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EFFECT OF IRON, ZINC AND MANGANESE FOLIAR APPLICATION ON VEGETATIVE GROWTH, DRY SEEDS YIELD AND YIELD COMPONENTS OF COMMON BEAN

BY

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ABSTRACT

Two field experiments, during the summer seasons of 2001 and 2002, at the Experimental Farm, Faculty of Agriculture, Fayoum University, were established in order to assess the response of vegetative growth, dry seeds yield and chemical composition of bean plants cv. Nebraska to the foliar application of Fe (200 and 400ppm), Zn (250, 375 and 500ppm) and Mn (250, 375, 500 and 625ppm). The experimental layout was a factorial experiment in a randomized complete blocks design. Results displayed significant differences between Fe concentrations with the superiority of 400ppm in plant height; leaf area leaf^{-1}; number and dry seeds yield and leaf Fe content. Increasing Zn concentration from 250 to 375ppm, but not further, increased plant height; dry weight of the canopy; seed index, dry seeds yield and seed carbohydrates content, while leaf K and Zn contents were the highest with the foliar application of 500ppm Zn. The foliar application of Mn at 375 or 500ppm was pronounced and significantly augmented the number and area of leaves; dry weight of vegetative aerial organs; number and dry seeds yield as well as seed index contents of K, Fe and Mn in leaves and carbohydrates in dry seeds than those achieved with 250 or 625ppm Mn. The obtained results, also, illustrated that, the dry seeds yield of bean and its components can be improve through the combined foliar application of Fe and Zn together at 400 and 375 or 500ppm, orderly.

Key words: Common bean, Foliar application, Microelements, Iron, Zinc, Manganese, Dry seeds yield, Yield components, Vegetative growth.

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is a leguminous vegetable crop and considers one of the major crops grown in Egypt for local consumption and exportation. Most of the bean cultivars are grown for the production of fresh pods and / or dry seeds yield. It is well known that bean dry seeds had a peculiar nutritional value due to its high content of protein, carbohydrates, vitamins and minerals. According to 2002 statistic [•], the total area devoted for the production of bean dry seeds yield was 34633 fed. This area produced a total dry seeds yield of 40645 tons with an average of 1.17 tons fed^{-1} which is not satisfactory.

[•] Ministry of Agriculture and land Reclamation. Agriculture Statistics, 2002.

Factors affect crop production in agriculture are multifarious. Of these, mineral nutrition considers a basic factor in this concern. It is well established that microelements are needed by plants in a relatively small amount. They participate in many biochemical processes occurring in cells, mainly through increasing the activity of enzymes and provides the special lubricants required for the variety of energy transfer mechanisms within organisms which by turn encourage the growth and yield of plants to go forward. Most of the cultivated area in Egypt was reported to suffer the deficit of available microelements (Fawzi, 1991), limited soil application of organic manure, fast exhaustion of the available micronutrients in soils as a consequence of cultivating high yielding cultivars and / or extensive cropping two or three times yearly. Moreover, the microelements applied as soil dressing, often, become unavailable to be utilized by the plant owe to the high pH and the high content of calcium carbonate. Therefore, the small quantities of microelements required by the plants are preferably supplied in the form of a dilute solution as foliar applications.

A large number of reports have denoted the valuable effects of spraying Fe on the morphological characters, seed yield and chemical constituents of bean plants (El-Naggar, 1998; El-Bendary *et al.*, 1999; and El-Mansi *et al.*, 1991). Also, Zn was found to have a pronounced effect on vegetative growth, yield and chemical composition of beans (Helal, 1995; El-Shamma, 1998; and Karaman *et al.*, 1999). Moreover, several investigators pointed to the valuable influence of Mn foliar application on bean growth, yield and chemical composition(El-Basyouny, 1995; El-Naggar, 1998; and Firgany and Hussein, 1984).

The current study was suggested in order to assess the influence of spraying the canopy of bean cv. Nebraska with various concentrations of Fe, Zn and Mn on the vegetative growth characters, dry seeds yield and its components and some chemical constituents of leaves and dry seeds.

MATERIALS AND METHODS

The objective of the study reported herein was suggested to assess the main effects of foliar nutrition with the micronutrients of iron (Fe), zinc (Zn) and manganese (Mn) as well as their different degree of interactions on the morphological characters, dry seeds yield and its components and the chemical composition of the common bean (*Phaseolus vulgaris* L.) cv Nebraska. In order to achieve the scope of the study, two field experiments, at the Experimental Station Farm, Faculty of Agriculture, in Fayoum, during the summer seasons of 2001 and 2002 were imposed.

Preceding the conduction of each experiment, soil samples of 25cm depth, from each experimental site, were collected, analysed for some important physical and chemical properties at the College of Agriculture Soil Testing Laboratory according to the published procedures (Wilde *et al.*, 1985) and the results are given in Table 1.

Each experiment comprised all possible combinations of two Fe concentrations (200 and 400ppm), three Zn concentrations (250, 375 and 500ppm) and four Mn concentrations (250, 375, 500 and 625ppm). The respective source of the former micronutrients was Prosol; a commercial fertilizer contained Fe, Zn or Mn in a chelated form and the chelating agent was citric acid. The concentrations of Fe, Zn and Mn in Prosol were 20, 25 and 20%, orderly. Local seeds of common bean cv. Nebraska were sown in the field on February 25, 2001 and March 2, 2002. After complete earthing were thinned to achieve within row spacing of 5 – 7cm. The experimental layout was a factorial experiment in a randomized complete blocks design with four replications. Each experimental unit was planned to cover an area of $10.8m^2$ including six rows of 3m long and 0.6m wide. Each two adjacent experimental unites were separated by 1.2m alley to protect against border effects. After 35 and 45 days of seed sowing, plants were sprayed with the specific micronutrients at the different concentrations to run off.

Table (1): Physical and chemical characteristics of the experimental site during the summer seasons of 2001 and 2002.

Property	2001	2002
Physical:		
Clay %	48.33	49.41
Silt %	25.93	26.14
Fine sand %	20.51	19.92
Coarse sand %	5.23	4.53
Soil texture	Clay	Clay
Chemical:		
pH of paste extract	7.48	7.54
CEC (meq/100 g soil)	36.72	38.93
Organic matter(%)	1.78	1.72
Calcium carbonate (%)	5.48	5.53
Total nitrogen (%)	0.45	0.43
Available K ($mg\cdot kg^{-1}$ soil)	422.00	417.00
Available P ($mg\cdot kg^{-1}$ soil)	23.00	21.00
Available Zn ($mg\cdot kg^{-1}$ soil)	0.77	0.80
Available Cu ($mg\cdot kg^{-1}$ soil)	3.12	3.21
Available Fe ($mg\cdot kg^{-1}$ soil)	3.56	3.49
Available Mn ($mg\cdot kg^{-1}$ soil)	7.63	7.75
Soluble K^+ ($meq\cdot 100g^{-1}$ soil)	0.05	0.05
Soluble Ca^{++} ($meq\cdot 100g^{-1}$ soil)	0.72	0.67
Soluble Mg^{++} ($meq\cdot 100g^{-1}$ soil)	0.69	0.64
Soluble Na^+ ($meq\cdot 100g^{-1}$ soil)	1.83	1.75
Soluble HCO_3^- ($meq\cdot 100g^{-1}$ soil)	0.16	0.15
Soluble Cl^- ($meq\cdot 100g^{-1}$ soil)	1.52	1.48
Soluble SO_4^{--} ($meq\cdot 100g^{-1}$ soil)	1.54	1.58

Basal soil dressing of 90, 31 and 48kg N, P_2O_5 and K_2Ofed^{-1}, as ammonium nitrate (33.5% N), calcium superphosphate (15.5% P_2O_5) and potassium sulphate (48% K_2O), orderly, were applied. During soil preparation, a fertilizer dose containing 31kg P_2O_5 + 20kg $Nfed^{-1}$ was broadcasted, meanwhile the remainder amounts of the basal fertilizers were banded at two equal applications; 21 and 40 days after seed sowing. All other recommended agromanagements for dry seed production were practiced whenever it was necessary. In each experimental unit, plants of the outer four rows were allocated to measure the morphological characters and chemical composition of leaves, whereas plants of the middle two rows were assigned to record the dry seed yield and its components as well as the chemical composition of seeds.

A random sample consisted of 8 plants, from each experimental unit, for morphological measurements, after 60 days from seed sowing was chosen. Plants were carefully cut off at the ground level and immediately carried to the laboratory where they were dissected into leaf-blades and shoots including leaf-petioles and small immature pods. Plant height was measured starting from the ground level to the terminal growing point, Number of leaves $plant^{-1}$, Leaves area $plant^{-1}$ using leaf area-leaf weight relationship as illustrated by Nassar (1986). Leaf area $leaf^{1}$ was calculated

using the following formula: $\text{leaf area leaf}^{1} = \frac{\text{Leaves area plant}^{-1}}{\text{Number of leaves plant}^{-1}}$,

and Dry weights of leaves and shoots $plant^{-1}$ were gained by drying at 70°C in a forced-air oven till the weight became constant. Canopy dry weight $plant^{-1}$ was determined from oven dried leaves and shoots by summation.

In each experimental unit, plants of the two middle rows were left growing till the pods approached the dry stage. The dry pods of one m^2 were picked, seeds were manually extracted, air dried till the moisture content reached about 10% and then weighed and seed index were estimated.

Leaf samples for chemical determination were collected after 60 days from planting, washed with tap water, and dried at 70°C in a forced-air oven till constant weight. The dried leaf samples were finely ground and weights of 0.2g of the fine powder were digested using a mixture of sulphoric and perchloric acids. The following determinations were performed: Leaf N content was estimated using the Microkjeldahal apparatus as described in A.O.A.C (1992).Leaf P content was colourimetrically estimated according to the Stannous molybdate chloride method as illustrated in A.O.A.C (1992). Leaf K content was photometrically measured using Flamphotometer as mentioned by Wilde *et al.* (1985). Leaf Fe, Zn, Mn and Mg contents were determined using atomic absorption spectrophotometer apparatus as outlined by Chapman and Pratt (1961). Random seed samples, after complete drying for at least 96 hours at 70°C in forced-air oven, were chosen. The dried seed samples were finely ground and weights of 0.2g of the dried fine powder were prepared for the following chemical determinations: Seed N Content was determined using the same analytical method used for the determination of leaf N content. Seed N content was multiplied by a factor of 6.25 for conversion of total N to protein percent (Kelly and Bliss, 1975). Seed carbohydrates content was colourimetrically estimated using the method exhibitive by Michel *et al.* (1956).

According to the experimental design used, appropriate analysis of variance on results of each experiment were achieved. The new least Significant Difference procedure at 0.05 level introduced by Al-Rawi and Khalf-Allah (1980) was utilized to verify difference between treatment means.

