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EFFECT OF DIFFERENT FERTILIZATION SOURCES ON GROWTH, CHEMICAL COMPOSITION AND YIELD OF PEA PLANTS GROWN UNDER FOLIAR APPLICATION OF ZINC

Salwa A.R. Hammad and Sabah M. El-Gamal
Agric Botany Dept., Faculty of Agric., Minufiya Univ., Shibin El-Kom, Egypt.

ABSTRACT

Two pot experiments were carried out during two winter seasons of 2002/2003 and 2003/2004 at the Experimental Station Farm of the Faculty of Agriculture, Minufiya University to study the effects of different fertilization sources (mineral P, organic fertilizer and biofertilizer) and four zinc levels (0.0, 100, 200 and 400 mg / l) as well as their interactions on growth, chemical composition and yield of pea plants. Growth characters were significantly increased by all fertilization treatments in both seasons. Meanwhile root dry weight did not significantly increased, whereas inorganic P and biofertilizer produced the highest values in most causes as compared to control. On the other hand, Zn application significantly increased leaf area and dry weights of pea plant organs. The combination of P with Zn at 200 mg /l significantly increased the leaf area, meanwhile, the application of biofertilizer combined with Zn application (100 mg / l) gave the highest values of the dry weights of root, stem and leaves. The concentrations of photosynthetic pigments (Chl. a, Chl. b and carotenoids), total carbohydrates (T.C), total free amino acids (T.A.A) and minerals (N, P, K and Zn) significantly increased by all fertilization treatments. Also, the obtained results recorded an increase in total soluble sugars (T.S.S) in pea leaves as compared to control plants. The highest values of T.S.S, T.C, T.A.A, N% and K% were obtained by biofertilizer, meanwhile the highest values of Chl. a, Chl. b, carotenoids, P and Zn were recorded with organic fertilizer. Zn treatments stimulated all chemical characters, the highest values were recorded under Zn treatment (400 mg / l) as compared to control. The combination of Zn and fertilization treatments showed a significant increase in Chl. a, Chl. b, T.S.S, T.C and T.A.A as well as carotenoids concentrations. Fertilization treatments significantly increased number and weight of seeds/plant, 100-seed weight and pod green weight. The highest values of seed weight/plant were recorded by organic fertilizer. Spraying plants with Zn significantly enhanced weight of seeds/plant and pod green weight. The combinations between Zn and different fertilizer treatments showed a significant increase in seed dry weight/plant, weight of green pods and 100-seed weight.

Keywords: Pea (*Pisum sativum* L.), P, organic fertilizers, biofertilizer, zinc, growth, chemical composition, yield.

INTRODUCTION

Pea (*Pisum sativum* L.) is considered one of the most important legume crops cultivated in Egypt. It is well known that the lack of macro and micronutrients and low organic matter are that the main characteristics of such soil. Many investigators reported the importance of zinc application for improving plant growth and yield attributes of groundnut (Sontakey *et al.* 1999) and it has positive effects on growth and yield of legume plant (El-Fadaly *et al.* 1980 and Ibrahim, 1990).

Organic matter plays an important role in improving the properties of soil. It plays a key role in the behavior of micronutrients in the soil. Both soluble and insoluble complexes are formed substantial evidence which play a prominent role in the dissolution of micronutrients and their transportance to plant roots. Abdel-Kariem (1989) found that, the addition of organic manures either alone or combined with $ZnSO_4$-$7H_2O$ increased dry matter yield of barley plant at different growth periods and N concentration of this plants. Moreover, growers neglected organic fertilization due to an excessive use of mineral fertilizers which gave maximum yield. However, in long term field experiments wehre mineral fertilizers have only been used soil structure have deteriorated and crop yield steady decreased (Ibrahim *et al.*, 1986).

There are several reports on the inoculation with azosprillium which increased dry weight of broad bean plants. El-Zeiny *et al.* (2001) showed that, treating tomato seeds with biofertilizers improved plant growth characters, chemical constituents and total yield. In addition El-Shal *et al.* (2002) found that, the application of biofertilizer (Halex 2) with micronutrients using spraying method significantly encouraged the different growth parameters and increased the yield of lettuce plants.

The role of zinc in plant is due to its requirement in the synthesis of tryptophan which is a precursor of indole acetic acid and the formation of this growth substance is directly influenced by Zn. It has also an important role in starch metabolism and closely involved in N-metabolism in plant. It is well known that zinc acts a co-factor of many enzymes and affects many biological processes such as photosynthesis reactions, nuclecie acids metabolism, protein and carbohydrate biosynthesis (Marschner, 1996).

The objectives of our research were to investigate the effect of different organic and bioorganic phosphorus fertilizers on growth, chemical composition and yield of pea plants grown under foliar application of zinc.

MATERIALS AND METHODS

Two pots experiments were carried out at the Experimental Station Farm, Faculty of Agriculture, Minufiya University during the winter seasons of 2002/2003 and 2003/2004, to investigate the performance of pea cultivar Master-B in relation to different organic and bioorganic phosphorus fertilizers with different levels of zinc.

Pea seeds were planted on October 10^{th} in the first season and October 6^{th} in the second at the rate of 10 seeds per pot, each holding 7 kg air-dry Nile clay soil. Some physical and chemical properties of soil used were determined according to Jackson (1967) which were expressed as percentage: $CaCO_3$ 1.7, sand 5.63, silt 43.6, clay 49.07. whereas the chemical properties were, pH 7.6, E.C., 0.52 mmhos / cm, organic matter, 1.56, Ca^{+2}, 30.2, Na^{+1}, 1.01, K^{+1} 1.21, HCO_3^{-1} 1.1, Cl^{-1} 1.5, SO_4^{+2} 1.95. Pots were 25 cm inner diameter and 30 cm in depth. Twenty days after sowing plants were thinned to leave three plants per pot.

