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Interactive Effect of Zinc and Phosphorus on Feba Bean Growth.

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ABSTRACT

In Egypt ,many farmers have adopted large quantities of P-fertilization in planting their crops ,especially faba bean plant . Although, surveying literature indicated that P-application at high rates induce imbalance between macro and micro nutrients. For this reason, afield experiment was conducted in a private farm, Borg El-Nor at Aga District, Dakahlia Governorate., under alluvial soil during the winter season of 2014/2015 to determine the effect of high doses of phosphorus fertilizer in the presence or absence of Zn foliar application under inoculation or without inoculation and investigate the interactive effects on growth parameters ,nutrient content and yield of faba bean (*Vicia faba L.)* Sakha1 at flowering and harvest stages. The combined effects of phosphorus, Zinc and Rhizobium were investigated by combining four P levels (0,13.08,26.16 and 39.42 kg P fed^{-1}) and two spraying rate of Zn (0 and 100 ppm Zn). Also, each treatment was studied twice; once in the presence of strains inoculants at the rate of 400 g / fed and the other without inoculation .The experimental design was split split plot with three replicates. The results show that the application of 26.16 kg P fed^{-1} (P_3) with the spraying of Zn under inoculation or without inoculation produced higher plant height , number of leaves, shoots fresh and dry weight, protein of grain , seed index and seed yield than that obtained for the control treatment. Moreover, increasing P-fertilization level to 39.34 kg P fed^{-1} with Zn spraying, under inoculation or without inoculation ,resulted in significant decrease in all growth parameters except straw yield than the levels of 26.16 kg P fed^{-1} . Also, the interaction between all studied treatments significantly affected chemical constituents at the two studied stages.

Keywords: Zn spraying , P-fertilization , inoculation, the interactive effects.

INTRODUCTION

Phosphorous(P) is one of the most major nutrients after nitrogen element needed by legumes in large quantity but their response to applied P-fertilizer is many a time low and uncertain . The phosphorous requirement is in the range of 0.25-0.55 % of dry weight at the vegetative stage of plant growth. Plants obtain their P insoluble ionic forms ($H_2PO_4^-$ and $HPO_4^{=}$) (Mousavi,2011). In Egypt, after constructing of the High Dam ,the Egyptian soils is suffering from a micronutrients shortage . Zinc (Zn) is one of these important elements. Zinc (Zn) plays an essential role as enzymes metal component (superoxide dismutase, alcohol dehydrogenase, carbonic anhydrase and RNA polymerase) or as a functional, structural, or regulator cofactor of a large number of enzymes(El-Gizawy and Mehasen, 2009). Zinc(Zn) is a cofactor of over 300 enzymes and constituent of many proteins that involved in cell division , protein synthesis and nucleic acid metabolism also, Zn is a component a variety of enzyme like protinaze, dehydrogenaze, peptidase, and phosphohydrolysis. Zinc is known to stimulate plant resistance to dry and hot weather and also to fungal and bacteria disease (Khurana and Chatterjee (2001). Phosphorus(P) is the most important element that interferes with uptake of zinc by grown plants , as zinc uptake by plants decreases by phosphorus increasing in soil. High levels of P may reduce Zn availability or the onset of Zn deficiency associated with P-fertilization may be due to some plant physiological factors. Some forms of P- fertilizers, like super phosphate fertilizer , contain significant amounts of Zn as impurities . The incidence of zinc deficiency has often been found to increase when super phosphate is replaced with "high analysis" forms of P- fertilizers, like diammonium phosphate and mono-ammonium phosphate .Zinc is an active element in biochemical processes and has a biological and chemical interaction with some other nutrients such as P(Gobarah *et al*., 2006). Baddour *et al.,(*2004) stated that foliar application of Zn and inoculation of phosphorus dissolving bacteria were necessary for correct the bad effects of P fertilization at high rates. Where, foliar application of Zn-EDTA in the presence of P fertilization either in mineral or bio form has been corrected the depressive effect of heavy phosphorus application. Then, P/Zn ratio tended to constant in the parts of snap bean plant which led to increasing in all parameters studied. Increased phosphorus uptake caused an increase in the nitrogen and potassium concentrations in cowpea grains, whereas the zinc and iron concentrations decreased(El-Ghamry *et al.* 2009). Mineral phosphorus combined with phosphorus solubilizing bacteria increased seed quality, seed yield and yield components of sunflower crop except seed content of Zn which decreased with mineral P application and increased with PSB application. Foliar application of chelated zinc increased the above mentioned parameters except seed content of P (Hammad *et al.,* 2012) .

Under Egyptian conditions, especially after rice cultivation, large amounts of phosphorus were added to soils .This lead to the appearance of zinc deficiency symptoms. Thus, the purpose of this investigation is to study the effect of the interaction between different phosphorus levels (0,13.08,26.16 and 39.42 Kg P fed^{-1}), different zinc rates (0 and 100 ppm Zn) and biofertilizer (without inoculation and with inoculation at the rate of 400 g fed^{-1}) under field experiment on growth, quality, and yield attributes and nutrients concentration of faba bean and find out the positive effect on grown plants because of the faba bean importance as afood.