RESULTS AND DISCUSSION

The results illustrating the general effects of spraying the above ground vegetative organs of bean plants with different concentrations of three microelements; Fe, Zn and Mn, two times; 35 and 45 days after seed sowing as well as their different degree of interactions on the various measured features will be presented under the following major headings; morphological characters, dry seeds yield and its components and chemical composition of leaves and dry seeds.

Morphological Characters

Plant height

The analysis of variance on data of plant height proved, clearly, that the general effects of the three studied microelements (Fe, Zn and Mn) were significant and the trend was similar in both seasons (Table, 2). Fe-treated plants at 400ppm displayed longer height than those treated with 200ppm Fe, in both years. The comparisons among Zn concentrations, obviously, indicated that increasing the concentration of Zn, in the spray solution, from 250 to 375ppm, markedly and significantly, increased the height of bean plant. However, further increase of Zn concentration to 500ppm did not promote plant height to go forward, in both 2001 and 2002 seasons. The comparisons among Mn concentrations, in both years, showed that the measured values of plant height at 375 and 500ppm Mn did not significantly differ from each other, but they appeared significantly higher than those achieved at 250 and 625ppm Mn.

The different degree of interactions between and among the three studied factors, generally, did not seem to have any valuable influence on the height of bean plant, in 2001 and 2002 seasons, except the interaction of Fe by Zn levels. The comparisons indicated that at any level of Fe, increasing Zn concentration to 375ppm increased plant height, while further increase to 500ppm, generally, was not effective or reduced plant height. Likely, at 250 and 375ppm Zn, increasing Fe concentration increased plant height, but at 500ppm Zn, increasing Fe concentration, generally, reduced plant height. Therefore, the treatment combination of Fe and Zn at 400 and 375ppm, orderly reflected the best result on plant height.

Dry weight of the vegetative aerial plant parts

The dry weight of leaves $plant^{-1}$, significantly, responded to the foliar application of Fe and the trend was exactly similar, in both seasons (Table, 2). Spraying the aerial plant parts with Fe at 200ppm stand favorably and was responsible for the statistical increase in leaves dry weight compared to 400ppm Fe. On the other extreme, whether the foliar application of Fe was at 200 or 400ppm. shoots and canopy dry weights were similar, in both seasons (Table, 3).

Table (2): Influence of foliar nutrition with the microelements of Fe, Zn and Mn on the height of bean plant (cm) and leaves dry weight of bean plant (g) during the summer seasons of 2001 and 2002.

Mn conc. (ppm)	Zn conc. (ppm)	Height of bean plant (cm)					
		First season			Second season		
		Fe conc. (ppm)		Avg.	Fe conc. (ppm)		Avg.
		200	400		200	400	
250	250	23.38	24.08	23.73	18.45	19.24	18.84
	375	25.64	27.77	26.70	20.48	21.60	21.04
	500	27.91	25.50	26.70	21.49	20.25	20.87
375	250	25.22	29.75	27.48	21.26	23.40	22.33
	375	28.48	30.60	29.54	22.83	23.77	23.30
	500	30.03	28.48	29.25	23.29	22.27	22.78
500	250	24.84	29.61	27.23	20.48	22.61	21.54
	375	29.04	30.32	29.68	23.62	23.77	23.70
	500	29.61	29.04	29.33	22.95	22.28	22.61
625	250	25.35	27.06	26.20	19.13	21.04	20.08
	375	26.49	27.48	26.99	21.60	20.81	21.21
	500	26.35	24.51	25.43	19.69	20.36	20.03
Main effects	250	24.70 d*	27.63 bc	26.16 B	19.83 c	21.57 b	20.70 C
	375	27.41 bc	29.04 a	28.23 A	22.13 ab	22.49 a	22.31 A
	500	28.48 ab	26.88 c	27.68 A	21.85 ab	21.29 b	21.57 B
250		25.64	25.78	25.71 B	20.14	20.36	20.25 B
375		27.91	29.61	28.76 A	22.46	23.15	22.80 A
500		27.83	29.66	28.74 A	22.35	22.89	22.62 A
625		26.06	26.35	26.21 B	20.14	20.74	20.44 B
	Avg.	26.86 B	27.85 A		21.27 B	21.78 A	
		Leaves dry weight of bean plant (g)					
250	250	5.77	5.81	5.79	5.43	5.51	5.47
	375	6.06	6.20	6.13	5.58	5.77	5.67
	500	6.04	5.87	5.96	5.75	5.55	5.65
375	250	6.90	6.60	6.75	6.13	6.11	6.12
	375	6.53	6.79	6.66	6.24	6.02	6.13
	500	6.91	6.30	6.61	6.12	6.04	6.08
500	250	6.72	6.50	6.61	6.15	6.09	6.12
	375	6.83	6.59	6.71	6.13	6.24	6.19
	500	6.63	6.61	6.62	6.33	5.73	6.03
625	250	5.92	6.26	6.09	5.59	5.44	5.51
	375	6.64	5.83	6.24	5.85	5.55	5.70
	500	6.10	5.81	5.96	5.90	5.14	5.52
Main effects	250	6.33 ab*	6.29 ab	6.31	5.82 abc	5.79 bc	5.81
	375	6.51 a	6.35 ab	6.43	5.95 ab	5.90 ab	5.92
	500	6.42 a	6.15 b	6.28	6.03 a	5.61 c	5.82
250		5.96	5.96	5.96 B	5.58	5.61	5.60 B
375		6.78	6.56	6.67 A	6.16	6.06	6.11 A
500		6.73	6.57	6.65 A	6.20	6.02	6.11 A
625		6.22	5.97	6.10 B	5.78	5.38	5.58 B
	Avg.	6.42 A	6.26 B		5.93 A	5.77 B	

* Values marked with the different alphabetical letter (s) within a comparable group of means are statistically different using revised L.S.D test at p= 0.05. Absence of the alphabetical letter (s) indicate a non-significant difference.

Table (3): Influence of foliar nutrition with the microelements of Fe, Zn and Mn on shoots dry weight of bean plant (g) and canopy dry weight of bean plant (g) during the summer seasons of 2001 and 2002.

Mn conc. (ppm)	Zn conc. (ppm)	Shoots dry weight of bean plant (g)					
		First season			Second season		
		Fe conc. (ppm)		Avg.	Fe conc. (ppm)		Avg.
		200	400		200	400	
250	250	4.32	4.98	4.65	4.20	4.74	4.47
	375	5.50	5.43	5.47	4.87	4.70	4.79
	500	5.26	4.98	5.12	4.93	4.76	4.84
375	250	5.30	5.45	5.37	4.62	5.08	4.85
	375	5.82	5.69	5.75	5.26	4.98	5.12
	500	5.86	5.29	5.58	5.09	5.10	5.10
500	250	5.26	5.53	5.40	4.70	5.14	4.92
	375	5.85	5.71	5.78	5.14	5.09	5.11
	500	5.64	5.45	5.55	5.26	4.74	5.00
625	250	4.44	5.34	4.89	4.47	4.64	4.56
	375	5.60	5.12	5.36	4.85	4.87	4.86
	500	5.08	5.06	5.07	5.00	4.49	4.74
Main effects	250	4.83 d*	5.32 bc	5.08 C	4.50 c	4.90 ab	4.70 B
	375	5.69 a	5.49 ab	5.59 A	5.03 a	4.91 ab	4.97 A
	500	5.46 ab	5.20 c	5.33 B	5.07 a	4.77 b	4.92 A
250		5.03	5.13	5.08 B	4.67	4.73	4.70 B
375		5.66	5.48	5.57 A	4.99	5.05	5.02 A
500		5.58	5.56	5.57 A	5.03	4.99	5.01 A
625		5.04	5.18	5.11 B	4.77	4.67	4.72 B
	Avg.	5.33	5.34		4.87	4.86	
		Canopy dry weight of bean plant (g)					
250	250	10.10	10.79	10.44	9.62	10.26	9.94
	375	11.56	11.63	11.60	10.45	10.47	10.46
	500	11.30	10.86	11.08	10.68	10.31	10.49
375	250	12.20	12.05	12.12	10.75	11.19	10.97
	375	12.35	12.48	12.42	11.50	11.00	11.25
	500	12.78	11.59	12.18	11.21	11.14	11.18
500	250	11.99	12.03	12.01	10.85	11.24	11.04
	375	12.67	12.30	12.49	11.27	11.33	11.30
	500	12.27	12.05	12.16	11.59	10.47	11.03
625	250	10.36	11.60	10.98	10.06	10.08	10.07
	375	12.24	10.95	11.60	10.70	10.42	10.56
	500	11.19	10.88	11.03	10.90	9.62	10.26
Main effects	250	11.16 d*	11.62 bc	11.39 B	10.32 d	10.69 bc	10.51 B
	375	12.21 a	11.84 ab	12.02 A	10.98 ab	10.81 ab	10.89 A
	500	11.88 ab	11.34 cd	11.61 B	11.09 a	10.39 cd	10.74 AB
250		10.98	11.09	11.04 B	10.25	10.35	10.30 B
375		12.44	12.04	12.24 A	11.15	11.11	11.13 A
500		12.31	12.13	12.22 A	11.24	11.01	11.12 A
625		11.26	11.14	11.20 B	10.55	10.04	10.30 B
	Avg.	11.75	11.60		10.80	10.63	

* Values marked with the different alphabetical letter (s) within a comparable group of means are statistically different using revised L.S.D test at p= 0.05. Absence of the alphabetical letter (s) indicate a non-significant difference.

The effect of Zn foliar application on the dry weight of leaves plant^{-1} was not significant, in both seasons (Table 2). However, Zn foliar application reflected significant influences on the dry weight of shoots and canopy plant^{-1}, in the two summer seasons of 2001 and 2002 (Table 3). Raising the concentration of Zn, in the spray solution from 250 to 375ppm was adequate and significantly augmented the dry weights of shoots and canopy plant^{-1}, in both years. The dry weight of leaves, shoots and canopy plant^{-1} seemed to be significantly affected by Mn applications and the response was exactly the same in 2001 and 2002 seasons (Tables 2 and 3).

All the interactions between and among the three studied variables (Fe, Zn and Mn) did not reflect any significant effect on leaves, shoots and canopy dry weight plant^{-1}. The combined foliar application of Fe at 200ppm with 375ppm Zn, in the 1st season, and with 500ppm Zn, in the 2nd one, achieved the heaviest dry weights of leaves, shoots and canopy plant^{-1}.

Leaves area plant^{-1} and its components

Foliar application of Fe at 200ppm, significantly, gave more number of leaves plant^{-1} and smaller leaf area leaf^{-1} than those achieved at 400ppm Fe, in both seasons. On the other direction, whether the foliar application of Fe was 200 or 400ppm, total leaves area plant^{-1} was not affected, in both summer seasons (Tables 4 and 5).The foliar feeding of Zn did not prove to have any significant influence on total leaves area plant^{-1} (Table 5).