Four treatments of different fertilization sources were conducted:

1. P_0, No application of phosphatic fertilizer.
2. P_1, 45 kg superphosphate 15% P_2O_5 / fed. (6.75 kg . P_2O_5 / fed.) was added

and mixed with soil before planting.

3. Organic fertilizer (compost) was added with soil at the rate of 2 ton per feddan before sowing. The characteristics of compost were determined according to El-Kouny (1999) which were expressed as percentage: dry matter 75.35, black density 620.50 kg m^3, E.C. 5.67 mmhos/cm^2, pH 7.1, total organic carbon 45.31, total N 3.18, C/N ratio 14.24, P 2.75, K 2.89, ash 18.51, humic substances 21.35.
4. Biofertilizer (Halex 2) was mixed with seeds (10 g/kg seeds) which was kindly supplied by Prof. Dr. M.G. Hassouna, biofertilization Unit Plant Pathology, Dept., Alex. Univ.

Zinc sulphate ($ZnSO_4 . 7H_2O$) was used as a source of zinc at the levels of 0.0, 100, 200 and 400 mg / l. Plant were sprayed by Zn solutions at two times, 30 and 45 days after sowing. Few drops of triton-B were added to the spraying solutions as a wetting agent.

A split-plot design with fertilizers (P, organic and biofertilizer) as main-plot treatments and the concentrations of Zn as sub-plot treatments with 3 replications was used in this study.

All pots were fertilized with N and K fertilizer in amount equivalent to 100 kg/fed. ammonium sulphate (20.5% N) at the rate of 2.25 g/pot and potassium sulphate (48% K_2O) at the rate of 0.71 g/pot at various growth stages represent 30 and 60 days after planting.

The plant samples were taken at 75 days from sowing and the following data were recorded:

1. Growth analysis:

Plant height (cm), number of leaves / plant, leaf area (cm^2 / plant) were estimated by using the dry weight method as suggested by Roods and Bloodworth (1964), dry weight of leaves, stems and roots (separated and dried at 70°C till a constant weight).

2. Chemical constituents:

a) **Photosynthetic pigments:** were extracted from fresh leaves by acetone 85% and estimated according to Wettestein (1957), then calculated in mg . g^{-1} dry weight.

b) **Total soluble sugars (T.S.S), total carbohydrates (T.C) and total free amino acids (T.A.A):** 0.1 g of dried leaves was extracted by ethyl alcohol 100% for their chemical analysis, T.S.S and T.C were determined according to Dubois *et al.* (1956) and T.A.A was determined according to Rosen (1957), then calculated in mg . g^{-1} dry weight.

c) **Minerals concentration:** 0.2 g of dried leaves was digested in H_2SO_4 : H_2O_2 (5 : 1) for chemical analysis of minerals, N, P, K and Zn. Total nitrogen was determined using micro-kjeldahel method described by A.O.A.C (1975), P was estimated according to Chapman and Pratt (1961), K was determined using flame photometer according to Allen (1974) and Zn by atomic absorption spectrophotometer (Cottenie, 1980).

3. Yield and its components:

At the end of the experiment (about 110 days after sowing), the following parameters were recorded: number of pods/plant, weight of green pods/plant, the average number of seeds/pod, number of seeds/plant, seed yield/plant (g) and weight of 100-seeds (g).

All data were statistically analyzed according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1. Growth parameters:

Data presented in Tables (1 and 2) indicated that, plant height, number of leaves and leaf area / plant were clearly influenced by mineral fertilizer (P and Zn), organic fertilizer and biofertilizer as compared to control plants. In this respect, P fertilizer showed the best results related to plant height in both seasons. The highest response of number of leaves was pronounced with organic or P fertilizer. In addition, the high response of pea leaf area was recorded due to application of biofertilizer as compared to control plants.

Table (2), generally shows that, dry weights of stems and leaves of pea plants were significantly stimulated as a result of the application of different fertilization treatments as compared to the control in both seasons. Data in the same table show clearly significant increments in plant height in the second season only and leaf area as well as the dry weights of different plant organs. Meanwhile, number of leaves was not affected as a result of zinc application compared to control in both seasons. Similar results were obtained by many investigators on several crops including. Bakry *et al.* (1989), Shalan *et al.* (2001) and Ibrahim and Abd El-Galil (2003) with respect to phosphorus, Subhan (1988), El-Sersawy *et al.* (1997) and El-Koumey (1998) with respect to the effect of organic manure. Also, Agwah and Sahaby (1993) and El-Shal *et al.* (2002) with respect to the effect of biofertilizer application, Hamail (1992), Hassawy (1993), Khurana and Chotterjee (2001) and Radwan *et al.* (2001) with respect to the effect of zinc application.

The stimulative effect in most growth parameters by using biofertilizer may be due to growth promotion directly or indirectly (Lazarovits and Nowak, 1997). Direct influences include production of phytohormones (Noel *et al.*, 1996), improving the availability and aqulisition of nutrients (Turner and Bakman, 1991). Micronutrients are known to be important in carbon-dioxide assimilation and in nitrogen metabolism, suggesting that plants may have metabolic systems that predominately require microelements application (Brown and Clark, 1977).

