables 3 and 4). These were true for all parameters of plant growth, with the exception of the average number of stems. These findings were similar in the two experimental seasons.

Generally, the tallest pea plants, which carried the highest number of leaves and stems, and the heaviest dry weight of the whole plant and its different organs, all of them were obtained with plants that received the highest amount of agricultural sulphur (400 kg S./ fed.) and with using mineral nitrogen as fertilization. The two experiments confirmed these findings.

3.4. Pigments content

3.4.1. Effect of sulphur addition

The addition of sulphur at rates up to 400 kg/fed. for pea plants statistically significantly affected the pigment contents (Table 5). Generally, with increasing rates of Sulphur, the content of total pigments (Chlorophyll a, b and carotenoids) increased to record their peaks with plants that received the highest Sulphur rates (400 kg/ fed.). The superiority in chlorophylls and carotenoid content with adding sulphur might be its important role in plant metabolism. Many workers had a similar trend, which supported the obtained data (Mohammed and Kandeel 1998).

Table 5: Effect of different rates of sulphur addition and nitrogen sources on the pigment content in pea plant leaves during 2021 and 2022 seasons.

Sulphur Kg / fed.	Fertilizer source	mgs/100g. fresh wt.				mgs/100g. fresh wt			
		Chl.(a)	Chl.(b)	Caroten	Total	Chl.(a)	Chl.(b)	Caroten	Total
			First Season		Second Season				
0	Organic	0.441	0.209	0.414	1.064	0.411	0.300	0.403	1.114
	Mineral	0.467	0.326	0.452	1.245	0.434	0.313	0.427	1.173
Mean		0.454	0.268	0.433	1.155	0.423	0.306	0.415	1.144
200	Organic	0.548	0.278	0.386	1.212	0.419	0.305	0.384	1.108
	Mineral	0.569	0.360	0.403	1.332	0.493	0.320	0.390	1.204
Mean		0.559	0.319	0394	1.272	0.456	0.313	0.387	1.156
400	Organic	0.683	0.342	0.295	1.320	0.491	0.313	0.305	1.110
	Mineral	0.726	0.383	0.316	1.425	0.560	0.346	0.325	1.231
Mean		0.705	0.363	0.305	1.373	0.526	0.330	0.315	1.170
Averages	Organic	0.557	0.276	0.365	1.199	0.440	0.306	0.364	1.110
	Mineral	0.587	0.356	0.390	1.334	0.496	0.326	0.381	1.203
L.S. D. at 5 % level:									
Sulphur		0.005	0.012	0.010	0.011	0.006	0.004	0.008	0.011
Fertilizer source		0.003	0.008	0.004	0.010	0.010	0.004	0.003	0.013
Interaction		0.006	0.014	0.007	0.017	0.018	0.007	0.006	0.023

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3.4.2. Effect of nitrogen sources

Table (5) shows clearly that pea plants that were supplied with nitrogen fertilizer in the mineral form had higher values of chlorophyll and carotenoids. Moreover, statistical analysis of the obtained data reveals that the differences between using organic and /or mineral sources of nitrogen concerning its effect on the pigment content were enough to be significant at 5 % level. These findings were true in both experimental seasons. The more green pea plants that received mineral nitrogen, may be attributed to the availability and the greater solubility of chemical nitrogen compared to the organic one, consequently speeding its absorption by the rooting system.

It is known that nitrogen plays an important role in photosynthetic and other metabolic processes in plant tissues. In addition, Nitrogen is present in the chlorophyll molecule and is a major component of all proteins (Takebe *et al.,* 1995).

3.4.3. Effect of the interaction

The interaction between nitrogen sources and sulphur addition treatments as well as its effect on the pigment content (chlorophyll a, b and carotenoids) are presented in Table (5). The obtained data showed that the highest values of chlorophyll a and b were determined in tissues of plant leaves of pea plants that received the highest rate of sulphur, i.e. 400 kg S / fed. With fertilization by mineral nitrogen. Concerning the carotenoid contents, its highest values were found in tissues of pea plants without adding sulphur, but fertilized by mineral nitrogen. These findings were true in the two experimental seasons. The statistical analysis of the obtained data indicates that the response of total pigments and their fractionations by the interaction treatments is significantly at 5 % level.