Comparisons among Mn concentrations obviously, indicated significant differences, at 375 and 500ppm Mn, number and total surface area of leaves plant^{-1} were similar, but both concentrations resulted in, significantly, more number and larger area of leaves plant^{-1} than those attained at 250 or 625ppm Mn (Tables 4 and 5). Likely, at 375 and 500ppm Mn, leaf area leaf^{-1} did not greatly differ from each other, but both concentrations, unlikely, appeared to depress the leaf area leaf^{-1} in comparison to that gained at 250 and 625ppm Mn (Table 4).

Comparisons within the mean values of leaves area plant^{-1} and its components showed that the sound of interaction effects between and among the three studied factors, through the two growing summer seasons, was absent except in case of the 1st order interaction of Fe by Zn on leaves area plant^{-1}, in both seasons (Table 5). The treatment combination of 200-500ppm Fe-Zn, respectively was pronounced and associated with the greatest mean value of leaves area plant^{-1}.

This result might be explained on the ground that the effectiveness of Fe on most of the metabolic process; carbohydrates and protein formations (Bidwell, 1980), chlorophyll synthesis and nucleic acid metabolism (Mohr and Schopfer, 1995), was better with the higher than the lower Fe concentration, with an eventual increase on plant height. This result conforms those of El-Gharably and El-Razek (1982) and Helal (1995), who clarified that plant height of bean cvs Giza 3 and Bronco was significantly longer with the foliar application of Fe at 200g fed^{-1} than the untreated control. Similar to the current results, Helal (1995) found that foliar application of Fe at 200g fed^{-1} was sufficient for bean plants to express their best performance on leaves fresh and dry weights. On the other side, results of El-Sawah (1988) and El-Bendary *et al.* (1999) did not coincide with the gained results of shoots and canopy dry weights, orderly. The achieved results of number of leaves $plant^{-1}$ and leaf area leaf-1 was differed with those of El-Sayed (1991) who observed that the number of leaves of bean plant was greater with the foliar application of Fe at higher than lower concentration. El-Sawah (1988) mentioned that increasing Fe applied level up to 160g fed^{-1} increased leaf area ratio.

Regarding the effect of Zn foliar application on morphological characters, the results of the current study might be discussed on the basis that Zn is necessary to chlorophyll formation, the principle agent of photosynthesis (Gilbeart and Collings, 1962), RNA and ribosomes synthesis, the major agents of N-metabolism (Price *et al.*, 1972) and the activation of a variety of enzymes particularly those of carbonic anhydrase and a number of dehydrogenises (Pillali, 1967) which in turn prompted the efficiency of photosynthesis to go forward with an eventual increase in the shoots and canopy dry weights. The relationship between Zn application and plant height was in a strong accordance with the results of Helal (1995) who found that Zn application at 100g fed^{-1} significantly increased plant height compared to the application of Zn either at 120 or 140g fed^{-1}. The stimulatory impact of Zn application on shoots and canopy dry weights appeared to be in close agreement with those reported by many investigators (El-Koumey, 1998 and El-Shamma, 1998). El-Sayed (1991) noticed that increasing the concentration of Zn application to 25ppm, significantly increased the dry weight of bean plant, but further increase above 25ppm was valueless.

The results of Mn foliar application showed favourable effects with the intermediate levels, such favourable effects of Mn on vegetative growth characters could be expected, since Mn plays major and vital roles in activating a number of enzymes, inducing a cycle of relations within the plants, splitting water during photosynthesis, carbon dioxide assimilation and N-metabolism. Parallel to the recorded results, plant height of common bean was demonstrated to be longer with the foliar application of Mn at 50 than 100ppm (El-Sayed, 1991), but results of Helal (1995), Abd El-Megeed *et al.* (1997) and El-Naggar (1998) exhibited ineffective influence of Mn foliar application on length of bean plant. The stimulatory effect on Mn on the dry weights of the vegetative aerial plant parts linked well with the findings of (El-Sayed, 1991; El-Basyouny, 1995 and Mohammed, 1998). The improving effect of Mn on number and area of leaves of bean plant were held by the findings of Mohammed and Kandeel (1994), El-Basyouny (1995) and Abd El-Megeed *et al.* (1997).

The results of the interaction of Fe by Zn levels indicates that the balance between the two studied microelements (Fe and Zn) is more important than either alone and the efficiency of utilization for each depends, greatly, upon the presence of a suitable dose of the other.

Table (4): Influence of foliar nutrition with the microelements of Fe, Zn and Mn on number of leaves of bean plant and leaf area leaf^{-1} of bean plant (cm^2) during the summer seasons of 2001 and 2002.

Mn conc. (ppm)	Zn conc. (ppm)	Number of leaves of bean plant					
		First season			Second season		
		Fe conc. (ppm)		Avg.	Fe conc. (ppm)		Avg.
		200	400		200	400	
250	250	14.97	15.47	15.22	15.15	14.70	14.93
	375	16.48	15.64	16.06	15.00	14.40	14.70
	500	16.14	15.47	15.81	15.15	15.00	15.08
375	250	18.50	17.33	17.92	16.98	16.65	16.82
	375	17.32	17.44	17.38	17.13	15.15	16.14
	500	18.67	17.15	17.91	16.23	16.20	16.22
500	250	18.50	17.32	17.91	17.32	16.65	16.98
	375	18.16	16.31	17.24	16.87	15.90	16.38
	500	17.49	17.67	17.58	17.10	15.90	16.50
625	250	16.31	16.15	16.23	15.30	14.25	14.78
	375	16.48	15.64	16.06	14.85	14.55	14.70
	500	15.47	15.47	15.47	14.85	13.80	14.33
Main effects	250	17.07	16.57	16.82	16.19	15.56	15.88
	375	17.11	16.26	16.69	15.96	15.00	15.48
	500	16.94	16.44	16.69	15.83	15.23	15.53
250		15.86	15.53	15.70 B	15.10	14.70	14.90 B
375		18.16	17.31	17.74 A	16.78	16.00	16.39 A
500		18.05	17.10	17.58 A	17.10	16.15	16.62 A
625		16.09	15.75	15.92 B	15.00	14.20	14.60 B
	Avg.	17.04 A*	16.42 B		15.99 A	15.26 B	
		Leaf area leaf^{-1} of bean plant (cm^2)					
250	250	87.52	85.28	86.40	90.26	95.69	92.97
	375	79.86	87.52	83.69	90.44	93.46	91.95
	500	85.69	84.67	85.18	94.04	91.69	92.87
375	250	77.89	83.59	80.74	86.66	88.18	87.42
	375	84.76	82.10	83.43	86.79	98.36	92.57
	500	80.71	84.75	82.73	89.70	90.86	90.28
500	250	77.05	85.42	81.24	85.32	91.39	88.36
	375	81.35	89.71	85.53	87.74	94.24	90.99
	500	84.34	81.96	83.15	90.36	91.20	90.78
625	250	81.22	87.74	84.48	89.36	97.64	93.50
	375	85.93	87.91	86.92	96.38	94.46	95.42
	500	89.21	86.23	87.72	96.10	96.50	96.30
Main effects	250	80.92	85.51	83.21	87.90	93.22	90.56
	375	82.97	86.81	84.89	90.34	95.13	92.73
	500	84.99	84.40	84.70	92.55	92.57	92.56
250		84.36	85.82	85.09	91.58	93.61	92.60 B
375		81.12	83.48	82.30	87.72	92.47	90.09 B
500		80.91	85.70	83.31	87.80	92.28	90.04 B
625		85.45	87.29	86.37	93.95	96.20	95.08 A
	Avg.	82.96 B*	85.57 A		90.26 B	93.64 A	

* Values marked with the different alphabetical letter (s) within a comparable group of means are statistically different using revised L.S.D test at p= 0.05. Absence of the alphabetical letter (s) indicate a non-significant difference.

Table (5): Influence of foliar nutrition with the microelements of Fe, Zn and Mn on total leaf area of bean plant (dm^2) and total number of dry bean pods m^{-2} during the summer seasons of 2001 and 2002.

Mn conc. (ppm)	Zn conc. (ppm)	Total leaf area of bean plant (dm^2)					
		First season			Second season		
		Fe conc. (ppm)		Avg.	Fe conc. (ppm)		Avg.
		200	400		200	400	
250	250	13.10	13.12	13.11	13.63	14.06	13.85
	375	13.15	13.64	13.39	13.47	13.40	13.43
	500	13.82	13.09	13.46	14.25	13.75	14.00
375	250	14.34	14.46	14.40	14.70	14.66	14.68
	375	14.66	14.29	14.48	14.80	14.83	14.81
	500	14.96	14.51	14.74	14.53	14.70	14.62
500	250	14.15	14.79	14.47	14.75	15.22	14.99
	375	14.74	14.61	14.67	14.73	14.98	14.85
	500	14.68	14.45	14.57	15.42	14.51	14.96
625	250	13.21	14.15	13.68	13.66	13.87	13.77
	375	14.07	13.74	13.91	14.32	13.74	14.03
	500	13.79	13.32	13.56	14.25	13.27	13.76
Main effects	250	13.70 c*	14.13 ab	13.91	14.19 ab	14.46 ab	14.32
	375	14.16 ab	14.07 ab	14.11	14.33 ab	14.24 ab	14.28
	500	14.31 a	13.84 bc	14.08	14.61 a	14.06 b	14.34
250		13.36	13.28	13.32 C	13.78	13.74	13.76 B
375		14.65	14.42	14.54 A	14.68	14.73	14.70 A
500		14.53	14.62	14.57 A	14.96	14.91	14.93 A
625		13.69	13.74	13.72 B	14.08	13.63	13.85 B
	Avg.	14.06	14.02		14.38	14.25	
		Total number of dry bean pods m^{-2}					
250	250	323.35	342.71	333.03	289.63	306.41	298.02
	375	326.42	345.26	335.84	300.78	300.69	300.74
	500	324.85	332.03	328.44	298.11	303.57	300.84
375	250	341.16	342.01	341.59	300.27	311.04	305.66
	375	337.84	350.50	344.17	305.20	307.11	306.15
	500	341.14	340.09	340.61	305.04	308.02	306.53
500	250	331.69	346.19	338.94	299.34	309.75	304.54
	375	340.34	354.17	347.26	304.34	311.90	308.12
	500	337.90	342.62	340.26	304.82	305.00	304.91
625	250	335.27	339.47	337.37	298.04	312.10	305.07
	375	334.25	343.11	338.68	301.70	301.72	301.71
	500	338.17	329.71	333.94	304.43	303.96	304.20
Main effects	250	332.87	342.60	337.73	296.82 b*	309.83 a	303.32
	375	334.71	348.26	341.49	303.01 ab	305.36 a	304.18
	500	335.51	336.11	335.81	303.10ab	305.14 a	304.12
250		324.87	340.00	332.44 B	296.17	303.56	299.87 B
375		340.04	344.20	342.12 A	303.50	308.72	306.11 A
500		336.65	347.66	342.15 A	302.83	308.88	305.86 A
625		335.89	337.43	336.66AB	301.39	305.93	303.66AB
	Avg.	334.36 B	342.32 A		300.98 B	306.77 A	

* Values marked with the different alphabetical letter (s) within a comparable group of means are statistically different using revised L.S.D test at p= 0.05. Absence of the alphabetical letter (s) indicate a non-significant difference.