As regard to the interaction effects between the different fertilization treatments and zinc application, the obtained results (Tables 1 and 2) show that there were non-significant effects on plant height, number of leaves/dry weight of root, meanwhile leaf area, dry weights of root and stems were significantly affected as compared to untreated plants. The same general trend was reflected in both seasons. The addition of zinc with organic manures increased dry matter content, this may be due to the role of this element in activating many and other functions which enhance growth rate of plant (El-Koumey, 1998). Several investigators proved that plants absorbed more phosphorus in the presence of phosphate dissolving microorganisms (Saber and Kabesh, 1988).

Table (1): Vegetative growth characters of pea plants as affected by phosphorus, organic and biofertilizers as well as zinc application treatments and its combinations during winter seasons 2002/2003 and 2003/2004.

Characters / Treatments	Plant height (cm)					Number of leaves / plant					Leaf area (cm^2 / plant)				
	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
	First season														
Control	28.0	29.3	31.0	32.3	30.1	8.0	9.0	9.3	9.7	9.0	468.6	507.7	609.4	667.2	563.2
Phosphorus	36.0	36.7	40.2	38.7	37.9	10.3	10.3	10.7	9.3	10.1	552.0	661.5	705.6	606.2	631.3
Compost	35.0	39.0	37.0	36.3	36.8	10.7	11.0	10.7	10.3	10.7	600.0	668.4	602.1	489.8	590.1
Biofertilizer	35.3	37.0	37.7	35.7	36.4	10.0	10.7	10.3	10.0	10.2	660.7	708.9	700.5	491.1	640.3
Mean	33.6	35.5	36.5	35.7		9.7	10.25	10.2	9.8		570.3	636.6	654.4	563.6	
L.S.D. 5%	A = 3.12 B = N.S. A × B = N.S					A = 0.29 B = 0.57 A × B = N.S.					A = 40.53 B = 26.18 A × B = 52.37				
	Second season														
Control	29.0	30.0	32.0	32.7	30.9	7.3	8.7	9.7	10.0	8.9	495.0	538.1	620.0	695.3	587.1
Phosphorus	35.7	36.3	39.0	37.7	37.2	10.7	10.7	11.0	10.3	10.7	588.1	691.7	785.9	629.1	673.7
Compost	34.3	38.0	37.3	37.0	36.6	10.3	10.7	10.3	10.0	10.3	640.8	701.1	690.7	511.4	636.0
Biofertilizer	34.7	38.3	38.7	36.0	36.9	9.7	10.3	10.0	9.7	9.9	680.0	730.0	711.0	530.1	662.8
Mean	33.4	35.6	36.7	35.8		9.5	10.1	10.2	10.0		601.0	665.2	701.9	591.5	
L.S.D. 5%	A = 1.13 B = 2.19 A × B = N.S					A = 0.66 B = N.S A × B = N.S					A = 24.19 B = 21.98 A × B = 43.97				

Zn_0 : 0.0 mg / l Zn_1 : 100 mg / l Zn_2 : 200 mg / l Zn_3 : 400 mg / l
A : Fertilizer B : Zinc A × B : Interaction

Table (2): Vegetative growth characters of pea plants as affected by phosphorus, organic and biofertilizers as well as zinc application treatments and its combinations during winter seasons 2002/2003 and 2003/2004.

Characters / Treatments	Dry weight of root (g)					Dry weight of stem (g)					Dry weight of leaves (g)				
	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
	First season														
Control	0.06	0.08	0.11	0.15	0.10	0.45	0.53	0.71	0.98	0.59	1.06	1.28	1.39	1.39	1.18
Phosphorus	0.09	0.10	0.12	0.09	0.10	0.65	0.69	0.67	1.14	0.71	1.30	1.47	1.25	1.25	1.29
Compost	0.10	0.11	0.09	0.07	0.09	0.70	0.75	0.62	1.20	0.69	1.37	1.24	1.01	1.01	1.20
Biofertilizer	0.11	0.13	0.12	0.09	0.10	0.80	0.81	0.75	1.36	0.80	1.45	1.37	1.05	1.05	1.31
Mean	0.09	0.10	0.11	0.10		0.65	0.69	0.76	0.69		1.17	1.29	1.34	1.17	
L.S.D. 5%	A = N.S B = 0.01 A × B = 0.028					A = 0.07 B = 0.04 A × B = 0.07					A = 0.07 B = 0.10 A × B = 0.20				
	Second season														
Control	0.05	0.07	0.10	0.14	0.09	0.55	0.61	0.69	0.82	0.67	0.90	1.15	1.34	1.45	1.21
Phosphorus	0.08	0.09	0.11	0.10	0.09	0.72	0.75	0.90	0.73	0.77	1.09	1.28	1.51	1.17	1.26
Compost	0.09	0.12	0.11	0.08	0.10	0.83	0.87	0.85	0.68	0.81	1.18	1.48	1.40	1.00	1.26
Biofertilizer	0.10	0.12	0.11	0.09	0.10	0.85	0.89	0.87	0.75	0.84	1.42	1.51	1.25	0.98	1.29
Mean	0.08	0.10	0.11	0.10		0.74	0.78	0.83	0.74		1.15	1.135	1.37	1.15	
L.S.D. 5%	A = N.S B = 0.01 A × B = 0.029					A = 0.03 B = 0.06 A × B = 0.11					A = 0.12 B = 0.12 A × B = 0.24				