MATERIALS AND METHODS

To achieve the goal of this study ,field experiment was conducted in private farm, Borg El-Nor at Aga District ,Dakahlia Governorate., during the winter season of 201 2015/4to study the response of faba bean) *Vicia faba L (*.Sakha1 variety to Rhizobia inoculation, mineral phosphorus fertilizer and foliar application with zinc under alluvial soil conditions .The combined effects of P, Zn and Rhizobium were investigated by combining four phosphorus levels and two spraying rates of zinc .Also, each treatment was studied twice; once in the presence of strains inoculants and the other without inoculation under a split split plot design, with three replicates for each treatment .The phosphorus levels were) :P 0.0 ($_1$Kg P fed) 1-Tap water) ,(P 13.08 (2Kg P fed) ,1-P 26.16 (3Kg P fed1-and) P 39.42 (4Kg P fed .1-As well as two rates of zinc) : Z 0 (1ppm and) Z 100 (2ppm , added as Zn -EDTA %6]Zn .[Each treatment was studied twice; once without inoculation) I (1and the other with inoculation at the rate of 400 g Fed)1-I . (2Surface soil samples (0-30 cm) were collected from the experimental area .The obtained soil samples were air dried, crushed and passed through a 2-mm sieve. The soil was analyzed for some physical and chemical properties as shown in Table (1 .(Planting date was the 27th of November. The rate of seeds was 40 kg fed- .1Irrigation was carried out every 2 days .Faba bean plants were harvested on 15/4/201 .5Some samples of leaves and stems of faba bean plants were randomly chosen from each sub sub plot at flowering stage (after 65 days from planting) and at harvesting stage to determine the vegetative growth parameters and nutrients concentrations.

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

Particle size distribution (%)				**Textural Class class**		**EC, dSm^{-1}***	**pH ****	**$CaCO_3$**	**O.M**	**F.C**	**SP**
C.sand sand	**F.sand**	**Silt**	**Clay**	**clay**		**(%)**					
2.00	22.05	24.05	50.0			1.40	7.85	3.10	1.17	35.0	70.0
Soluble cations (meq L^{-1})				Soluble anions (meq L^{-1})				Available element, mg kg $^{-1}$			
Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	N	P	K	Zn
4.50	2.70	5.10	1.70	-	0.75	6.55	6.70	53.3	5.93	289.2	0.95

*** Soil Electrical Conductivity (EC) and soluble ions were determined in soil paste extract. ** Soil pH was determined in soil paste.**

Nitrogen fertilization, as ammonium nitrate with the above-mentioned rates, was added in one dose; the addition was after 15 days from sowing before the 1st irrigation. Phosphorus fertilization was applied in three equal doses at 15, 30 and 45 days from sowing; with the above-mentioned rates; using ordinary super phosphate (6.58%P). All the agricultural operations were performed according to the usual local agriculture management. Potassium fertilization; as potassium sulfate was added in one dose (with the N-addition). Zinc fertilization; as Zn -EDTA [6% Zn] was added by foliar after 50 days from planting. Biofertilization Treatments: Seeds were coated with inoculums before planting using 40% Arabic gum as a sticker, and then planted on the 27th of November,2014.

Particle size distribution of the studied soil was carried out according to Piper, (1950). Soil field capacity(F.C) was determined by the method described by Richards (1954). Soil reaction (pH), and soil electrical conductivity (EC) was determined according to Richards (1954). Total carbonate was estimated using Collin's Calcimeter and calculated as calcium carbonate according to Piper, (1950). Soluble ions (meq L^{-1}) were determined using the atomic absorption spectrophotometer by the method described by Mathieu and Pieltain, (2003). Available zinc was analyzed using the atomic absorption spectrophotometer according to Mathieu and Pieltain, (2003).To determine the concentrations of elements in faba bean plant tissues and seeds , 0.2 g from each shoot sample was digested using 5.0 cm^3 from the mixture of perchloric and sulphuric acids (1:1) as described by Piper(1950) .N was determined by micro-Kjeldahl method as explained by Hesse (1971). P was determined colorimetrically using spectrophotometer as mentioned by Olsen and Sommers ,(1982).K was determined by using flame photometer as described by Jackson (1967). Zinc was measured in the digested feba bean shoot samples using an Atomic Absorption Spectrophotometer according to Chapman and Pratt, (1961).

RESULTS AND DISCUSSION

1-Plant height (cm), number of leaves plant^{-1}, shoots fresh and dry weight (g plant^{-1}) of faba bean plants as affected by interaction between phosphorus, zinc applications and bio fertilizer at flowering stage.

Data presented in Table (2) show the effect of interaction between phosphorus, zinc applications and bio fertilizer on the average values of plant height , number of leaves , shoots fresh and dry weight of faba bean plants grown on alluvial soil at flowering stage during winter season of 2014/ 2015.

Table 2. Plant height (cm), Number of leaves plant^{-1}, Shoots fresh and dry weight (g plant^{-1}) of faba bean plants after 65 days from sowing as affected by interaction between phosphorus, zinc applications and bio fertilizer during 2014/2015 season under field experiment.