Dry Seed Yield and its Components

Number of dry bean pods

The response of dry bean pods to Fe foliar application was, however, significant and the trend was similar in both years (Table 5). Comparisons between the two investigated Fe concentrations indicated that total dry pods was increased with increasing Fe level. Spraying the foliage of bean plants with different concentrations of Zn did not appear to reflect any appreciable influence on number of dry bean pods, in both 2001 and 2002 seasons (Table 5).

Applied Mn significantly, affected number of dry bean pods and the trend was approximately similar, in both 2001 and 2002 seasons (Table 5). Foliar application of Mn at 375 and 500ppm, significantly, resulted in more number of dry bean pods, than those achieved with the foliar application of 250 and 625ppm Mn, and the difference between the addition of 375 and 500ppm Mn was not significant.

The interactions of the three studied main factors (Fe, Zn and Mn) did not seem to be effectual on number of dry bean pods in both seasons, except the interaction of Fe by Zn, comparisons indicated that the greatest number of dry bean pods was recorded with the dual application of Fe at 400ppm and Zn at 250ppm.

Dry seeds yield

Results of the analysis of variance, obviously, showed that the dry seeds yield significantly responded to the foliar application of Fe at 400ppm greater than 200ppm, in both seasons (Table 6). In 2001 season, the increments in dry seed yields at 400 over 200ppm Fe was 5.62%, while in 2002 season it was 4.97%, respectively.

The comparisons among means of the dry seeds yield as affected by the application of Zn at 250, 375 and 500ppm, in the two experiments of 2001 and 2002, reflected significant differences (Table 6). Increasing Zn concentration from 250 to 375ppm was distinct and associated with enhancing effects on the dry seeds yield. Further increase of Zn concentration to 500ppm, however, did not appear to have any beneficial influence. The true increment in dry seeds yield of bean pod was due to the application of Zn at 375 than 250ppm was 2.5% in 2001 season, while in 2002 season the increment was 4.2%, orderly.

Data of Table (6) clarified that spraying the canopy of bean plants with various concentrations of Mn was responsible for the statistical differences among the means of dry seeds yield in the two growing summer seasons of 2001 and 2002. Total dry seeds yield appeared significantly heavier with the addition of 375 or 500 than 250 and 625ppm Mn. Difference between the application of 375 and 500ppm Mn, however, was not significant. The increments at 375 over 250 and 625ppm Mn were 12.0 and 8.7% in 2001 season and 9.8 and 7.3% in 2002 season, respectively. Meanwhile, the increments at 500 over 250 and 625ppm Mn averaged 11.8 and 8.5% in 2001 season and 10.8 and 8.3% in 2002 season, consecutively.

Table (6): Influence of foliar nutrition with the microelements of Fe, Zn and Mn on total dry seeds yield of bean pods m^{-2} (g) and seed index (g) of dry bean pods during the summer seasons of 2001 and 2002.

Mn conc. (ppm)	Zn conc. (ppm)	Total dry seeds yield of bean pods m^{-2} (g)					
		First season			Second season		
		Fe conc. (ppm)		Avg.	Fe conc. (ppm)		Avg.
		200	400		200	400	
250	250	336.63	389.74	363.18	298.18	335.67	316.93
	375	355.99	393.72	374.85	322.43	345.47	333.95
	500	364.08	367.47	365.78	331.69	334.46	333.07
375	250	391.85	421.86	406.85	334.56	365.08	349.82
	375	406.97	428.04	417.50	356.96	379.54	368.25
	500	414.14	409.90	412.02	364.51	360.56	362.53
500	250	378.83	426.29	402.56	335.23	373.79	354.51
	375	405.13	431.34	418.24	359.19	379.65	369.42
	500	410.07	416.48	413.28	365.77	366.92	366.34
625	250	362.87	386.58	374.72	320.61	344.67	332.64
	375	374.03	399.83	386.93	331.95	347.44	339.70
	500	382.21	369.34	375.78	339.46	329.18	334.32
Main effects	250	367.54 c*	406.11 a	386.83 B	322.15 e	354.80 b	338.48 B
	375	385.53 b	413.23 a	399.38 A	342.63 d	363.03 a	352.83 A
	500	392.63 b	390.80 b	391.71 B	350.35 bc	347.78 cd	349.07 A
250		352.23 e	383.64 cd	367.94 C	317.43	338.53	327.98 C
375		404.32 b	419.93 a	412.12 A	352.01	368.39	360.20 A
500		398.01 b	424.70 a	411.36 A	353.40	373.45	363.43 A
625		373.04 d	385.25 c	379.14 B	330.67	340.43	335.55 B
	Avg.	381.90 B	403.38 A		338.38 B	355.20 A	
		Seed index (g) of dry bean pods					
250	250	50.55	52.40	51.47	49.99	51.35	50.67
	375	52.59	52.85	52.72	51.75	53.37	52.56
	500	52.62	51.95	52.28	51.45	51.56	51.50
375	250	52.06	54.13	53.10	51.56	52.92	52.24
	375	53.37	54.68	54.03	53.30	54.74	54.02
	500	54.07	53.48	53.78	53.63	52.63	53.13
500	250	51.96	53.88	52.92	51.39	53.30	52.34
	375	53.82	54.60	54.21	53.22	54.59	53.90
	500	53.89	53.71	53.80	53.40	53.14	53.27
625	250	51.04	53.06	52.05	50.88	51.69	51.28
	375	52.30	53.41	52.86	51.52	53.28	52.40
	500	53.31	52.05	52.68	52.28	50.86	51.57
Main effects	250	51.40 b*	53.37 a	52.39	50.95 c	52.32 b	51.64 B
	375	53.02 a	53.89 a	53.45	52.45 b	54.00 a	53.22 A
	500	53.47 a	52.80 ab	53.13	52.69 ab	52.05 bc	52.37 AB
250		51.92	52.40	52.16 B	51.06	52.09	51.58 B
375		53.17	54.10	53.63 A	52.83	53.43	53.13 A
500		53.22	54.06	53.64 A	52.67	53.67	53.17 A
625		52.22	52.84	52.53 AB	51.56	51.95	51.75 B
	Avg.	52.63	53.35		52.03	52.79	

* Values marked with the different alphabetical letter (s) within a comparable group of means are statistically different using revised L.S.D test at p= 0.05. Absence of the alphabetical letter (s) indicate a non-significant difference.

The interaction of Fe by Zn concentrations indicated significant impacts on the dry seeds yield (Table 6). Comparisons among means clearly, showed that the heaviest dry seeds yield of bean was achieved as a result of the combination between 400ppm Fe and 375ppm Zn. Generally, the treatment combination of Fe at 400 by Mn at 375 or 500ppm gave the highest dry seeds yield.

Seed index

The foliar application of Fe at two different concentrations; 200 and 400ppm, gave similar effects on seed index in both seasons (Table 6). The statistical comparison among the mean values of the three studied concentrations of Zn within the seed index was significant in the 2nd season. (Table 6). The mean value of seed index, was generally, higher with the foliar application of 375 and 500 than 250ppm Zn.

Spraying the canopy of bean plants with four Mn concentrations, ranged between 250-625ppm, reflected significant differences on seed index in the two assessed seasons of 2001 and 2002 (Table 6). Comparisons among the four concentrations of Mn indicated that at 375 and 500ppm, the mean value of seed index for dry bean was significantly higher than that achieved at 250ppm Mn. Difference between Mn concentrations of 375 and 500ppm, however, was not significant.

The dual foliar application of Fe at 400ppm and Zn at 375ppm was adequate and sufficient for the plants to express their best performance on seed index .The overall evidence possessed from these results indicated that the desirable influence of spraying Fe at the higher than the lower concentration on the total dry seeds yield strongly and mainly associated with number of seeded pods, but did not appear to be associated with the seed indices. Fernandez and Miller (1985) and Nassar (1986) declared that the number of pods plant^{-1} was generally the most sensitive yield component, but it was highly unstable and generally influenced by physiological and morphological features of plant growth and development and highly susceptible to environmental changes. The number of pods was illustrated to be influenced by Fe treatments. A positive relationship between number of pods plant^{-1} and Fe application was documented, but there was no a consensus on an optimal level of applied Fe (El-Sawah, 1988; Zaiter *et al.*, 1992; Helal, 1995). Such relationship was evident under the conditions of the current study. Parallel to the results of the present study, El-Sawah (1988) concluded a positive linear association between Fe levels up to 160g fed.$^{-1}$ and number of seeds pod^{-1}, which by turn increased the dry seeds yield. Zaiter *et al.* (1992) reported that the increment in dry seeds yield of different bean cvs and lines as a consequence of Fe application.

However, the dry seeds yield and seed index of bean seemed to be significantly heavier with increasing Zn application up to 375ppm, Khan and Soltanpour (1978) mentioned that foliar application of Zn at 1% increased the dry seeds yield of bean by 18-29% compared to the control. Likewise, Helal (1995) obtained better results on weight of 100-seed with the foliar application of 120 than 100 or 140g Zn fed^{-1}. El-Shamma (1998) reported that the increase in dry seeds yield of bean in relation to Zn application was due to increased number of pods $plant^{-1}$ and weight of 100-seed.

The overall evidence possessed from the results of spraying Mn indicated a positive relationship between the application of 375 or 500ppm Mn and the total dry seeds yield which is positively associated with its major components i.e. number of pods $plant^{-1}$, number of seeds pod^{-1} and average seed weight The promoting effect of spraying Mn on number of bean pods $plant^{-1}$ was in line with the findings of Mitkees (1974) who concluded that Mn application had a peculiar stimulative influence on number of pods $plant^{-1}$. Results of Saeed (1993) demonstrated a great increase on number of pods $plant^{-1}$. Likewise, Firgany *et al.* (1988) and Kotecki (1990) working on other leguminous vegetable crops emphasized the beneficial influence of spraying Mn on number of pods $plant^{-1}$. Parallel to the results of dry seeds yield and 100-seed weight, Abd El-Megeed, (1997) and El-Naggar (1998),mentioned that the foliar application of 100ppm Mn increased the total dry seeds yield and 100-seed weight of bean plants.