Zn_0 : 0.0 mg / l Zn_1 : 100 mg / l Zn_2 : 200 mg / l Zn_3 : 400 mg / l

A : Fertilizer   B : Zinc   A × B : Interaction

2. Chemical constituents:

a) Photosynthetic pigments:

Regarding the influence of different fertilization treatments on photosynthetic pigments of pea leaves, the results presented in Table (3) indicate that, the application of organic fertilizer significantly increased the concentrations of chlorophyll a, b and carotenoids followed by plants treated with inorganic P or plants inoculated with biofertilizer as compared to control plants in both seasons. Similar results were obtained by Moussa *et al.* (1993) who reported an increment in chlorophyll content of lettuce leaves due to organic fertilization. In the same line, Abdel-Aty (1997) found that using manure fertilizers produced the highest value of chlorophyll in pepper leaves.

Table (3) shows also that there was a significant increase in chlorophyll a, b and carotenoids concentrations as compared to untreated plants. Similar results were also mentioned by Abd El-Fattah and El-Ghinbihi (2001) on broad bean, Elwan *et al.* (2001) on sugar beet plants and by Ohki (1978) who reported that photosynthetic rates were related to Zn concentration and Zn deficiency reduced photosynthesis ratio of soybean plants. Also Cakmak and Marschner (1993) showed that Zn deficiency decreased bean leaf chlorophyll.

Concerning the effect of the interaction between the different fertilization treatments and zinc application, the obtained results (Table 3) reveal that there was a significant increment in photosynthetic pigments. Moreover, the combination of organic fertilizer with Zn at 100 mg / l showed the maximum values of Chl. a, Chl. b and carotenoids as compared to the control and other combined treatments. These findings were true in both seasons. Similar results were obtained by Abd El-Fattah and El-Ghinbihi (2001) on broad bean plants and El-Shal *et al.* (2002) on lettuce plants.

b) Total soluble sugars (T.S.S) and total carbohydrate (T.C) concentrations:

The different data in Table (4) show clearly that, T.S.S and T.C concentrations of pea leaves were significantly increased as a result of the application of different fertilization treatments compared with the control plants, with the exception of T.S.S in the first season only. The highest values were recorded by using of biofertilizer. Similar results were obtained by El-Garhy (2002) who stated that, inoculation with biofertilizer significantly increased total soluble sugars and total carbohydrates of faba bean plants. Also, Hammad (2004) on pepper plants observed that, the application of biofertilizer (Halex 2) increased significantly T.S.S and T.C. The same trend was observed by Abd El-Fattah and Sorial (2000) on squash plants. Regarding the effect of foliar application of Zn, it was observed that the increase of Zn levels caused significant increases in total soluble sugars and total carbohydrates as compared to untreated plants in both seasons. The maximum mean values were recorded with spraying zinc at 400 mg / l. The effect of zinc may suggest that Zn increased the synthesis of carbohydrates (Omel Chenka and Rusakov, 1973). It could also be attributed to the fact that zinc is involved in starch formation and there is a close relationship between Zn nutrition and starch formation (Jyung *et al.*, 1975). Similar results were reported by Abd El-Fattah and El-Ghnibihi (2001) on broad bean and Elwan *et al.* (2001) on sugar beet.

Table (3): Photosynthetic pigments (as mg/g d.wt.) in pea leaves as affected by phosphorus, organic and biofertilizers as well as zinc application treatments and its combinations during winter seasons 2002/2003 and 2003/2004.

Characters / Treatments	Chlorophyll a					Chlorophyll b					Carotenoids				
	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
	First season														
Control	2.20	2.54	2.99	3.19	2.73	1.19	1.41	1.65	1.79	1.51	0.68	0.75	0.85	0.92	0.80
Phosphorus	3.20	3.30	3.43	3.37	3.32	1.92	2.11	2.35	2.20	2.14	1.01	1.07	1.22	1.18	1.12
Compost	3.50	3.70	3.58	3.36	3.53	2.01	2.50	2.30	2.21	2.25	1.06	1.54	1.29	1.14	1.25
Biofertilizer	2.65	3.21	3.38	3.01	3.08	1.82	2.08	2.27	1.95	2.03	0.81	1.30	1.48	1.20	1.20
Mean	2.89	3.19	3.34	3.23		1.73	2.02	2.14	2.04		0.89	1.16	1.21	1.11	
L.S.D. 5%	A = 0.23 B = 0.22 A × B = 0.44					A = 0.08 B = 0.11 A × B = 0.23					A = 0.06 B = 0.08 A × B = 0.16				
	Second season														
Control	2.60	2.88	3.05	3.36	2.97	1.25	1.55	1.71	1.85	1.59	0.81	0.95	1.05	1.10	0.20
Phosphorus	3.75	3.89	3.95	3.55	3.78	1.88	2.20	2.46	2.00	2.13	1.16	1.29	1.33	1.20	1.44
Compost	3.80	4.01	3.90	3.72	3.86	1.96	2.51	2.18	2.01	2.16	1.20	1.41	1.35	1.26	1.30
Biofertilizer	3.02	3.30	3.58	3.10	3.25	1.77	2.00	2.15	1.85	1.94	1.00	1.27	1.35	1.19	1.20
Mean	3.29	3.52	3.62	3.43		1.71	2.05	2.12	1.93		1.04	1.23	1.27	1.19	
L.S.D. 5%	A = 0.18 B = 0.17 A × B = 0.32					A = 0.12 B = 0.10 A × B = 0.19					A = 0.06 B = 0.07 A × B = N.S				

Zn_0 : 0.0 mg / l Zn_1 : 100 mg / l Zn_2 : 200 mg / l Zn_3 : 400 mg / l

A : Fertilizer B : Zinc A × B : Interaction

Table (4): Total soluble sugars, total carbohydrates and total free amino acids in pea leaves as affected by phosphorus, organic and biofertilizers as well as zinc application treatments and its combinations during winter seasons 2002/2003 and 2003/2004.