Treatments		**Plant height (cm)**		**No. of leaves plant^{-1}**		**Fresh weight (g plant^{-1})**		**Dry weight (g plant^{-1})**	
		Z_1	**Z_2**	**Z_1**	**Z_2**	**Z_1**	**Z_2**	**Z_1**	**Z_2**
	P_1*	52.57	53.73	29.33	31.00	102.67	104.57	13.37	13.60
I_1	P_2	55.40	61.17	33.67	35.67	106.83	112.40	13.81	14.60
(With inoculation)	P_3	57.40	65.53	35.67	41.00	108.73	116.47	14.97	15.17
	P_4	58.80	63.63	36.00	39.00	110.47	114.60	14.44	14.94
Main		56.04	61.01	33.66	36.66	107.17	112.01	14.14	14.57
LSD $_{at\ 5\%}$		1.02	1.02	1.95	1.95	1.75	1.75	0.25	0.25
	P_1	48.50	49.93	25.00	27.00	93.60	95.60	12.16	12.48
I_2	P_2	51.90	57.60	28.33	32.00	97.47	102.37	12.72	13.34
(Without inoculation)	P_3	53.17	60.27	29.67	36.00	98.87	107.03	12.85	13.97
	P_4	55.57	59.17	32.00	35.00	101.53	104.40	13.07	13.54
Main		52.28	56.74	28.75	32.50	97.86	102.35	12.70	13.33
LSD $_{at\ 5\%}$		1.02	1.02	1.95	1.95	1.75	1.75	0.25	0.25

***P_1: 0.0 Kg P fed^{-1} (Tap water) P_2: 13.08 Kg P fed^{-1} P_3:26.16 Kg P fed^{-1} P_4:39.42 Kg P fed^{-1}.**

The statistical analysis of the data presented in Table (2) indicate that applying phosphatic fertilization (without inoculation and Zn addition) at the rate of 13.08, 26.16 and 39.34 kg P fed^{-1} significantly affected the growth parameters such as plant height , number of leaves , shoots fresh and dry weight of faba bean at flowering stage during season of experimentation . The data indicate that the application of 39.34 kg P fed^{-1} produced higher plant height, number of leaves , shoots fresh and dry weight than that obtained for the control treatment (without inoculation and Zn addition). The increase percent in plant height is 7.0 , 9.6 and 14.6 % and 13.3 , 18.67 and 28% for number of leaves and 4.1, 5.6 and 8.5% for shoots fresh weight and 4.6 ,5.7 and 7.5 for shoot dry weight at the rates of 13.08, 26.16 and 39.34 kg P fed^{-1} , respectively over the control treatment.

With regard to the effect of interaction between P , Zn and inoculation on plant height , number of leaves , shoots fresh and dry weight at flowering stage, data in Table (2) indicate that the application of 26.16 kg P fed^{-1} (P_3) with the application of Zn under inoculation or without inoculation produced higher plant height , number of leaves, shoots fresh and dry weight than that obtained for the control treatment. Moreover, increasing P-fertilization level to 39.34 kg P fed^{-1} with Zn addition, under inoculation or without inoculation ,resulted in a significant decrease in all growth parameters than the levels of 26.16 kg P fed^{-1} except plant number of leaves without inoculation where the decrease is not significant. The differences between the treatment of 26.16 and 13.08 kg P fed^{-1} reach the level of significance for all studied growth parameters. The data show also that applying either Zn or inoculation gave higher plant height , number of leaves , shoots fresh and dry weight at any level of phosphorus compared to that P level without Zn or inoculation application. The increase percent due to Zn application with inoculation in plant height is 13.8 , 21.9 and 18.4 % and 15.0,32.2 and 25.8% for number of leaves and 7.4 ,11.3 and 9.5% for shoots fresh weight and 7.3 ,11.5 and 9.8% for shoot dry weight at the rates of 13.08, 26.16 and 39.34 kg P fed^{-1} , respectively over the control treatment. The increase percent due to Zn application without inoculation in plant height is 15.3, 20.7 and 18.5 % and 18.5 ,33.3 and 29.6% for number of leaves and 7.0 ,11.9 and 9.2% for shoots fresh weight and 6.8,11.9 and 8.4% for shoot dry weight at the rates of 13.08, 26.16 and 39.34 kg P fed^{-1} , respectively over the control treatment. The increase in the plant height due to inoculation is 5.4,9.2 and 11.9 % and 14.8, 21.6 and 22.7 % for number of leaves and 4.0 ,5.9 and 7.6% for shoots fresh weight and 3.3 ,11.9 and 8.0% for shoot dry weight at the above level of P , respectively. Also, applying Zn and inoculation together gave higher growth parameters than applying each element individually. These results lead to the conclusion that there is a mutual interaction or antagonism between P , Zn , which mainly affected the translocation of these nutrients whenever either element exceeded some threshold value. The results support the observation of Baddour *et al.*,(2004); El-Ghamry *et al.*,(2009);El-Gizawy and Mehasen (2009); Osman *et al.,* (2010); Mousavi (2011) and Bouain *et al* .,(2014) who reported that Zn-EDTA (0.03% foliar spray) in combination with 90 or 180 kg P_2O_5/fed, as soil application resulted in highest values of dry matter of faba bean plants.

2-Protein of grain (%), seed index (g/100seed), seed yield (kg/fed) and straw yield (kg/fed) of faba bean plants as affected by interaction between phosphorus, zinc applications and bio fertilizer at harvest stage.