Results of the two growing seasons clearly exhibited that the interaction between and among the three studied main factors, .i.e., Fe, Zn and Mn did not seem to show any valuable effect on number of pod except the interaction of Fe by Zn in the 2^{nd} season. The stimulative impact of Fe-Zn foliar application at particular concentrations on number of bean pods $plant^{-1}$ was in general accordance with the results of previous researchers. Saeed (1993) observed that the number of bean pods $plant^{-1}$ was comparatively higher with than without the combined foliar application of 600ppm Fe + 500ppm Zn. Fawzi *et al.* (1993), working on pea, mentioned that the combined foliar application of Fe and Zn each at 100ppm was superior and associated with the best results on number of pods $plant^{-1}$. On the same direction, El-Bendary *et al.* (1999) showed enhancing impacts on number of bean pods $plant^{-1}$ as a consequence of spraying the canopy with chelated Fe and Zn. On the other extreme, the gained results did not agree with those of El-Sawah (1988) and Ibrahim (1989) who found that the number of bean pods $plant^{-1}$ was at par whether the plant canopy was sprayed with Fe and Zn each at 1.5g L^{-1} or not. On the same hand, the total dry seeds yield and 100 seed weight of pea were illustrated to improve with the foliar nutrition of Fe and Zn together (Fawzi *et al.*, 1993). Negm *et al.* (1997) reached similar results on pea. El-Bendary *et al.* (1999) supported the current result of nutrition with Fe and Zn or Mn, but Zn was more effective than Mn.

Chemical Composition

The content of macroelements (N, P, K and Mg) and microelements (Fe, Zn and Mn) in leaves as well as the content of protein and carbohydrates in dry seeds of bean plants treated with various concentrations of Fe, Zn and Mn, in the two growing summer seasons of 2001 and 2002, are presented in Tables(7, 8, 9,10 and 11).

The influence of foliar fertilization with Fe at 200 and 400ppm through the vegetative growth stage, in 2001 and 2002 seasons, did not reflect any significant difference on leaf N, P, K and Mg contents (Tables 7 and 8).

The foliar nutrition of bean plants with Zn at the concentrations of 250, 375 and 500ppm resulted in similar effects on leaf N, P and Mg content, in both seasons (Tables 7 and 8). Oppositely, leaf K content showed significant difference, but the trend was not exactly the same, in both years (Table 8). In 2001 season, the addition of 375 and 500ppm Zn gave significantly better content of K in leaves than 250ppm Zn. In 2002 season, the addition of 500ppm Zn only significantly achieved higher content of K in leaves than 250ppm Zn.

The comparison among the four investigated concentrations of Mn (250, 375, 500 and 625ppm) within the leaf N, P and K contents of bean exhibited significant differences, in both years (Tables 7and 8). Leaf Mg content, on the other side, did not seem to be significantly affected as a consequence of Mn application (Table 8). Mn, at 375 and 500ppm in comparison with 250 and 625ppm, significantly, depressed leaf N content (Table 7), but showed positive significant effect on leaf K content (Table 8). Difference between applied Mn at 375 and 500ppm on leaf N and K contents, on the other direction, was not significant, in both seasons. The relationship between Mn application and leaf P content was significant, but the trend was not exactly the same in both years (Table 7). The addition of Mn at 250ppm, in 2001 season, and at 250, 375 and 500ppm, in 2002 season significantly attained higher leaf P content than the other Mn treatments.

The interactions between and among the three studied variables on leaf N, P, K and Mg contents was not significant, in both 2001 and 2002 seasons, except the interaction of Fe by Zn on leaf N content (Tables 7 and 8). Generally, it was noticed that the treatment combination of Fe-Zn at 400-500ppm, consecutively associated with the greatest mean value of leaf N content, in both seasons.

Applied Fe displayed significant differences on leaf Fe and Mn contents and the trend was exactly the same, in both seasons (Tables 9 and 10). Increasing the concentration of Fe from 200 to 400ppm, increased leaf Fe content, but depressed leaf Mn content, significantly. Leaf Zn content, on the other hand, did not seem to be significantly affected by Fe application (Table 9).

The influence of foliar nutrition with Zn at different concentrations did not exhibit any significant difference on leaf Fe and Mn contents, in both 2001 and 2002 seasons (Tables 9 and 10). Leaf Zn content, on the other extreme, seemed to be significantly affected by Zn application with the superiority of 375 and 500 than 250ppm, in both seasons (Table 9).

Regarding the effect of nutrition with various Mn concentrations, results of Tables (9 and 10) indicated significant differences on leaf Fe and Mn contents, in both 2001 and 2002 seasons. The comparison among means of Mn concentrations showed clearly that leaf Fe and Mn contents were significantly higher with 375 and 500 than 250 and 625ppm Mn. Difference between the addition of 375 and 500ppm Mn, however, was not significant. Unlikely, results of Table (9) indicated that the four utilized concentrations of Mn had similar impact on leaf Zn content, in both seasons.

Table (7): Influence of foliar nutrition with the microelements of Fe, Zn and Mn on leaf N content of bean plant (%) and leaf P content of bean plant (%) during the summer seasons of 2001 and 2002.

Mn conc. (ppm)	Zn conc. (ppm)	Leaf N content of bean plant (%)					
		First season			Second season		
		Fe conc. (ppm)		Avg.	Fe conc. (ppm)		Avg.
		200	400		200	400	
250	250	3.46	3.18	3.32	3.42	3.11	3.26
	375	3.16	3.36	3.26	3.08	3.33	3.21
	500	3.18	3.48	3.33	3.11	3.45	3.28
375	250	3.19	3.06	3.13	3.11	2.96	3.04
	375	3.05	3.06	3.06	2.98	2.98	2.98
	500	3.08	3.22	3.15	3.02	3.16	3.09
500	250	3.23	3.12	3.17	3.14	3.07	3.11
	375	3.08	3.12	3.10	2.99	3.00	2.99
	500	3.15	3.26	3.21	3.08	3.20	3.14
625	250	3.26	3.42	3.34	3.18	3.37	3.28
	375	3.19	3.28	3.24	3.12	3.21	3.16
	500	3.16	3.32	3.24	3.09	3.25	3.17
Main effects	250	3.28 ab*	3.20 bc	3.24	3.21 a	3.13 bc	3.17
	375	3.12 c	3.21 bc	3.16	3.04 c	3.13 bc	3.08
	500	3.14 c	3.32 a	3.23	3.08 bc	3.27 a	3.17
250		3.27	3.34	3.30 A	3.20	3.30	3.25 A
375		3.11	3.11	3.11 B	3.04	3.03	3.03 B
500		3.15	3.17	3.16 B	3.07	3.09	3.08 B
625		3.20	3.34	3.27 A	3.13	3.28	3.21 A
	Avg.	3.18	3.24		3.11	3.17	
		Leaf P content of bean plant (%)					
250	250	0.57	0.55	0.56	0.56	0.53	0.55
	375	0.56	0.56	0.56	0.55	0.55	0.55
	500	0.55	0.55	0.55	0.54	0.54	0.54
375	250	0.55	0.53	0.54	0.54	0.53	0.53
	375	0.55	0.55	0.55	0.54	0.54	0.54
	500	0.52	0.56	0.54	0.52	0.54	0.53
500	250	0.56	0.52	0.54	0.55	0.52	0.54
	375	0.56	0.53	0.55	0.55	0.53	0.54
	500	0.53	0.55	0.54	0.52	0.53	0.53
625	250	0.50	0.52	0.51	0.48	0.51	0.50
	375	0.53	0.52	0.53	0.52	0.50	0.51
	500	0.51	0.52	0.52	0.50	0.51	0.50
Main effects	250	0.54	0.53	0.54	0.53	0.52	0.53
	375	0.55	0.54	0.54	0.54	0.53	0.53
	500	0.53	0.55	0.54	0.52	0.53	0.52
250		0.56	0.55	0.56 A*	0.55	0.54	0.54 A
375		0.54	0.54	0.54 B	0.53	0.54	0.53 A
500		0.55	0.54	0.54 B	0.54	0.53	0.53 A
625		0.51	0.52	0.52 C	0.50	0.51	0.50 B
	Avg.	0.54	0.54		0.53	0.53	

* Values marked with the different alphabetical letter (s) within a comparable group of means are statistically different using revised L.S.D test at p= 0.05. Absence of the alphabetical letter (s) indicate a non-significant difference.

Table (8): Influence of foliar nutrition with the microelements of Fe, Zn and Mn on leaf K content of bean plant (%) and leaf Mg content of bean plant (%) during the summer seasons of 2001 and 2002.

Mn conc. (ppm)	Zn conc. (ppm)	Leaf K content of bean plant (%)					
		First season			Second season		
		Fe conc. (ppm)		Avg.	Fe conc. (ppm)		Avg.
		200	400		200	400	
250	250	2.28	2.29	2.29	2.30	2.35	2.33
	375	2.28	2.31	2.30	2.33	2.34	2.34
	500	2.31	2.30	2.30	2.36	2.36	2.36
375	250	2.45	2.40	2.43	2.50	2.48	2.49
	375	2.58	2.48	2.53	2.63	2.54	2.58
	500	2.66	2.52	2.59	2.68	2.58	2.63
500	250	2.51	2.44	2.48	2.52	2.49	2.50
	375	2.65	2.53	2.59	2.64	2.57	2.61
	500	2.67	2.55	2.61	2.68	2.59	2.64
625	250	2.33	2.30	2.32	2.37	2.34	2.36
	375	2.35	2.40	2.37	2.38	2.38	2.38
	500	2.44	2.45	2.45	2.48	2.49	2.48
Main effects	250	2.39	2.36	2.38 B*	2.42	2.41	2.42 B
	375	2.47	2.43	2.45 A	2.49	2.46	2.48 AB
	500	2.52	2.46	2.49 A	2.55	2.50	2.53 A
250		2.29	2.30	2.30 C	2.33	2.35	2.34 B
375		2.57	2.47	2.52 A	2.60	2.53	2.57 A
500		2.61	2.51	2.56 A	2.61	2.55	2.58 A
625		2.38	2.38	2.38 B	2.41	2.40	2.41 B
	Avg.	2.46	2.41		2.49	2.46	
		Leaf Mg content of bean plant (%)					
250	250	1.00	0.97	0.99	0.99	0.96	0.98
	375	0.97	0.94	0.96	0.98	0.94	0.96
	500	0.93	0.95	0.94	0.94	0.96	0.95
375	250	1.01	0.96	0.98	1.01	0.98	0.99
	375	1.01	0.97	0.99	1.00	0.97	0.98
	500	0.97	0.97	0.97	0.96	0.97	0.97
500	250	1.01	0.98	1.00	1.01	0.98	0.99
	375	1.00	0.97	0.99	0.99	0.97	0.98
	500	0.97	0.97	0.97	0.97	0.96	0.97
625	250	1.00	1.00	1.00	1.01	1.01	1.01
	375	0.98	1.02	1.00	1.00	1.01	1.00
	500	0.96	1.01	0.99	0.96	1.01	0.99
Main effects	250	1.01	0.98	0.99	1.00	0.98	0.99
	375	0.99	0.98	0.98	0.99	0.97	0.98
	500	0.96	0.97	0.97	0.96	0.97	0.97
250		0.97	0.95	0.96	0.97	0.95	0.96
375		0.99	0.97	0.98	0.99	0.97	0.98
500		1.00	0.98	0.99	0.99	0.97	0.98
625		0.98	1.01	1.00	0.99	1.01	1.00
	Avg.	0.98	0.98		0.99	0.98	

* Values marked with the different alphabetical letter (s) within a comparable group of means are statistically different using revised L.S.D test at p= 0.05. Absence of the alphabetical letter (s) indicate a non-significant difference.