Characters / Treatments	Total soluble sugars (mg / g dry wt.)					Total carbohydrates (mg / g dry wt.)					Total free amino acids (mg/g dry wt.)				
	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
	First season														
Control	19.30	26.16	31.50	38.11	28.77	119.50	127.06	135.90	144.11	131.64	31.05	36.11	38.60	45.07	37.71
Phosphorus	25.66	29.12	32.22	26.00	28.25	123.33	130.11	145.20	136.01	133.66	40.11	42.10	43.00	40.00	41.30
Compost	26.88	32.66	30.06	27.00	29.15	130.00	148.05	140.00	132.00	137.51	38.06	40.80	39.65	39.00	39.38
Biofertilizer	27.15	31.06	31.80	25.50	27.88	138.13	142.06	141.15	137.22	139.64	41.00	42.60	43.11	41.00	41.78
Mean	24.75	29.75	31.39	29.15		127.74	136.82	140.56	137.33		37.55	40.40	41.09	44.27	
L.S.D. 5%	A = N.S B = 1.01 A × B = 2.03					A = 4.68 B = 3.13 A × B = 6.26					A = 2.85 B = 1.73 A × B = 3.47				
	Second season														
Control	17.46	28.00	32.11	35.85	28.35	121.81	129.81	134.80	147.11	133.38	30.07	38.00	39.80	44.10	37.99
Phosphorus	29.10	31.50	32.00	28.60	30.30	125.66	132.50	150.06	134.08	135.57	41.70	42.85	44.01	40.03	42.15
Compost	29.20	33.00	31.10	29.01	30.58	128.95	146.33	136.90	131.70	135.29	39.10	41.03	40.11	39.70	39.98
Biofertilizer	29.60	30.50	31.05	27.20	29.59	135.71	143.20	140.60	134.40	138.48	42.00	42.88	44.00	41.03	42.48
Mean	26.34	30.75	31.56	30.16		128.03	137.96	140.59	136.82		38.22	41.19	41.98	41.21	
L.S.D. 5%	A = 1.55 B = 1.68 A × B = 3.36					A = 5.40 B = 3.68 A × B = 7.35					A = 0.94 B = 1.34 A × B = 2.68				

Zn_0 : 0.0 mg / l Zn_1 : 100 mg / l Zn_2 : 200 mg / l Zn_3 : 400 mg / l
A : Fertilizer B : Zinc A × B : Interaction

The data given in the previous table show that the interaction between foliar application of Zn and different fertilization treatments on T.S.S and T.C led to significant increases in both seasons. Data also indicate that, plants treated with Zn at (200 mg / l) coupled with P fertilizer gave the highest values of T.S.S and T.C. These results are in complete accordance with those found by Abd El-Fattah and El-Ghinbihi (2001) on broad bean.

c) Total free amino acids (T.A.A):

Data in Table (4) show that, the application of different fertilization sources significantly increased the concentration of T.A.A in pea leaves. In this regard, biofertilizer treatment gave the highest values of T.A.A as compared to control treatments in both seasons. The positive effect of biofertilizer on T.A.A may be due to the role of the bacteria in the production of auxins and gibberellins like substances, that promoted the plant root growth which absorbed more N as a source of T.A.A (Amara and Nasr, 1995). Besides, Hamdia and El-Koumy (1998) reported that biofertilizer application (Azospirillum) was active in increasing the content of amino acids in maize plant and they added that biofertilizer might play an important role in the protein biosynthesis by direct supply (through fixation of nitrogen) or indirectly by enhancing the uptake of soil nitrogen or by enhancing the photosynthetic apparatus. Similar results were observed by El-Garhy (2002) on faba bean, who found that biofertilizer treatment gave the highest values of T.A.A compared with control.

Data presented in the same table show clearly that, application of Zn at different concentrations significantly increased T.A.A concentration in pea leaves compared with control plants. Moreover, the highest values were recorded under Zn (400 mg / l) treatment in both seasons. Similar results were stated by Mansy *et al.* (1991) who found that, foliar application of Zn at 0.03% increased protein concentration. Also, Abd El-Fattah and El-Ghinbihi (2001) found that, spraying broad bean plants with Zn at 500 mg / l gave the highest significant increase in total protein. The effect of Zn on the concentration of T.A.A may be due to that micronutrients may play an important role, as activators or co-enzymes in all vital processes via the different growth stages of plant (Billan, 1967) or enhancing the concentrations of N and P of pea plants and this, in turn, was reflected on protein biosynthesis.

With respect to the combination effect of different fertilizers and Zn concentrations, data in the same Table show that, there was a significant increase in T.A.A concentrations of pea leaves by using Halex 2 (biofertilizer) with Zn at 200 mg / l as compared to control plants or other treatments in the two seasons.

d) Mineral concentrations:

Data in Table (5) obviously show that, N, P, K and Zn concentrations in leaves of pea plants were enhanced significantly with the application of all fertilization treatments as compared to control in both seasons. Whereas inoculation with biofertilizer (Halex 2) gave the highest values of N and K.