Data presented in Table (3) show the effect of interaction between phosphorus, zinc applications and bio fertilizer on the average values of protein of grain , seed index , seed yield and straw yield of faba bean plants grown on alluvial soil at harvest stage during winter season of 2014 /2015.

Table 3. Protein of grain (%), seed index (g/100seed), seed yield (kg/fed) and straw yield (kg/fed) of faba bean plants at harvest as affected by interaction between phosphorus, zinc applications and bio fertilizer during 2014/2015 season.

Treatments		Protein of grain (%)		seed index(g/100seed)		seed yield (kg/fed)		straw yield (kg/fed)	
		Z_1	Z_2	Z_1	Z_2	Z_1	Z_2	Z_1	Z_2
I_1 (With inoculation)	P_1*	12.75	13.31	58.98	59.12	1076.00	1125.00	2817.00	2761.33
	P_2	13.81	15.79	59.32	60.04	1133.33	1296.67	2723.00	2594.00
	P_3	14.46	16.58	59.56	60.45	1196.00	1343.67	2682.33	2511.33
	P_4	15.17	16.13	59.82	60.24	1256.67	1322.67	2636.67	2555.33
Main		14.04	15.44	59.42	59.96	1165.5	1272.00	2714.75	2605.49
LSD $_{at\ 5\%}$		0.36	0.36	0.36	0.36	21.85	21.85	27.83	27.83
I_2 (Without inoculation)	P_1	11.96	12.67	56.71	56.99	974.67	1009.00	2548.33	2491.33
	P_2	13.25	14.75	57.19	58.20	1042.33	1195.67	2419.00	2286.00
	P_3	13.71	16.17	57.46	58.24	1085.67	1252.33	2376.00	2199.33
	P_4	14.29	15.50	57.69	58.02	1134.00	1213.33	2328.33	2243.67
Main		13.30	14.77	57.26	57.86	1059.16	1167.58	2417.91	2305.08
LSD $_{at\ 5\%}$		0.36	0.36	0.36	0.36	21.85	21.85	27.83	27.83

***P_1: 0.0 Kg P fed^{-1} (Tap water) P_2: 13.08 Kg P fed^{-1} P_3:26.16 Kg P fed^{-1} P_4:39.42 Kg P fed^{-1}.**

Data in Table 3 show that P-fertilization significantly affected protein of grain , seed index , seed yield and straw yield of faba bean plants at harvest. Without Zn addition and inoculation , the average of grain protein are 11.96 ,13.25, 13.71 and 14.29 %due to an application of 0, 13.08, 26.16 and 39.34 kg P fed^{-1} , respectively. Also, the averages are 56.71 ,57.19,57.46 and 57.69(g/100seed) for the seed index. Also, the averages are 974.67 ,1042.33 ,1085.67 and 1134.0 (kg/fed) for the seed yield for the same previous P-levels. On the contrary the straw yield significantly decreased due to an application of 0, 13.08, 26.16 and 39.34 kg P fed^{-1} , respectively ,where the averages of straw yield are 2548.33 ,2419.0, 2376.0 and 2328.33(kg/fed), respectively . As shown from the data applying , phosphatic fertilization at the rate of 39.34 kg P fed^{-1} high significantly increased protein of grain , seed index , seed yield and high significantly decreased straw yield. Generally ,raising the phosphatic fertilization rate from 0.0 to 13.08 26.16 and 39.34 kg P fed^{-1} led to a highly significant decrease in the straw yield.

With regard to the effect of interaction between P , Zn and inoculation on protein of grain , seed index , seed yield and straw yield of faba bean plants at harvest stage, data in Table (3) indicate that the application of 26.16 kg P fed^{-1} (P_3) with the application of Zn under inoculation or without inoculation produced higher protein of grain , seed index and seed yield than that obtained for the control treatment. On the contrary, the application of 26.16 kg P fed^{-1} (P_3) with the application of Zn under inoculation or without inoculation produced lower straw yield .Moreover, increasing P-fertilization level to 39.34 kg P fed^{-1} resulted in a highly significant decrease in protein of grain , seed index and seed yield than the levels of 13.08, 26.16 kg P fed^{-1} .The differences between the treatment of 26.16 and 13.08 kg P fed^{-1} reach the level of significance . The data show also that applying either Zn or inoculation gave higher protein of grain , seed index and seed yield at any level of phosphorus compared to that P level without Zn or inoculation application. The increase% due to Zn application with inoculation in protein of grain is 18.6 ,24.6 and 21.2 % and 1.6 ,2.2 and 1.9% for seed index and 15.3 ,19.4 and 17.6% for seed yield at the rates of 13.08, 26.16 and 39.34 kg P fed^{-1} , respectively over the control treatment.The present results are in agreement with those obtained by Baddour *et al.*,(2004); El-Ghamry *et al.*,(2009); El-Gizawy and Mehasen (2009); Osman *et al.,* (2010); Mousavi (2011) and Bouain *et al* .,(2014) .

3 - Chlorophyll content at flowering stage.

Data in Table (4) indicate that different photosynthetic pigments such as chlorophyll a, b and total chlorophyll positively responded to the effect of interaction between phosphorus, zinc applications and bio fertilizer on faba bean plants grown on alluvial soil at flowering stage during winter season of 2014 and 2015.

