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Response of Faba Bean to Bio, Mineral Phosphorus Fertilizers and Foliar Application with Zinc

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Abstract: Faba bean (*Vicia faba* L.) is one of the major leguminous crops grown in the world. It is important source of protein for humans and animals. A 2-yr field study was carried out in the Research and Experimental Center of Faculty of Agriculture at Moshtohor, Benha University, Egypt, during 2006/2007 and 2007/2008 seasons. The aim of this study was to determine the effect of six phosphorus (P) fertilizer treatments [0, 15, 30 kg P_2O_5, phosphate dissolving bacteria (PDB), PDB + 15 kg P_2O_5 and PDB+30 kg P_2O_5/ fed] and four spraying treatments with Zinc [Tap water, 0.02, 0.04 and 0.06% as Zn EDTA(14% Zn)] on yield, yield components and chemical contents of faba bean seeds cv. Giza 843. Adding 30 kg P_2O_5 mixed with PDB markedly increased plant height, No. of branches and pods/plant, 100-seed weight, seed yield/plant, seed and straw yields/fed, protein%, N%, P%, N and P uptake. The results indicated that there were significant differences between foliar applications of zinc treatments in all traits studied. The maximum values of 100-seed weight, seed yield/plant and seed yield/fed were 71.86 g, 28.10 g and 1.657 ton, respectively, when plants received 0.04% Zn EDTA. The interaction between phosphorus and zinc treatments were significantly affected on plant height, No. of branches/plant, seed yield/fed, P%, N and P uptake in the combined analysis. Generally, it can be concluded that adding 30 kg P_2O_5 mixed with PDB under sprayed of 0.04% Zn EDTA (14% Zn) may be the recommended treatment for improving the productivity of faba bean crop under the conditions of the present study.

Key words: Faba bean % zinc & P fertilization % biofertilizer % yield and yield components

INTRODUCTION

Faba bean (*Vicia faba* L.) is an important feeding crop grown in winter season in Egypt. It's seed not only provide a cheap source of protein but also a food of high calorific and nutritive value especially in the diet of low income people. Egyptian Government is pressing hard to increase the yield and quality of faba bean plant through improving agricultural practices such as fertilization with phosphorus, seed inoculation with phosphate dissolving bacteria and foliar application with zinc.

Phosphorus is a major nutrient, especially for legumes. It is considered the second essential nutrient element for both plants and microorganisms. In spite of the considerable addition of phosphorus to soil, the amount available for plant is usually low. Phosphate dissolving bacteria and soil microorganisms can play an important role in improving plant growth and phosphate uptake efficiency by releasing phosphorus from rock or tri-calcium phosphate. Many researchers showed positive effect of phosphorus fertilization on faba bean.

Significant increases were achieved in faba bean yield and its attributes by increasing phosphorus fertilization rate up to 45-46.5 kg P_2O_5/fed [1-4] or 30-31 kg P_2O_5/fed [5-9] or 22.5 kg P_2O_5/fed [10]. Microorganisms can play an important role in the availability of phosphorus in the soils. More phosphorus is proved to be taken by the plant in the presence of phosphate dissolving microorganisms [11]. Many investigators reported that phosphate dissolving bacteria enhance crop growth, improve seed and straw yields and increase nutrient uptake [3, 4, 7, 10, 12].

The Egyptian soil is suffering from shortage of micro-nutrients after constructing of the High Dam. Zinc is one of these important elements, in addition it has high pH that affects the absorption ability of phosphorus as macro-element. Zinc plays an important role as a metal component of enzymes (alcohol dehydrogenase, superoxide dismutase, carbonic anhydrase and RNA polymerase) or as a functional, structural, or regulator cofactor of a large number of enzymes [13]. Mahady [14] found that foliar application of Zn SO_4 for faba bean

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plants increased number of pods/plant and seed yield/fed. Marked improvement in faba bean yield and its components as well as seed quality were also reported by Hamed [10], Gomaa [15], El-Hosary and Mehasen [16], Abd-Alrahman *et al*. [17] and El-Masri *et al.* [18].

The aim of this investigation was to study the effect of bio, mineral P fertilizers and foliar application with zinc on yield and yield components as well as chemical contents of faba bean seeds.

MATERIALS AND METHODS

Experimental Site and Soil Characteristics: This study was conducted in the Research and Experimental Center of the Faculty of Agriculture at Moshtohor, Benha University, Kalubia, Egypt, during the two successive growing seasons 2006/07 and 2007/08, to study the effect of six P fertilizer treatments and four spraying with Zinc on yield, yield components and chemical contents of faba bean seeds cv. Giza 843. Soil of the experiment was clay with pH 7.99 and 7.95, organic matter content 1.72 and 1.85%, total P 0.15 and 0.20% and contained 1.23 and 1.20 mg/kgof zinc in the first and second seasons, respectively.