Table (5): Mineral concentration in pea leaves as affected by phosphorus, organic and biofertilizers as well as zinc application treatments and its combinations during winter seasons 2002/2003 and 2003/2004.

Characters / Treatments	N %					P %					K %					Zn µg / g dry wt.				
	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
	First season																			
Control	3.95	4.31	4.75	5.17	4.54	0.42	0.58	0.62	0.70	0.58	1.45	1.80	1.95	2.07	1.82	36	48	52	57	48.25
Phosphorus	5.07	4.65	5.20	5.00	4.98	0.55	0.66	0.70	0.62	0.63	2.15	2.33	2.59	2.00	2.27	46	51	57	62	54.00
Compost	4.85	5.50	5.40	4.80	5.14	0.65	0.83	0.71	0.67	0.71	1.88	2.21	2.10	2.00	2.05	50	57	61	65	58.25
Biofertilizer	5.44	6.30	6.40	5.70	5.96	0.58	0.75	0.79	0.64	0.69	2.25	2.43	2.55	2.11	2.33	45	49	53	60	51.75
Mean	4.83	5.19	5.44	5.17		0.55	0.70	0.70	0.66		1.93	2.19	2.30	2.04		44.25	51.25	55.75	61.00	
L.S.D. 5%	A=0.20 B=0.16 A × B =0.31					A=0.03 B=0.03 A × B =0.05					A=0.06 B=0.10 A × B =0.19					A=1.75 B=2.70 A × B =N.S				
	Second season																			
Control	4.05	4.48	4.81	5.07	4.60	0.39	0.51	0.59	0.76	0.56	1.38	1.66	1.89	2.06	1.75	38	47	55	61	50.25
Phosphorus	5.03	4.80	5.05	4.91	4.95	0.53	0.63	0.73	0.60	0.62	2.11	2.19	2.41	2.01	2.18	48	56	63	64	57.75
Compost	4.78	5.31	5.28	5.01	5.09	0.68	0.77	0.72	0.69	0.71	1.91	2.31	2.08	1.98	2.07	54	61	65	68	62.00
Biofertilizer	5.11	6.06	6.50	5.82	5.87	0.55	0.78	0.82	0.61	0.69	2.09	2.50	2.58	2.00	2.29	46	53	58	65	55.50
Mean	4.74	5.16	5.41	5.20		0.54	0.67	0.71	0.66		1.87	2.16	2.24	2.01		46.50	54.25	60.25	64.50	
L.S.D. 5%	A=0.27 B =0.23 A × B =0.45					A=0.03 B=0.04 A × B =0.07					A=0.13 B =0.12 A × B =0.23					A=2.19 B=3.37 A × B =N.S				

Zn_0 : 0.0 mg / l **Zn_1 : 100 mg / l** **Zn_2 : 200 mg / l** **Zn_3 : 400 mg / l**

A : Fertilizer **B : Zinc** **A × B : Interaction**

The application of organic fertilizer produced highest values of P or Zn. In respect of organic fertilizer, Roe *et al.* (1997) reported that, N, P and K concentration in pepper plant were significantly affected by manure application. Also, El-Zawily *et al.* (2002) reported that, the increase in N, P and K in leaf of pepper plants due to applying the organic fertilizer was resulted from increasing these elements in the soil and improving both availability and uptake of nutrients in soil. Moreover, the effect of biofertilizer on N, P, K and Zn may be due to its favourable effect on dry matter content of plant (Table 2) and / or the high absorbing efficiency by roots. Similar results were recorded by El-Shal *et al.* (2002) and Tartoura (2002).

Data presented in the same Table show clearly that supplying Zn at different concentrations significantly increased N, P, K and Zn concentrations in pea leaves compared with control plants in both seasons. Furthermore, the moderate Zn concentration (200 mg / l) gave the maximum N and K concentrations in both seasons whereas P-increment was recorded in the first season only. Moreover, the highest Zn rate (400 mg / l) gave the maximum Zn concentration in both seasons. These results are in agreement with those obtained by El-Sherif *et al.* (1993) on tomato, Hassawy (1993) on lettuce and Abd El-Fattah and El-Ghinbihi (2001) on broad bean. In this concern Loneragan *et al.* (1982) revealed that the addition of Zn in solution culture markedly enhanced the accumulation of P in leaves of okra plants by increasing the amounts of P absorbed by roots and transported to tops.

With regard to the effect of interaction between different fertilization treatments and zinc on N, P, K and Zn concentrations, it is clear from that data in the same Table that applying Zn and P significantly promoted N, P, K concentrations compared with the control in both seasons. In this concern, Loneragan *et al.* (1979) reported that the application of high P level increased the Zn requirement of plant tissue. In addition Pazzarossa *et al.* (1994) observed that in the presence of Zn, leaf P concentration increased with increasing P rates.

3. Yield and its components:

Significant differences in number of pods/plant, weight of green pods/plant, number of seeds/pod, number and weight of seeds/plant as well as weight of 100-seeds were detected due to each inorganic P, organic fertilizer and biofertilizer (Tables 6 and 7) compared with control plants in both seasons. Pod green weight and number of seeds/plant did not significantly affected in the second season only, and the number of seeds/pod did not significantly affected in both seasons. The highest increases in seed weight/plant were about 60.32 and 79.35% compared with control respeolined in both seasons as a result of the application of organic fertilizer. On the contrary, the highest values of 100-seed weight were recorded with applying of organic fertilizer which reached about 52.5 and 77% compared with untreated plants in both seasons respectively. Similar results were detected by Abd El-Fattah (1997) on broad bean and Hewedy *et al.* (2003) on common bean with respect of P fertilizer, El-Shimi *et al.* (1987) on vegetables, Moussa *et al.* (1993) on lettuce and Hammad (2005) on tomato regarding organic fertilizer.