Table 4. Chlorophyll a, chlorophyll b and total chlorophyll (mg/g FW) of faba bean plants after 65 days from sowing as affected by interaction between phosphorus, zinc applications and bio fertilizer.

Treatments		Chlorophyll a.		Chlorophyll b.		Chlorophyll a + b.	
		mg/g F.W					
		Z_1	Z_2	Z_1	Z_2	Z_1	Z_2
I_1 (With inoculation)	P_1 *	0.594	0.602	0.418	0.423	1.012	1.024
	P_2	0.610	0.632	0.431	0.452	1.041	1.084
	P_3	0.616	0.652	0.443	0.474	1.060	1.126
	P_4	0.622	0.642	0.446	0.464	1.068	1.106
Main		0.610	0.632	0.434	0.453	1.045	1.085
LSD $_{at\ 5\%}$		0.008	0.008	0.007	0.007	0.010	0.010
I_2 (Without inoculation)	P_1	0.515	0.524	0.374	0.386	0.889	0.910
	P_2	0.533	0.558	0.392	0.422	0.925	0.979
	P_3	0.537	0.579	0.402	0.438	0.939	1.017
	P_4	0.545	0.569	0.412	0.425	0.957	0.994
Main		0.532	0.557	0.395	0.417	0.927	0.975
LSD $_{at\ 5\%}$		0.008	0.008	0.007	0.007	0.010	0.010

***P$_1$: 0.0 Kg P fed^{-1} (Tap water) P$_2$: 13.08 Kg P fed^{-1} P$_3$:26.16 Kg P fed^{-1} P$_4$:39.42 Kg P fed^{-1}.**

The statistical analysis of the data presented in Table (4) indicate that applying phosphatic fertilization (without inoculation and Zn addition) at the rate of 13.08, 26.16 and 39.34 kg P fed^{-1} significantly affected the photosynthetic pigments such as chlorophyll a, b and total chlorophyll of faba bean at flowering stage during season of experimentation . The gradual increase in P levels give gradual increase in photosynthetic pigments, where application of 39.34 kg P fed^{-1} (P_4) produced higher chlorophyll a, b and total chlorophyll than that obtained for the control treatment(without inoculation and Zn addition). Without inoculation and Zn addition, the increase percent in chlorophyll a, b and total chlorophyll is 3.5,4.3 and 5.8% ,4.8 ,7.5 and 10.2% and 4.0 ,5.6 and 7.6% at the rates of 13.08, 26.16 and 39.34 kg P fed^{-1} , respectively over the control treatment.

With regard to the effect of interaction between P , Zn and inoculation on chlorophyll a, b and total chlorophyll at flowering stage, data in Table (4) indicate that the application of 26.16 kg P fed^{-1} (P_3) with the application of Zn under inoculation or without inoculation produced higher chlorophyll a, b and total chlorophyll than that obtained for the control treatment. Moreover, increasing P-fertilization level to 39.34 kg P fed^{-1} resulted in a highly significant decrease in chlorophyll a, b and total chlorophyll than the level of 26.16 kg P fed^{-1} . The photosynthetic pigments under 39.34 kg P fed^{-1} was less than the P_3 treatment (26.16 kg P fed^{-1}) and more than the P_1 and P_2 treatments (0 .0 and 26.16 kg P fed^{-1}) . The differences between the treatment of 26.16 and 13.08 kg P fed^{-1} reach the level of significance for the chlorophyll a, b and total chlorophyll. The data show also that applying either Zn or inoculation gave higher chlorophyll a, b and total chlorophyll at any level of phosphorus compared to that P level without Zn or inoculation application. The increase percent due to Zn application with inoculation in chlorophyll a, b and total chlorophyll is 5.0 ,8.3 and 6.6% ,6.9,12.0 and 9.7% and 5.9 ,9.96 and 8.0% at the rates of 13.08, 26.16 and 39.34 kg P fed^{-1} , respectively over the control treatment. The increase percent due to Zn application without inoculation in chlorophyll a, b and total Chlorophyll is 6.5,10.5 and 8.6% ,9.3 ,13.5 and 10.1% and 7. ,11.8 and 9.2% at the rates of 13.08, 26.16 and 39.34 kg P fed^{-1} , respectively over the control treatment. The results support the observation of Baddour *et al.*,(2004); El-Ghamry *et al.*,(2009); El-Gizawy and Mehasen (2009); Osman *et al.,* (2010); Mousavi (2011) and Bouain *et al* .,(2014) .

4- Chemical constituents in leaves, stems and seeds of faba bean plants as affected by interaction between phosphorus, zinc applications and bio fertilizer at the two different stages.

The foliar application effect of Zn or inoculation effect each and combined together with and without P-fertilization on N,P ,K and Zn concentrations in faba bean leaves and stems at flowering stage are presented in Table (5) .

The statistical analysis of the data in Table (5) indicate that due to the application of phosphate fertilizer, there are significant increases in N,P and K- concentrations and significant decreases in Zn-content of leaves .Also, there are significant decreases in P- concentration and significant increase in Zn-content of stems at the different rates compared to the control treatment at flowering stage.