Table (9): Influence of foliar nutrition with the microelements of Fe, Zn and Mn on leaf Fe content of bean plant (mg kg^{-1}) and leaf Zn content of bean plant (mg kg^{-1}) during the summer seasons of 2001 and 2002.

Mn conc. (ppm)	Zn conc. (ppm)	Leaf Fe content of bean plant (mg kg^{-1})					
		First season			Second season		
		Fe conc. (ppm)		Avg.	Fe conc. (ppm)		Avg.
		200	400		200	400	
250	250	177.67	163.00	170.33	172.67	162.00	167.33
	375	155.00	186.67	170.83	154.00	182.33	168.17
	500	153.00	177.33	165.17	152.00	176.33	164.17
375	250	185.67	192.67	189.17	184.67	191.33	188.00
	375	191.00	226.00	208.50	190.00	224.33	207.17
	500	189.00	197.00	193.00	188.00	196.00	192.00
500	250	195.67	219.33	207.50	194.33	218.00	206.17
	375	208.00	209.00	208.50	206.67	207.67	207.17
	500	186.00	221.67	203.83	184.67	220.00	202.33
625	250	184.67	164.33	174.50	183.33	163.33	173.33
	375	177.00	201.33	189.17	175.67	199.33	187.50
	500	182.33	202.00	192.17	181.00	199.33	190.17
Main effects	250	185.92 b*	184.83 b	185.38	183.75 b	183.67 b	183.71
	375	182.75 b	205.75 a	194.25	181.58 b	203.42 a	192.50
	500	177.58 b	199.50 a	188.54	176.42 b	197.92 a	187.17
250		161.89	175.67	168.78 C	159.56	173.56	166.56 C
375		188.56	205.22	196.89 A	187.56	203.89	195.72 A
500		196.56	216.67	206.61 A	195.22	215.22	205.22 A
625		181.33	189.22	185.28 B	180.00	187.33	183.67 B
	Avg.	182.08 B	196.69 A		180.58 B	195.00 A	
		Leaf Zn content of bean plant (mg kg^{-1})					
250	250	56.67	59.00	57.83	57.67	58.00	57.83
	375	60.33	60.00	60.17	59.67	58.67	59.17
	500	62.00	60.00	61.00	60.00	61.33	60.67
375	250	59.67	60.00	59.83	60.33	60.33	60.33
	375	60.67	61.67	61.17	62.67	62.00	62.33
	500	63.00	63.33	63.17	63.67	61.67	62.67
500	250	60.67	59.67	60.17	60.00	59.33	59.67
	375	62.00	61.67	61.83	63.33	62.00	62.67
	500	63.00	62.33	62.67	64.33	62.00	63.17
625	250	56.67	58.00	57.33	56.33	57.67	57.00
	375	61.00	60.33	60.67	59.33	59.67	59.50
	500	61.00	61.00	61.00	61.67	60.33	61.00
Main effects	250	58.42	59.17	58.79 B*	58.58	58.83	58.71 B
	375	61.00	60.92	60.96 A	61.25	60.58	60.92 AB
	500	62.25	61.67	61.96 A	62.42	61.33	61.88 A
250		59.67	59.67	59.67	59.11	59.33	59.22
375		61.11	61.67	61.39	62.22	61.33	61.78
500		61.89	61.22	61.56	62.56	61.11	61.83
625		59.56	59.78	59.67	59.11	59.22	59.17
	Avg.	60.56	60.58		60.75	60.25	

* Values marked with the different alphabetical letter (s) within a comparable group of means are statistically different using revised L.S.D test at p= 0.05. Absence of the alphabetical letter (s) indicate a non-significant difference.

The interactions of the three examined variables generally did not appear to exert any considerable influence on leaf Fe, Zn and Mn contents except for leaf Fe content as affected by Zn in both seasons of 2001 and 2002 (Tables 9 and 10).

The general effect of spraying Fe, Zn and Mn to the growing bean plants, on the protein content of dry seeds was not significant, in 2001 and 2002 seasons (Table 10). However, seed carbohydrates content was significantly affected by all the three variables and the trend was homologous, in both seasons (Table 11). The comparison made between the two assessed Fe concentrations indicated higher seed carbohydrates content with 200 than 400ppm. With regard to Zn application the mean values of seed carbohydrates content were similar when the addition of Zn was at 250 and 375ppm, but both concentrations significantly gave higher mean values of seed carbohydrates content than 500ppm Zn. Regarding the effect of spraying Mn, to the growing bean plants, the results given in Table (11) showed significant differences on the content of carbohydrates in dry seeds throughout the two seasons. The different comparisons among Mn concentrations clarified that the mean values of carbohydrates content in dry seeds did not significantly differ from each other at 375 and 500ppm, but both concentrations appeared to result in higher mean values of carbohydrates content than those achieved at 250 and 625ppm. The exception was in 2002 season, where the difference between Mn applications at 250 and 500ppm on seed carbohydrates content was not true.

The sound of interactions between and among the three studied main variables (Fe, Zn and Mn) on the content of protein in the dry seeds of bean was absent, in 2001 and 2002 seasons (Table 10). Nevertheless, results of Table (11) obviously, illustrated that all the interactions of the three studied factors, except that of Fe by Mn, reflected significant effects on the content of carbohydrates in dry seeds, in both seasons. The comparisons across the six treatment combinations of Fe by Zn revealed that the greatest content of carbohydrates in dry seeds was recorded when 200ppm Fe together with 375ppm Zn were applied. The comparisons along with the twelve treatments of the interaction between Zn and Mn concentrations displayed that the highest mean value of carbohydrates content was accomplished with 250ppm Zn plus 375ppm Mn. Also, the comparisons among the twenty four combined treatments of the three studied microelements cleared that the combined treatment of Fe, Zn and Mn at 200, 250 and 375ppm, orderly was favorable and tended to maximize the carbohydrate content in the dry seeds of bean.

Parallel to the current results, Hurley *et al.* (1986) reached to the conclusion that leaf Fe concentration was a function of Fe applied level. Sadiq and Hussain (1994) concluded that the use of ferric nitrate in fertilizing bean plants increased the content of Fe in the tissues. The favorable influence of Fe application at the lower than the higher concentration on leaf Mn content was in agreement with those of Sadiq and Hussain (1994). Karaman *et al.* (1999) who exhibited that the foliar application of 10 or 20ppm Fe caused a significant depression on leaf Mn content of bean. Regarding the contents of protein and carbohydrates in dry seeds, Singh *et al.* (1995) coincided the gained results when the application of 5kg Fe ha^{-1}, to the grown bean plants, did not show any appreciable impact on the content of protein in dry seeds. Meanwhile, results of Saeed (1993) displayed that the protein content of dry bean seeds tended to increase as a result of spraying Fe at 600ppm. The retarding influence of increasing Fe concentration from 200 to 400ppm on the content of carbohydrates in dry seeds was not in parallel with the results of El-Sawah (1988). Who demonstrated that the application of Fe up to 160g fed^{-1} was accompanied by a successive increase in protein percent, while the carbohydrates percent was not affected.

Regarding the influence of spraying various concentrations of Zn on the chemical composition of leaves and dry seeds of bean, results of the two experimental summer seasons was in full accordance with the results of Dahdoh and Moussa (2000) who pointed out that increasing Zn application to faba bean plants was accompanied with a corresponding increment in K uptake. On the same extreme, Abdel-Reheem *et al.* (1992a) indicated that the highest K content in leaves of broad bean was found as a result of Zn and K applications. The promoting influence of Zn application at the higher than the lower Zn concentration on leaf Zn content may be explained on the ground that the optimum concentration of Zn in young mature leaves of bean at early flower stage was documented to be 23ppm (Halliady *et al.*, 1992), whereas the estimated amounts of available Zn in the soil of the experimental fields were found to be 0.77 and 0.80mg kg^{-1} soil in 2001 and 2002 seasons, orderly; which were too low to meet the requirements of normal and healthy growth. Several investigators as Hussain *et al.* (1988) and Hussain and Ramarao (1989) reported a positive association between Zn foliar application and foliage Zn content of bean. Moraghan (1994) stated that the relationship between Zn application, to a particular rate, and Zn contents of leaf blades, stem and dry seeds of bean, at maturity, was parallel. Results of the chemical analysis of bean dry seeds showed that non of the utilized Zn concentrations seemed to have any valuable influence on the content of protein. Meanwhile, seed carbohydrates content appeared to be significantly affected by Zn foliar applications with the superiority of 375ppm. The desirable impacts of the aforementioned Zn concentration may be raised as a result of indirect action on leaf K content. Perusal of the tabulated results it was clear that at 375ppm Zn, values of leaf K content was 2.45 and 2.48% in 2001 and 2002 seasons, orderly which seemed to be like the optimal content of K in young mature leaves of bean at early flower stage i.e 2.4%, on dry matter basis (Halliday *et al.*, 1992). The major and effective roles of K in enzyme activation, stabilization of the native conformation of enzymes and metabolism of carbohydrates are well known. The present results appeared to be in close agreement with the results reported by Miranova and Kloloptsera (1964, c. a. Abo El-Hassan, 1974) who mentioned that foliar application of Zn at a particular dose increased the synthesis of sucrose and starch and encouraged the translocation of carbohydrates to pea seed. Hassan (1982) showed that spraying Zn at 0.4% increased the soluble carbohydrates in seeds of faba bean with an eventual increase in the total carbohydrates content.

Table (10): Influence of foliar nutrition with the microelements of Fe, Zn and Mn on leaf Mn content of bean plant (mg kg^{-1}) and seed protein content of bean plant (%) during the summer seasons of 2001 and 2002.