Table (6): Green pods yield in pea plants and its components as affected by phosphorus, organic and biofertilizers as well as zinc application treatments and its combinations during winter seasons 2002/2003 and 2003/2004.

Characters / Treatments	Average number of green pod/plant					Total weight of green pods (g)/plant					Average number of seed/pod				
	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
	First season														
Control	4.00	4.67	5.00	5.33	4.75	8.25	9.44	10.21	11.00	9.72	4.00	4.33	4.67	5.00	4.50
Phosphorus	5.33	5.67	6.33	4.67	5.50	10.01	10.55	10.88	10.00	10.36	4.67	5.33	5.00	4.67	4.92
Compost	5.67	6.67	6.33	6.00	6.17	10.77	10.55	10.88	10.00	10.55	5.00	5.33	5.67	5.00	5.25
Biofertilizer	5.00	5.67	5.33	5.00	5.25	9.65	10.61	10.30	10.05	10.15	4.33	4.67	4.33	4.00	4.33
Mean	5.00	5.67	5.75	5.25		9.67	10.29	10.57	10.26		4.50	4.91	4.92	4.67	
L.S.D. 5%	A = 0.52 B = N.S A × B = N.S					A = 0.52 B = 0.47 A × B = 0.93					A = N.S B = N.S A × B = N.S				
	Second season														
Control	5.33	5.67	6.00	6.33	5.83	10.64	11.49	12.15	13.00	11.82	4.33	4.67	5.00	5.33	4.83
Phosphorus	6.67	7.00	7.67	6.00	6.83	12.36	13.15	13.56	12.80	12.97	5.00	5.67	5.33	5.00	5.25
Compost	7.00	7.67	7.33	7.00	7.25	13.02	12.09	12.62	11.70	12.36	4.67	5.00	5.33	4.67	4.92
Biofertilizer	6.00	6.67	6.33	6.00	6.25	11.50	12.40	12.25	12.03	12.04	4.33	5.00	4.67	4.33	4.58
Mean	6.25	6.75	6.83	6.33		11.88	12.28	12.64	12.38		4.58	5.08	5.08	4.83	
L.S.D. 5%	A = 0.89 B = N.S A × B = N.S					A = N.S B = N.S A × B = N.S					A = N.S B = N.S A × B = N.S				

Zn_0 : 0.0 mg / l Zn_1 : 100 mg / l Zn_2 : 200 mg / l Zn_3 : 400 mg / l

A : Fertilizer   B : Zinc   A × B : Interaction

Table (7): Seed yield and its components in pea plants as affected by phosphorus, organic and biofertilizers as well as zinc application treatments and its combinations during winter seasons 2002/2003 and 2003/2004.

Characters / Treatments	Number of seeds / plant					Weight of seeds / plant (g)					Weight of 100-seeds (g)				
	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
	First season														
Control	16.00	20.33	23.67	26.67	21.67	3.05	3.64	4.88	3.69	3.81	12.80	13.04	16.64	17.63	15.03
Phosphorus	24.67	30.33	32.00	21.33	24.33	4.86	5.70	5.60	3.88	5.01	18.48	18.87	17.72	14.17	17.31
Compost	28.00	35.67	34.67	30.33	23.17	4.89	6.71	6.64	5.52	5.94	19.52	21.42	18.51	18.40	19.46
Biofertilizer	24.33	26.67	23.00	20.33	23.58	4.05	4.13	3.70	3.60	3.87	15.48	15.60	13.28	13.00	14.34
Mean	23.25	28.25	28.33	24.66		4.21	5.04	5.20	4.17		16.57	17.23	16.54	15.80	
L.S.D. 5%	A = 6.99 B = N.S A × B = N.S					A = 0.44 B = 0.48 A × B = 0.95					A = 0.82 B = N.S A × B = 2.97				
	Second season														
Control	23.00	26.33	30.33	34.00	28.41	3.39	4.41	5.80	5.73	4.83	10.35	12.87	16.00	16.98	14.05
Phosphorus	33.33	39.67	41.00	30.67	36.17	5.99	7.31	6.90	4.31	6.13	18.23	18.42	16.88	14.37	16.97
Compost	32.00	37.33	39.00	32.33	35.16	6.08	7.50	7.21	6.01	6.70	18.32	19.20	18.45	18.38	18.59
Biofertilizer	26.00	33.67	29.67	28.33	29.42	4.25	5.15	4.84	4.28	4.63	14.34	15.44	12.99	12.62	13.85
Mean	28.58	34.25	35.00	31.33		4.93	6.09	6.19	5.08		15.31	16.48	16.08	15.59	
L.S.D. 5%	A = N.S B = N.S A × B = N.S					A = 0.41 B = 0.64 A × B = 1.27					A = 0.77 B = 0.90 A × B = 1.81				

Zn_0 : 0.0 mg / l **Zn_1 : 100 mg / l** **Zn_2 : 200 mg / l** **Zn_3 : 400 mg / l**

A : Fertilizer **B : Zinc** **A × B : Interaction**

Yield increases may be attributed to the effect of P or organic fertilizer on increasing the number of pods and seeds/plant or its effect on photosynthesis activity (Saleh and Nawar, 2003).