The data in Table (5) reveal that without Zn addition and inoculation at flowering stage ,the maximum N,P and K concentrations in leaves are realized at 39.34 kg P fed^{-1},while the maximum P concentration in stems are realized at control treatment (0.0 kg P fed^{-1}) . Also, the maximum Zn –content in leaves are realized at control treatment (0.0 kg P fed^{-1}), while the maximum Zn –content in steams are realized at 39.34 kg P fed^{-1}. These results are in agreement with the findings of Sorour(1993) and El-Gizawy and Mehasen (2009) who reported that phosphatic fertilization caused significant increases in phosphorus concentration of faba bean plant tissues at the different stages of growth during both seasons and were not in harmonic with those of Osman (1989) who stated that P-concentration at flowering stage decreased significantly at 23.3 kg P_2O_5/fed. compared to control and 46.6 kg P_2O_5/fed.

Table 5. Nitrogen, Phosphorus, potassium and Zinc concentration in leaves and P , Zn concentration in stems of faba bean plants after 65 days from sowing as affected by interaction between phosphorus, zinc applications and bio fertilizer.

Treatments		leaves								stems			
		N %		P %		K %		Zn ppm		P %		Zn ppm	
		Z_1	Z_2	Z_1	Z_2	Z_1	Z_2	Z_1	Z_2	Z_1	Z_2	Z_1	Z_2
I_1 (With inoculation)	P_1 *	3.60	3.65	0.301	0.287	1.98	2.07	39.13	47.53	0.192	0.205	21.30	15.50
	P_2	3.72	3.97	0.331	0.311	2.15	2.41	36.63	45.50	0.172	0.182	22.60	16.93
	P_3	3.81	4.13	0.376	0.342	2.39	2.62	34.90	43.53	0.132	0.155	24.37	18.37
	P_4	3.89	4.08	0.394	0.360	2.32	2.48	32.90	41.53	0.123	0.144	25.93	19.43
Main		3.75	3.95	0.350	0.325	2.21	2.395	35.89	44.52	0.154	0.171	23.55	17.55
LSD at 5%		0.08	0.08	0.009	0.009	0.14	0.14	1.16	1.16	0.006	0.00	1.39	1.39
I_2 (Without inoculation)	P_1	3.22	3.30	0.259	0.244	1.66	1.76	33.00	41.33	0.186	0.197	17.27	11.17
	P_2	3.35	3.65	0.283	0.272	1.81	2.10	30.77	39.30	0.159	0.173	18.80	13.10
	P_3	3.46	3.84	0.331	0.303	1.91	2.21	28.73	37.33	0.127	0.149	20.40	14.13
	P_4	3.53	3.74	0.344	0.319	2.00	2.31	26.53	35.13	0.114	0.135	21.90	15.57
Main		3.39	3.63	0.304	0.284	1.84	2.09	29.75	38.27	0.146	0.163	19.59	13.49
LSD at 5%		0.08	0.08	0.009	0.009	0.14	0.14	1.16	1.16	0.006	0.00	1.39	1.39

***P_1: 0.0 Kg P fed^{-1} (Tap water) P_2: 13.08 Kg P fed^{-1} P_3:26.16 Kg P fed^{-1} P_4:39.42 Kg P fed^{-1}.**

Data show that the foliar application of Zn and inoculation separate or combined on faba bean plant gave gradual significant increase in P % of leaves and gradual significant decrease in P% of stems with raising the phosphatic fertilization level, while there are gradual significant decreases in Zn-content of leaves and gradual significant increase in Zn-content of stems with raising the phosphatic fertilization level. Also, the application of 26.16 kg P fed^{-1} (P_3) with the application of Zn under inoculation or without inoculation produced higher N%, while the same trend was found under inoculation and Zn addition for K% with raising the phosphatic fertilization level. Also, data reveal that inoculation increases the N,P and K % in leaves and Zn-content in stems at flowering stage at any level of P fertilization. The effect of Zn on P% in stems is in contrast to its effect of P% in leaves. It can be said that the foliar application of Zn prevents the translocation of P from stems to leaves. These results are in agreement with those of Amin and Ghaly (1984) and Bouain *et al* .,(2014) who stated that Zn-translocation into faba bean leaves decreased by P-application especially when Zn was applied as foliage. P-translocation showed the same general trend as affected by Zn-treatments. They concluded that there is a mutual interaction between phosphorus and zinc , which affected the translocation of both nutrients whenever either element exceeded some threshold value.

Data in Table (6) show the effect of the interaction between phosphorus, zinc applications and bio fertilizer on N,P and K percentages in leaves ,seeds and stems and Zn-content in leaves and stems of faba bean plant at the harvest stage.