Mn conc. (ppm)	Zn conc. (ppm)	Leaf Mn content of bean plant (mg kg^{-1})					
		First season			Second season		
		Fe conc. (ppm)		Avg.	Fe conc. (ppm)		Avg.
		200	400		200	400	
250	250	105.00	97.00	101.00	104.00	96.67	100.33
	375	95.00	94.33	94.67	95.00	94.67	94.83
	500	95.33	90.00	92.67	93.67	90.00	91.83
375	250	119.33	111.33	115.33	117.93	111.33	114.63
	375	118.00	110.67	114.33	116.67	109.33	113.00
	500	118.00	105.67	111.83	115.67	105.00	110.33
500	250	120.67	116.33	118.50	119.00	113.33	116.17
	375	119.00	109.67	114.33	118.33	109.00	113.67
	500	118.67	104.33	111.50	117.33	103.33	110.33
625	250	111.67	101.00	106.33	108.67	100.00	104.33
	375	100.67	99.00	99.83	99.00	97.33	98.17
	500	98.67	100.33	99.50	98.00	99.00	98.50
Main effects	250	114.17	106.42	110.29	112.40	105.33	108.87
	375	108.17	103.42	105.79	107.25	102.58	104.92
	500	107.67	100.08	103.88	106.17	99.33	102.75
250		98.44	93.78	96.11 B	97.56	93.78	95.67 B
375		118.44	109.22	113.83 A	116.76	108.56	112.66 A
500		119.44	110.11	114.78 A	118.22	108.56	113.39 A
625		103.67	100.11	101.89 B	101.89	98.78	100.33 B
	Avg.	110.00A*	103.31 B		108.61 A	102.42 B	
		Seed protein content of bean plant (%)					
250	250	18.65	18.84	18.75	18.20	18.51	18.36
	375	18.89	19.12	19.00	18.48	18.60	18.54
	500	18.60	19.12	18.86	18.83	18.60	18.71
375	250	18.62	19.69	19.15	18.55	18.93	18.74
	375	18.83	19.49	19.16	18.98	20.00	19.49
	500	18.83	19.15	18.99	19.33	19.58	19.46
500	250	19.67	18.55	19.11	19.23	18.89	19.06
	375	19.28	19.82	19.55	19.45	20.00	19.72
	500	18.83	18.83	18.83	18.60	19.67	19.13
625	250	18.28	18.16	18.22	18.20	19.26	18.73
	375	19.23	19.91	19.57	18.83	19.49	19.16
	500	18.16	18.83	18.50	18.60	18.88	18.74
Main effects	250	18.80	18.81	18.81	18.55	18.90	18.72
	375	19.06	19.58	19.32	18.93	19.52	19.23
	500	18.60	18.98	18.79	18.84	19.18	19.01
250		18.71	19.02	18.87	18.50	18.57	18.54
375		18.76	19.44	19.10	18.96	19.50	19.23
500		19.26	19.07	19.16	19.09	19.52	19.30
625		18.56	18.97	18.76	18.54	19.21	18.88
	Avg.	18.82	19.13		18.77	19.20	

* Values marked with the different alphabetical letter (s) within a comparable group of means are statistically different using revised L.S.D test at p= 0.05. Absence of the alphabetical letter (s) indicate a non-significant difference.

Table (11): Influence of foliar nutrition with the microelements of Fe, Zn and Mn on seed carbohydrates content of bean plant (%) during the summer seasons of 2001 and 2002.

Mn conc. (ppm)	Zn conc. (ppm)	Seed carbohydrates content of bean plant (%)		
		First season		
		Fe conc. (ppm)		Avg.
		200	400	
250	250	54.65 I*	58.94 fgh	56.79 e
	375	64.41 abc	61.28 bcdef	62.84 ab
	500	60.11 defgh	56.99 hi	58.55 de
375	250	65.58 a	62.84 abcde	64.21 a
	375	63.24 abcd	58.16 fghi	60.70 bcd
	500	60.11 defgh	58.16 fghi	59.14 cde
500	250	59.33 efgh	64.80 ab	62.06 ab
	375	64.02 abc	58.94 fgh	61.48 bc
	500	60.89 cdefg	57.38 ghi	59.14 cde
625	250	60.11 defgh	57.77 fghi	58.94 de
	375	58.94 fgh	56.60 hi	57.77 e
	500	58.55 fgh	57.77 fghi	58.16 e
Main effects	250	59.92 bc	61.09 ab	60.50 A
	375	62.65 a	58.75 cd	60.70 A
	500	59.92 bc	57.57 d	58.75 B
250		59.72	59.07	59.40 B
375		62.97	59.72	61.35 A
500		61.41	60.37	60.89 A
625		59.20	57.38	58.29 B
Avg.		60.83 A	59.14 B	
		Second season		
250	250	55.90 h	60.30 defg	58.10 f
	375	65.89 a	62.69 abcde	64.29 ab
	500	61.49 bcdefg	58.30 fgh	59.90 def
375	250	66.42 a	64.29 abcd	65.35 a
	375	64.69 abc	59.50 efgh	62.09 bcde
	500	61.49 bcdefg	59.50 efgh	60.50 cdef
500	250	60.70 cdefg	66.29 a	63.49 abc
	375	65.49 ab	60.30 defg	62.89 abcd
	500	62.29 abcdef	58.70 efgh	60.50 cdef
625	250	61.49 bcdefg	59.10 efgh	60.30 def
	375	60.30 defg	57.90 gh	59.10 ef
	500	59.90 efgh	59.10 efgh	59.50 ef
Main effects	250	61.13 bc	62.49 ab	61.81 A
	375	64.09 a	60.10 cd	62.09 A
	500	61.29 bc	58.90 d	60.10 B
250		61.09	60.43	60.76 BC
375		64.20	61.09	62.65 A
500		62.83	61.76	62.29 AB
625		60.56	58.70	59.63 C
Avg.		62.17 A	60.50 B	

* Values marked with the different alphabetical letter (s) within a comparable group of means are statistically different using revised L.S.D test at p= 0.05. Absence of the alphabetical letter (s) indicate a non-significant difference.

Regarding the effects of spraying various Mn concentrations on the studied chemical constituents of bean plant, Firgany and Hussain (1984) who demonstrated that leaf K concentration of bean significantly increased when the addition of Mn increased to 1ppm in the nutrient solution. In a like manner, Ibrahim (1989) reported that spraying the foliage of pea plants increased the content of K in the different vegetative plant organs. Similarly, Mohammed (1998) found that increasing Mn application was responsible for the statistically increment in the content of K, Firgany and Hussain (1984) stated that increasing Mn concentration, in the nutrient solution was adequate and aided in attainment highest content of Fe in leaves of bean. Firgany *et al.* (1988) demonstrated a positive significant influence on Fe concentration of soybean plants as a consequence of spraying Mn. Likewise, Ibrahim (1989) working on pea reached similar results. Wallace (1989) illustrated a reverse relationship between leaf Fe concentration of bean and Mn applied rate. The enhancing influence on leaf Mn content due to increasing Mn foliar application from 250 to 375 or 500ppm, in the current study, can be discussed on the basis that the optimal concentration of Mn in young mature leaves at early flower growth stage for normal and healthy growth of bean plants was found to be 92ppm as illustrated by Halliday *et al.* (1992). On the other hand, the chemical analysis of the experimental sites (Table 1) declared that the available amounts of Mn in 2001 and 2002 seasons were 7.63 and 7.75ppm, orderly. The estimated soil Mn amounts seemed too small to face the elevated Mn requirements of bean plants. Therefore, the response of leaf Mn content to increasing Mn application, up to a particular level, appeared to be positive. A number of investigators coincided the pervious results. A consistent increase in leaf Mn content of bean was arised due increasing Mn application in the nutrient solution, (Firgany and Hussain, 1984). The foliar application of Nervanid or Pholase Mn reflected positive effect on leaf Mn content of soybean (Firgany *et al.*, 1988). The improving effects of Mn foliar application at 375 and 500ppm on the content of carbohydrates in seeds can be expected as Mn applications at the aforementioned concentrations augmented the content of K in leaves to a level similar to the optimum one in young mature leaves at early flower stage (Halliday *et al.*, 1992), which by turn probably enhanced the synthesis and translocation of carbohydrates to the seeds. Similar to the obtained results, spraying the canopy of bean with the intermediate concentration of Mn gave significantly higher seed carbohydrates content than the lower or higher concentration (Firgany and Hussain, 1984).

REFERENCES

Abd El-Megeed, H.A.; Hatem, A.K. and Farag, S S.A. (1997): Effect of seed size grading and manganese foliar spray on vegetative growth, chemical composition of leaves, and seed yield and quality of Giza 3 common bean. Menofiya J. Agric. Res. 22 (4): 1175 – 1186.

Abdel-Reheem, M.A.; Gendy, E.N. and El-Awady, R.M. (1992a):. Response of broad bean plants grown in alluvial soil to potassium and zinc application. Egypt. J. Soil Sci. 32 (4): 537 – 545.

A.O.A.C. (1992): Official methods of analysis, 12th Ed. Association of official analytical chemists. Washington, D. C.

Al-Rawi, K.M. and Khalf-Allah, A.M. (1980): Design and analysis of agricultural experiments. Text book. El-Mousl Univ. Press. Ninawa, Iraq. 487. p.

Bidwell, R.G.S. (1980.): "Plant Physiology" 2nd ed. Callier Macmillan Publisher London New York.

Chapman, H.D. and Pratt, P.F. (1961): Methods of analysis for soils, plants and waters. University of California, Division of Agricultural Science, Berkeley, CA.

Dahdoh, M.S.A. and Moussa, B.I.M. (2000): Zn-Co and Fe-Ni interaction and their effect on peanut and broad bean plants. Egypt. J. Soil Sci. 40 (4): 453 – 467.

El-Basyouny, M.S. (1995): The response of snap beans to some nutritional levels of macro and micro elements. M.Sc. Thesis, Fac. Agric., Al-Azhar Univ., Egypt.

El-Bendary, A.A.; El-Masry, M.F. and Shaaban, M.M. (1999): Effect of foliar iron doses in combination with zinc and manganese on growth and yield of snap bean. Alex. J. Agric. Res. 44 (1): 201 – 211.

El-Gharably, G.A. and El-Razek, M.A. (1982): Responses of snap beans to applications of phosphorus and iron in calcareous soil. J. Plant Nutr. 5 (4-7): 421 – 428.

El-Koumey, B.Y. (1998): Influence of P, K, and Zn on kidney bean plant (*Phaseolus vulgaris* L.). Zagazig J. Agric. Res. 25 (3): 535 – 545.

El-Mansi, A.A.; Khalil, M.A.; El-Ghamriny, E.A. and Afia, F.H. (1991): Effect of foliar spray with zinc, manganese and iron on growth and yield of broad bean plants. Zagazig J. Agric. Res. 18 (6): 1947 – 1958.