With respect to the effect of zinc concentrations on yield and its components, data in Tables (6 and 7) show clearly significant increments in weight of seeds/plant and 100-seed weight compared with control plants in both seasons, meanwhile weight of green pods/plant showed significant values in the first season only. In addition, the highest values of seed weight/plant were recorded due to Zn sprying at (100 mg/l). Moreover, no significant increase was observed in the number of pods/plant, the average number of seeds/pod and the number of seeds/plant compared with untreated plants in both seasons. Similar results were revealed by Etman (1992) and Ali (1993) on broad bean and Daoud and Nashed (2003). These results would suggest that zinc is an essential components or activator for many enzymes involved in photosynthesis and hence has an important role in early seedlings vigor (Graham and Webb, 1991).

The data given in previous Tables show that, the interaction effect between Zn and different fertilization treatments resulted in an increase of weight of seeds/plant and 100-seeds weight compared with control in both seasons, meanwhile pod green weight did not significantly affected in the first season only. However, no significant effects were observed due to interaction treatments on the number of pods and seeds/plant as well as average number of seeds/pod compared with control plants in both seasons. In this respect, plants treated with organic fertilizer and Zn at the rate of (100 mg / l) gave significantly higher values of seed dry weight and 100-seeds weight than the control or other combined treatments.

Finally, it could be concluded that the importance of using organic and biofertilizers not only recognized as an economic factor, from the view point of reducing the use of chemical P fertilizers and, in turn, saving money, but also, it is an important factor in reducing the soil pollution with phosphorus.

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تأثير مصادر مختلفة من الأسمدة مع الرش بالزنك على النمو والمحتوى الكيماوى والمحصول فى البسلة

سلوى عبد الرحمن حماد - صباح محمد الجمل
قسم النبات الزراعى – كلية الزراعة – جامعة المنوفية

أجريت تجربتين أصص بالمزرعة التجريبية لكلية الزراعة جامعة المنوفية خلال الموسمين الزراعيين الشتويين ٢٠٠٢/٢٠٠٣ ، ٢٠٠٣/٢٠٠٤ لدراسة تأثير معاملات سمادية مختلفة (الفوسفور المعدنى – السماد العضوى والسماد الحيوى) وأربع مستويات من الزنك (صفر ، ١٠٠ ، ٢٠٠ ، ٤٠٠ ملليجرام / لتر) وكذلك التفاعل بينهما على النمو التركيب الكيماوى والمحصول لنباتات البسلة صنف ماستر – ب . **وقد بينت النتائج الآتى :**

- زادت صفات النمو الخضرى للبسلة معنوياً مع استخدام جميع المعاملات السمادية فى كلا الموسمين بينما الزيادة فى وزن الجذر لم تكن معنوية فى حين أن الفوسفور الغير عضوى والسماد الحيوى غالباً حقق أعلى القيم فى هذا الصدد مقارنة بالكنترول .
- على الجانب الآخر أدى إضافة الزنك إلى زيادة معنوية فى مساحة الأوراق والأوزان الجافة لأعضاء النبات .
- حقق التفاعل بين الفوسفور والمستوى الثانى من الزنك (٢٠٠ ملليجرام / لتر) أعلى القيم لمساحة الأوراق بينما أعلى القيم للأوزان الجافة للجذور والساق والأوراق كان باستخدام السماد الحيوى مع المستوى الأول من الزنك (١٠٠ ملليجرام / لتر) .
- تركيز صبغات كلوروفيل أ، ب ، الكاروتين والكربوهيدرات الكلية والأحماض الأمينية الحرة ، العناصر (ن ، فو ، بو، الزنك) زادت معنوياً باستخدام جميع المعاملات السمادية . كما سجلت النتائج زيادة فى السكريات الكلية الذائبة مقارنة بنباتات الكونترول . استخدام السماد الحيوى حقق أعلى القيم فى السكريات الكلية الذائبة والكربوهيدرات الكلية والأحماض الأمينية الحرة ، ن% ، فو% ، بو% بينما أعلى القيم لكلورفيل أ ، ب والكاروتينات ، فو ، زنك قد تحقق مع استخدام السماد العضوى .
- إضافة الزنك أدت إلى زيادة معنوية فى كل التركيب الكيماوى حيث سجلت أعلى القيم عند المعاملة العالية من الزنك (٤٠٠ ملليجرام / لتر) مقارنة بالكنترول .
- أوضح التفاعل بين الزنك ومختلف المعاملات السمادية إلى حدوث زيادة معنوية فى كلوروفيل أ ، ب والسكريات الكلية الذائبة ، الكربوهيدرات الكلية والأحماض الأمينية الحرة وأيضاً الكاروتينات .
- المعاملات السمادية زادت معنوياً وزن بذور النبات ووزن ١٠٠ بذرة وزارت وزن القرون الأخضر وعدد البذور / نبات . كما حقق التسميد العضوى أعلى القيم لوزن بذور النبات .
- أدى رش النباتات بالزنك إلى زيادة فى وزن البذور / نبات ووزن القرون الأخضر.
- أظهر التفاعل بين الزنك والأسمدة المختلفة إلى زيادة معنوية فى وزن بذور النبات ووزن القرون الأخضر ووزن ١٠٠ بذرة .