Table 6. Concentration of N and P in leaves and seeds, P in leaves, seeds and stems and Zn concentration in leaves and stems faba bean plants at harvest as affected by interaction between phosphorus, zinc applications and bio fertilizer

Treatments		Leaves								seeds						stems			
		N %		P %		K %		Zn ppm		N %		P %		K%		P %		Zn ppm	
		Z_1	Z_2	Z_1	Z_2	Z_1	Z_2	Z_1	Z_2	Z_1	Z_2	Z_1	Z_2	Z_1	Z_2	Z_1	Z_2	Z_1	Z_2
I_1 (With inoculation)	P_1 *	1.32	1.28	0.139	0.149	0.75	0.83	18.29	19.46	2.04	2.13	0.189	0.179	2.34	2.44	0.139	0.149	7.79	7.07
	P_2	1.44	1.74	0.104	0.133	0.91	1.20	18.79	19.32	2.21	2.53	0.230	0.199	2.52	2.72	0.107	0.133	7.53	7.16
	P_3	1.55	1.87	0.099	0.121	0.99	1.32	18.59	19.15	2.32	2.65	0.241	0.209	2.56	2.92	0.100	0.121	7.63	7.26
	P_4	1.64	1.84	0.092	0.116	1.09	1.27	18.45	18.91	2.42	2.59	0.247	0.219	2.65	2.85	0.092	0.116	7.72	7.39
Main		1.48	1.68	0.108	0.129	0.93	1.155	18.53	19.21	2.24	2.47	0.226	0.201	2.51	2.73	0.109	0.129	7.66	7.22
LSD at 5%		0.07	0.07	0.007	0.007	0.05	0.05	0.13	0.13	0.06	0.06	0.006	0.006	0.05	0.05	0.007	0.007	0.10	0.10
I_2 (Without inoculation)	P_1	1.15	1.25	0.140	0.153	0.65	0.71	17.31	18.32	1.91	2.03	0.176	0.162	2.12	2.19	0.140	0.153	7.23	6.47
	P_2	1.33	1.60	0.099	0.128	0.79	1.07	17.73	18.20	2.12	2.35	0.214	0.189	2.27	2.54	0.099	0.133	6.87	6.57
	P_3	1.45	1.81	0.091	0.126	0.89	1.20	17.64	18.02	2.19	2.59	0.225	0.198	2.35	2.72	0.091	0.126	7.03	6.68
	P_4	1.53	1.74	0.083	0.105	0.97	1.12	17.46	17.88	2.29	2.48	0.232	0.209	2.46	2.66	0.083	0.106	7.12	6.75
Main		1.36	1.60	0.103	0.128	0.82	1.025	17.53	18.10	2.12	2.36	0.211	0.189	2.30	2.52	0.103	0.129	7.06	6.61
LSD at 5%		0.07	0.07	0.007	0.007	0.05	0.05	0.13	0.13	0.06	0.06	0.006	0.006	0.05	0.05	0.007	0.007	0.10	0.10

***P_1: 0.0 Kg P fed^{-1} (Tap water) P_2: 13.08 Kg P fed^{-1} P_3:26.16 Kg P fed^{-1} P_4:39.42 Kg P fed^{-1}.**

The statistical analysis of the data in Table (6) indicate that due to the application of phosphate fertilizer without Zn addition and inoculation , there are significant increases in N and K- concentrations and significant decrease in P% and Zn-content in leaves .Also, there are significant increases in N,P and K in seeds ,while there are significant decreases in P% and irregular increase in Zn-content of stems at the different rates compared to the control treatment at harvest stage.The data in Table (6) reveal that without Zn addition and inoculation at harvest stage ,the maximum N and K concentrations in leaves are realized at 39.34 kg P fed^{-1},while the maximum P concentration are realized at control treatment (0.0 kg P fed^{-1}) . Also, the maximum Zn –content in leaves are realized at control treatment (0.0 kg P fed^{-1}). The maximum N,P and K concentrations in seeds are realized at 39.34 kg P fed^{-1}, while the maximum P and Zn concentrations in steams are realized at control treatment (0.0 kg P fed^{-1}).

Data show that the foliar application of Zn and inoculation separate or combined on faba bean plant gave gradual significant decrease in P % of leaves and stems . Also, there are gradual significant increase in P% of seeds with raising the phosphatic fertilization level, while there are gradual significant decrease in Zn-content of leaves and gradual significant increase in Zn-content of steams with raising the phosphatic fertilization level. Also, the application of 26.16 kg P fed^{-1} (P_3) with the application of Zn under inoculation or without inoculation in leaves and seeds produced higher N and K % with raising the phosphatic fertilization level. Also, data reveal that inoculation increases the N,P and K % in leaves and seeds in addition the same trend found for Zn-content in leaves and steams at harvest stage at any level of P fertilization. The effect of Zn on P% in stems is in contrast to its effect of P% in leaves. It can be said that the foliar application of Zn prevents the translocation of P from stems to leaves. These results are in agreement with those of Amin and Ghaly (1984) and Bouain *et al* .,(2014) who stated that Zn-translocation into faba bean leaves decreased by P-application especially when Zn was applied as foliage. P-translocation showed the same general trend as affected by Zn-treatments. They concluded that there is a mutual interaction between phosphorus and zinc , which affected the translocation of both nutrients whenever either element exceeded some threshold value.