3.5. Total pod yield and its some physical and chemical properties

3.5.1. Effect of sulphur addition

Tables (6 and 7) indicate clearly that adding sulphur within the range of up to 400 kg S./ fed. this resulted in an increase in the total pods and green seed yield of pea plants, as well as the physical and chemical properties of the pod yield. Whereas, with increasing sulphur rate up to 400 kg /F., the total yield and its quality recorded a constant and gradually increase.

Table 6: Effect of different rates of sulphur addition and nitrogen sources on total yield of pea plant and its nutritional values during 2021 and 2022 seasons.

Treatments		Total yield t / fed		Pod physical properties			Macronutrients (%)			Micronutrients (ppm)			
Sulphur Kg/ fed	Nitrogen Source	Pods	Green seeds	Length cm.	Wt. g/pod	Seeds wt. g/ pod	N	P	K	Fe	Mn	Zn	Cu
0	Organic	2.04	0.836	6.57	3.47	1.43	0.40	1.33	1.68	500.0	25.00	25.00	30.00
	Minerals	2.36	1.11	8.30	4.11	1.96	0.53	1.96	1.80	500.0	50.00	40.00	45.00
Mean		2.20	0.973	7.43	3.79	1.69	0.46	1.64	1.74	500.0	37.50	32.50	37.50
200	Organic	2.47	0.963	7.64	4.45	1.75	0.80	1.47	2.08	200.0	40.00	50.00	35.00
	Minerals	2.96	1.33	9.10	4.71	2.15	0.52	1.13	1.60	98.33	15.00	25.00	40.00
Mean		2.71	1.145	8.28	4.8	1.95	0.56	1.30	1.84	149.2	27.50	37.50	37.50
400	Organic	3.06	1.33	8.00	4.89	2.34	0.57	2.03	1.68	300.0	60.00	70.00	80.00
	Minerals	3.28	1.67	10.77	5.23	2.61	0.54	2.12	1.84	400.0	30.00	45.00	40.00
Mean		3.17	1.50	9.38	5.06	2.47	0.55	2.08	1.76	350.0	45.00	57.50	60.0
Average	Organic	2.52	1.36	7.34	4.27	1.84	0.52	1.61	1.81	333.3	41.67	48.33	41.67
	Minerals	2.87	1.58	9.68	4.68	2.24	0.53	1.74	1.75	332.8	31.67	36.67	41.67
L.S.D. at 5% level:													
Sulphur		0.17	N.S	0.39	0.44	0.22	0.02	0.10	N.S	46.29	2.31	4.63	2.31
Fertilizer source		0.06	N.S	0.23	0. 04	0.05	N.S	N.S	N.S	N.S	N.S	3.72	N.S
Interaction		0.10	0.25	0.40	0.07	0.08	0.05	0.18	0.09	57.70	16.82	6.45	12.24

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Table 7: Effect of different rates of sulphur addition and nitrogen sources on total yield of pea plant and its nutritional values during 2021 and 2022 seasons.

Treatments		Total yield t/fed		Pod physical properties			Macronutrients (%)			Micronutrients (ppm)			
Sulphur Kg/ fed	**Nitrogen Source**	**Pods**	**Green seeds**	**Length cm.**	**Wt. g/pod**	**Seeds wt. g/ pod**	**N**	**P**	**K**	**Fe**	**Mn**	**Zn**	**Cu**
0	**Organic**	1.91	0.85	6.33	3.63	1.64	0.48	1.60	1.78	589.0	26.17	30.00	35.67
	Minerals	2.02	1.09	7.77	4.37	2.38	0.64	2.38	2.01	603.3	55.00	49.33	54.67
	Mean	1.97	0.97	7.05	4.00	2.01	0.56	1.99	1.90	596.2	40.58	39.87	45.17
200	**Organic**	1.98	0.91	7.00	4.56	2.07	0.72	1.76	2.29	233.3	41.00	59.33	42.00
	Minerals	2.39	1.33	8.63	4.76	2.64	0.63	1.43	1.83	128.0	16.50	31.00	48.67
	Mean	2.18	1.12	7.82	4.66	2.35	0.67	1.59	2.06	180.7	28.75	45.17	45,33
400	**Organic**	2.22	1.28	7.70	4.83	2.81	0.68	2.40	1.85	356.7	64.33	83.00	71.33
	Minerals	3.19	1.88	10.50	5.16	3.07	0.65	2.55	2.06	480.0	33.00	56.83	50.00
	Mean	2.71	1.57	9.10	4.99	2.94	0.66	2.47	1.95	418.3	48.67	69.83	60.67
Average	**Organic**	2.04	0.99	7.01	4.34	2.17	0.63	1.92	1.97	393.0	43.83	57.44	49.67
	Minerals	2.53	1.41	8.97	4.76	2.70	0.64	2.12	1.97	403.8	34.83	45.67	51.11
L.S.D. at 5% level:													
Sulphur		0.04	N.S	0.52	0.45	0.33	0.03	0.10	N.S	48.66	1.94	5.75	4.63
Fertilizer source		0.04	0.25	0.31	0.10	0.11	N.S	0.11	N.S	N.S	N.S	3.91	N.S
Interaction		0.07	N.S	0.53	0.17	0.18	0.06	0.18	0.10	68.43	18.61	6.78	15.4