El-Naggar, A.H. (1998): Effect of iron, zinc, manganese and their combinations as foliar application on growth, yield and quality of snap bean (*Phaseolus vulgaris* L.). M.Sc. Thesis, Fac. Agric., Alex. Univ., Egypt.

El-Sawah, N.A. (1988): Influence of Fe and Zn foliar application on vegetative growth, yield and nutritional quality of bean (*Phasoelus vulgaris* L.). M.Sc. Thesis, Fac. Agric., Cairo Univ., Egypt.

El-Sayed, H.A. (1991): Effect of Fe, Mn, Zn and B on the growth and yield of snap bean plants. J. Agric. Sci. Mansoura Univ. 16 (2): 402 – 406.

El-Shamma, H.A. (1998): Response of common bean to NPK and Zn applications. Menofiya J. Agric. Res. 23 (4): 1081 – 1095.

Fawzi, A.F.A. (1991): Micronutrients effects on field crops in Egypt. Proc. 4th Micronutrients Workshop, Amman, Jordan, pp. 5 – 30.

Fawzi, A.F.A.; El-Fouly, M.M. and Moubarak, Z.M. (1993): The need of grain legumes for iron, manganese and zinc fertilization under Egyptian soil conditions: Effect and uptake of metalosates. J. Plant Nutr.16 (5): 813 – 823.

Fernandez, G.C.J. and Miller, J.C. (1985): Yield components analysis in five cowpea cultivars. J. Amer. Soc. Hort. Sci. 110: 553 – 559.

Firgany, A.H. and Hussein, M.M. (1984): Growth and chemical composition of *Vicia faba* and *phaseolus vulgaris* seedlings affected by different concentrations of manganese in water culture. Ann. Agric. Sci., Ain Shams Univ. 29 (1): 19 – 28.

Firgany, A.H.; Nour, T.A. and Kabesh. M.O. (1988): Response of growth and yield of soybean plants to micronutrient fertilizers. Ann. Agric. Sci. Moshtohor 26: 2185 – 2195.

Gilbeart, H. and Collings, C.H. (1962): Commercial fertilizers. 5th Ed., Tata McGraw-Hill Publishing Company LTD. Bombay, India.

Halliday, D.J.; Trenkel, M.E. and Wichmann, W. (1992): International Fertilizer Industry Association, Paris. Printed in Germany.

Hassan, A.S. (1982): Effect of some micronutrient on pea and bean plants. M.Sc. Thesis, Fac. Agric., Cairo Univ., Egypt.

Helal, F.E. (1995): Studies on common bean. Ph. D. Thesis, Fac. Agric. Kafr El-Sheikh, Tanta Univ., Egypt.

Hurley, A.K.; Jolley, V.D.; Brown, J.C. and Walser., R.H. (1986): Response of dry beans to iron deficiency stress. J. Plant Nutr. 9 (3-7): 805 – 814.

Hussain, I.S.A. and Ramarao, S. (1989): Leaf phosphorus, chlorophyll a and b as influenced by varying levels of zinc in French beans. South Ind. Hort. 37 (1): 54 – 58.

Hussain, I.S.A.; Rao, S.R. and Setty, T.A.S. (1988): Zinc nutrition in French beans. South Ind. Hort. 36 (1-2):21 – 26. (c. a. Hort. Abst. 1990, 60: 7267).

Ibrahim, S.A. (1989): Growth, yield and nutrients uptake responses of pea plants to phosphorus and micronutrients. Egypt. J. Soil Sci. 29 (3): 251 – 259.

Karaman, M.R.; Brohi, A.R.; Unal, A. and Tuban., S. (1999): Effect of iron and zinc application on growth and mineral nutrient concentrations of beans (*Phaseolus vulgaris* L.) grown in artificial siltation soils. Turkish J. Agric. and Forest. 23: 341 – 348.

Kelly, J.D., and Bliss, F.A. (1975): Habitability estimated of percentage seed protein and available methionine and correlations with yield in dry bean. Crop Sci. 15: 753 – 757.

Khan, A. and Soltanpour, P.N. (1978): Factors associated with Zn chlorosis in dry land beans. Agron. J. 70: 1022 – 1026.

Kotecki, A. (1990): Effect of manganese nutrition applied to the leaves on yield in varieties of faba bean. Zaszyty Naukowe Akademmii Rolniczej we Wroclawiu Rolnictwo 52: 109 – 120. (c. a. CAB Abst. No. 931698189).

Michel, D; Gilles, K.A.; Hamilton, G.K.; Rebers, P.A. and Smith, F. (1956): Colorimetric method for determination of sugars and related substances. Analytical Chemistry 28: 350 – 356.

Miranova, M.P. and Kloloptseva, N.P. (1964): Action of trace elements on some biochemical and physiological processes in peas and beans. Uchen Zap. Petrozavodsk Gas Univ. 12:32-35. (c. a. Abo El-Hassan, E. A. 1974. Grewth regulators and minor elements effect on the productivity and quality of bean plants *Phasiolus vulgaris* L. M. Sc. Thesis Cairo Univ., Egypt).

Mitkees, A. (1974): Response of snap bean plants to fertilization with phosphorus, potassium and manganese. Agric. Res. Rev. Egypt. 52: 149 – 159.

Mohammed, A.A. (1998): Effect of phosphorus and manganese foliar applications on uptake and translocation of some nutrients in bean plants (*Phaseolus vulgaris* L.). J. Agric. Sci. Mansoura Univ. 23 (7): 3473 – 3479.

Mohammed, F.I., and Kandeel, S.H. (1994): Effect of iron and manganese foliar application on growth, green yield, N, P, and protein content of snap bean. Egyp. J. Appl. Sci. 9 (1): 638 – 646.

Mohr, H. and Schopfer, P. (1995): "Plant Physiology". Translated by Gudrum and Lawler D. W. Springer-Verlag Berlin Heidelberg New York.

Moraghan, J.T. (1994): Accumulation of zinc, phosphorus and magnesium by navy bean seed. J. Plant Nutr. 17 (7): 1111 – 1125.

Nassar, H.H. (1986): The relationship between yield and growth characteristics in some snap bean varieties. Ann. Agric. Sci., Ain Shams Univ. 31: 1351- 1366.

Negm, A.Y.; Abdel-Samad, A.M.; Abdel-Aziz, O. and Waly, A.F.A. (1997): Yield and some seed constituents of pea as affected by some micronutrients application methods. Egyp. J. Agric. Res.75 (4): 855 – 866.

Pillali, K.M. (1967): Crop nutrition. Jaya Singh, P. S., Asia Publishing House, Bombay. India 136 p.

Price, C.A; Clark, H.E. and Funkhouser, H.E. (1972): Function of micronutrients in agriculture. Soil Sci. Soc. Amer. Madison Wisc P. 731 - 742.

Sadiq, M. and Hussain, G. (1994): Effect of chelate fertilizers on dry matter and metallic composition of bean plants in a pot experiment. J. Plant Nutr. 17: 1477 – 1488.

Saeed, R.K. (1993): Effect of zinc, iron and manganese application on growth, yield and quality of beans. M.Sc. Thesis, Fac. Agric., Alex. Univ., Egypt.

Singh, A.K; Singh, K.; Singh, U.N.; Raju, M.S. and Singh, J.P. (1995): Effect of potassium, zinc and iron on yield, protein harvest and nutrient uptake in French bean (*Phaseolus vulgaris* L.) J. Potassium Res. 11 (1): 75 - 80.

Wallace, A. (1989): Effects of zinc when manganese was also varied for bush beans grown in solution culture. Soil Sci. 147 (6): 444 – 448.

Wilde, S.A.; Corey, R.B.; Lyer, J.G. and Voigt. G.K. (1985): Soil and plant analysis for tree culture. Oxford and IBM Publishers, New Delhi, 3rd ed., pp 93 – 106.

Zaiter, H.Z.; Coyne, D.P.; Clark, R.B.; Lindgren, D.T.; Nordquist, P.T.; Stroup, W.W. and Pavlish. L.A. (1992): Leaf chlorosis and seed yield of dry beans grown on high pH calcareous soil following foliar iron sprays. HortScience 27 (9): 983 – 985.

تأثيرالرش بالحديد والزنك والمنجنيز على النمو الخضرى ومحصول البذورالجاف ومكوناته للفاصوليا

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نفذت تجربتان حقليتان أثناء المواسم الصيفية لعامى ٢٠٠١، ٢٠٠٢ بمزرعة كلية الزراعة - جامعة الفيوم بهدف اختبار استجابة النمو الخضرى، محصول البذور الجاف ومكوناته والتركيب الكيماوى للفاصوليا صنف نبراسكا لرش المجموع الخضرى بالعناصر الصغرى للحديد (٢٠٠، ٤٠٠ جزء فى المليون)، الزنك (٢٥٠، ٣٧٥، ٥٠٠ جزء فى المليون)، المنجنيز (٢٥٠، ٣٧٥، ٥٠٠، ٦٢٥ جزء فى المليون).

تم تنفيذ التجارب فى صورة تجارب عاملية فى تصميم قطاعات عشوائية كاملة. أظهرت النتائج فروقاً معنوية بين تركيزى الحديد بتفوق تركيز ٤٠٠ جزء فى المليون فى طول النبات، مساحة الورقة الواحدة، عدد ومحصول البذور الجافة الكلى، بالإضافة إلى محتوى الحديد بالأوراق.

أوضحت النتائج أن زيادة تركيز الزنك بمحلول الرش من ٢٥٠ إلى ٣٧٥ جزء فى المليون أدى إلى زيادة طول النبات، الوزن الجاف للمجموع الخضرى، محصول البذور الجاف ومتوسط وزن ١٠٠ بذرة بالإضافة إلى محتوى الكربوهيدرات بالبذور، فى حين سجلت الإضافة الورقية للزنك بتركيز ٥٠٠ جزء فى المليون أعلى محتوى للبوتاسيوم والزنك بالأوراق.

حقق رش المجموع الخضرى للنباتات بالمنجنيز بتركيز ٣٧٥ أو ٥٠٠ جزء فى المليون زيادة معنوية فى كل من عدد ومساحة الأوراق، الوزن الجاف لأجزاء النبات الخضرية الهوائية، عدد ومحصول بذور القرون الجافة بالإضافة إلى متوسط وزن ١٠٠ بذرة للقرون الجافة ، محتوى البوتاسيوم والحديد والمنجنيز بالأوراق، محتوى الكربوهيدرات بالبذور مقارنة بتركيزات ٢٥٠ أو ٦٢٥ جزء فى المليون منجنيز.

أشارت النتائج أيضاً أن المعاملة المختلطة للحديد بتركيز ٤٠٠ جزء فى المليون مع الزنك بتركيز ٣٧٥ أو ٥٠٠ جزء فى المليون ساهمت فى زيادة محصول البذور الجافة ومكوناته معنوياً.