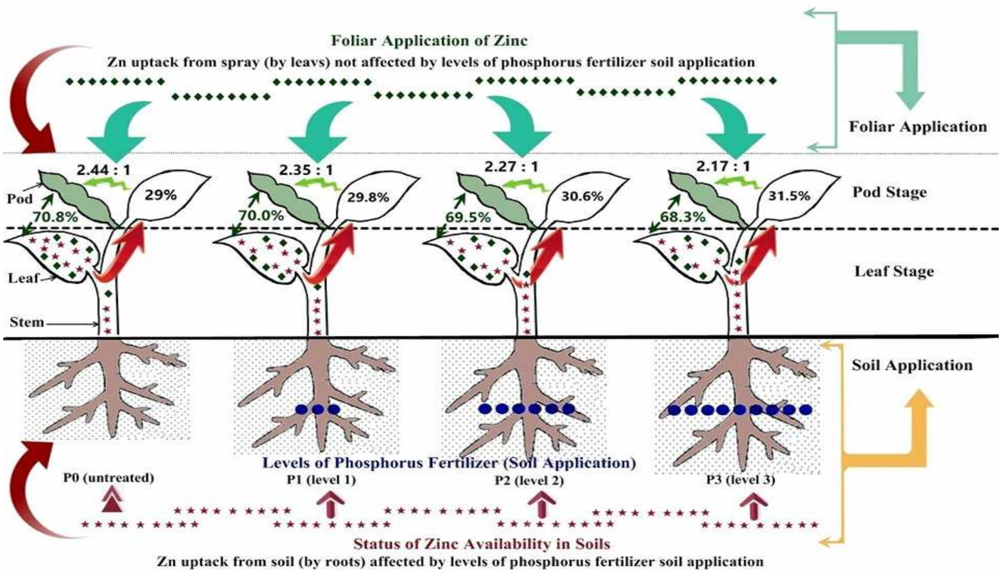

Fig. 1. Relationship between P-soil application and Zn-foliar application on faba bean plant.

CONCLUSION

Under the same condition of this investigation it could be concluded that the high level of phosphatic fertilization to faba bean plants encourages the plant root to absorb Zn from soil, so the concentration of Zn in stems increased, but the high concentration of phosphorus in leaves which accompanied with the high level of P-fertilization reduces the translocation of Zn from stems to the leaves due to the antagonistic relationship between P and Zn uptake by plants.

To avoid zinc deficiency, must be Zn-foliar application on foliage, thus enter directly into the process of photosynthesis . The ratio of zinc foliar added don’t influenced by different levels of P soil application as shown in the following figure(1).

Results indicate decrease in Zn-content of leaves at harvest stage due to movement of large quantity of zinc from leaves to the seeds (with or without Zn addition) as shown in the following figure (1).

Also, inoculation of faba bean seeds gave the highest values of all parameters under study. Finally, based on the obtained results of this investigation ,it could be detect that phosphorus fertilization at high rates induce imbalance between macro and micro nutrient such as phosphorus and zinc due to the antagonism between them .

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تأثير التداخل بين الزنك والفسفور علي نمو الفول البلدي

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في مصر إعتاد العديد من الفلاحين علي استخدام كميات كبيرة من التسميد الفوسفاتي في زراعة محاصيلهم خصوصا الفول البلدي علي الرغم من أن الدراسات الاستقصائية أشارت إلي أن إضافة الفسفور بمعدلات كبيرة تقلل التوازن بين العناصر الغذائية الكبرى والصغرى. لهذا الغرض أجريت تجربة حقلية بمزرعة خاصة بمنطقه برج النور –مركز أجا – محافظة الدقهلية . حيث تمت الدراسة تحت ظروف الأراضي الرسوبية خلال الموسم الشتوي 2015/2014 لتقييم تأثير إضافة الجرعات العالية من التسميد الفوسفاتي تحت تأثير كل من رش أو عدم رش الزنك و التلقيح البكتيري أو عدم التلقيح ومن ثم دراسة تأثيرات التداخل علي عوامل النمو والمحتوي العنصري والمحصول للفول البلدي(سخا1) في مرحلتي التزهير والحصاد. تم دراسة التأثير المشترك لكل من الزنك والفسفور والريزوبيم باستخدام 4 مستويات إضافة للسماد الفوسفاتي (0.0 & 13.08 & 26.16 & 39.42 كجم فسفور /الفدان) ومعدلين رش للزنك (0.0 & 100 مليجرام زنك /اللتر) .كل معاملة تم دراستها مرتين : الأولي مع التلقيح البكتيري بمعدل 400ملجرام /الفدان والمرة الأخري بدون التلقيح البكتيري .التصميم التجريبي المستخدم كان قطع منشقة منشقة مع تكرار كل معامله 3 مرات . أشارت النتائج إلي أن إضافة التسميد الفوسفاتي بمعدل 26.16 كجم فسفور /الفدان مع الرش بالزنك سواء في وجود أو عدم وجود التلقيح البكتيري أعطي أعلي القيم لكل من ارتفاع النبات وعدد الأوراق و الوزن الطازج والجاف للمجموع الخضري ومحصول الحبوب ومحتواها من البروتين مقارنة بالكنترول .علاوة علي ذلك فإن زيادة معدل التسميد الفوسفاتي إلي 39.42 كجم فسفور /الفدان مع الرش بالزنك سواء في وجود أو عدم وجود التلقيح البكتيري نتج عنه نقص معنوي بكل عوامل النمو المدروسة ماعدا محصول القش مقارنة بمعدل الإضافة 26.16 كجم فسفور /الفدان . وجد أيضا أن التداخل بين كل العوامل المدروسة أثر بشكل معنوي علي المكونات الكيماوية في كلا مرحلتي الدراسة.