These findings were true in the two experiments for all pods yield assessments, with the exception of the K and Fe concentrations. Moreover, the statistical analysis of the obtained data reveals that the different sulphur treatments significantly affected the total pods yield and its components.

It could be summarized that the sulphur addition at different rates caused an enhancement in total pods yield and its components. These findings agree with those of Saleep and Abd El-Ghani (2000).

Concerning elemental nutrition, the statistical analysis showed that the treatments of sulphur addition had significant differences. These held well in the two experiments, except that of Zn in two seasons.

It could be concluded that adding sulphur to pea plants caused an enhancement in total pods yield and its components as well as improved the physical and chemical properties of yield. Many investigators obtained similar trends supporting the obtained data (Saleep and Abd El-Ghani, 2000).

3.6. Effect of nitrogen sources

Also, the mineral fertilization recorded 1.38 and 1.41 tons/ fed. of the green seeds of a pea if compared to 1.36 and 0.99 tons/fed. for the organic production in the 1st and 2nd seasons, respectively.

The response of the pod physical assessments, i.e. length, weight, and its seeds weight, all followed the same pattern of change that was above mentioned. It means that the better physical quality of pea pods was obtained with those plants receiving nitrogen fertilizer as the chemical source. Moreover, the statistical analysis of the obtained data indicates that the differences between the two treatments were enough to be significant at 5 % level. All of these were true for all criteria of pods yield and its physical quality, except the weight of green seeds in both seasons.

The response of the total pods yield of the pea plant and its components to the nitrogen fertilizer followed the same pattern of change as that obtained by El-Afifi *et al.,* (1995) and Zdrakovic *et al.,* (2002).

Concerning the chemical composition of seed tissues, particularly nitrogen and phosphorus percentages, data from both experiments show that higher percentages resulted from receiving nitrogen fertilizer in the mineral form. The other nutritional elements, i.e. K, Fe, M, and Zn recorded fluctuation values within the two experiments.

It could be concluded that using organic manure (Nile compost), which came from recycling agricultural residues, gave nutritional values equal to or a little less than that were obtained when chemical nitrogen fertilizers were used.

Previous research on the benefits of organic and/or inorganic nitrogen fertilizer, particularly for the nutritional value of pea pods and yields, is consistent with El-Basyouny (1995) and Ahmed *et al.* (2002).

3.6.2. Effect of the interaction

The interaction treatments between sulphur addition rates and nitrogen sources had a significant effect on the total pods yield of peas and their physical and chemical properties in both seasons, except for the yield of green pea seeds in 2nd season.

Generally, the heaviest pods and seed yield and the highest physical quality of pods were all recorded with plants which received 400 kg S. / fed. with the application of mineral fertilizer.

Organic nitrogen fertilization had the highest nitrogen and potassium values when sulphur was added at a rate of 200 kg S/fed, but the highest Mn, Zn, and Cu values were obtained when sulphur was added at a rate of 400 kg S/fed. Concerning phosphorus, it recorded its highest values with the sulphur addition at 400 kg S. /fed. with mineral nitrogen fertilizer.

The pea plants which received mineral nitrogen fertilizer only without sulphur application gained the highest values of Fe in their seed yield tissues. The previously mentioned results held good in the two experiments.

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