Treatments and Experimental Design: Each experiment included 24 treatments which were the combination of six P fertilizer treatments (zero, 15 kg P_2O_5, 30 kg P_2O_5, phosphate dissolving bacteria (PDB), PDB+15 kg P_2O_5, PDB+30 kg P_2O_5/fed) and four spraying with Zinc (Tap water, 0.02, 0.04, 0.06% Zn EDTA 14% Zn). Zinc chelate (organic material) was used in the form of Ethylene Diamine Tetra Acetic Acid.

Split plot design with three replications, in which P fertilizer treatments were allocated in the main plots, while the sub plots were devoted for foliar application with zinc treatments. Each sub plot was 5 ridges 3.5 m long and 60 cm wide, the sub plot area 10.5 m^2 (1/400 fed. one feddan = 4200 m^2) .

Crop Management Practices: Before planting, with respect to P bio-fertilizer treatments, faba bean seeds were washed with water, air dried and soaked in cell suspension of *Bacillus megatherium* ($1.2x10^8$ viable cell/ml) for 30 min. Thereafter, for all treatments faba bean seeds were inoculated by specific *Rhizobium* strain. Gum Arabic (16%) was added as an adhesive agent prior to inoculation. *Bacillus megatherium* var. Phosphaticum (Pure local strain) used in this study were obtained from Biofertilizers Production Unit and Agric. Microbiology. Dept., Soils, Water and Environment Res. Inst., Agric. Res. Center, Giza, Egypt. Seeds of faba bean were planted on the two ridge sides with hills separated 20 cm, on 18 and 25 Nov., in the 1st and 2nd seasons, respectively. Phosphorus levels were added before planting in the form of calcium super phosphate (15.5% P_2O_5). Faba bean plants were sprayed once with the aqueous solution of this chelated Zn at 40^{th} days after planting, while control plants were sprayed with tap water. The volume of the sprayed aqueous solution of this zinc was 400 L/fed (using hand sprayer 1 L.). The preceding crop was corn in both seasons. Other cultural practices were kept the same as normally practiced in faba bean fields.

Data Collected: At harvest, ten guarded plants were taken at random from the central ridge to estimate: plant height (cm), number of branches and pods/plant, weight of 100-seed (g), seed yield/plant (g), seed and straw yields/fed(ton), straw and seed yields were determined from the three central ridges. Moreover, samples of faba bean seeds were oven dried at 60-70°C for 48 hours ground to pass through a 0.5 mm sieve and sub samples of 0.2 g portions were wet digested using a mixture of sulphuric (H_2SO_4) and perchloric ($HClO_4$) acids. The digest was analyzed for N and P. Total nitrogen percentage (N %) in seeds was determined to the modified micro Kjeldahl method [19]. Crude protein content in seeds was estimated by multiplying nitrogen percentage X 6.25. Phosphorus content (P %) in seeds was determined as reported by Fric *et al.* [20] using clorimetric determination with ascorbic acid. Nitrogen uptake (NUP) in seeds kg/fed= seed yield kg / fed x total N% in seed. Phosphorus uptake (PUP) in seeds kg/fed= seed yield kg / fed x total P% in seed.

Statistical Analysis: Analysis was done for the data of variance of each season separately and combined analysis of variance for two seasons was conducted testing the error homogeneity according to Snedecor and Cochran [21] using the MSTAT-C Statistical Software Package [22]. Where the F-test showed significant differences among means, Least Significant Differences (LSD) test was performed at the 0.05 level of probability to separate means.

RESULTS AND DISCUSSION

Analyses of variances for all traits in each season as well as the combined analysis are presented in Table 1. Test of homogeneity revealed that the error variance for the two seasons were homogenous, therefore combined analysis was processed. Year's mean squares were significant *($P<0.05$)* for all the studied traits except for 100-seed weight only were not significant. The P fertilizer mean squares were highly significant ($P<0.01$) for all

Table 1: Mean square values and significance for faba bean yield and yield components in 2006/2007, 2007/2008 seasons and their combined analysis

S.O.V.	d.f	Plant height (cm)	No. of branch/plant	No. of pods/plant	100-seed weight (g)	Seed yield/plant (g)
2006/2007 season						
Rep.	2	4.264	0.113*	0.097	12.056	0.96
P fert.	5	509.256**	0.720**	20.489**	546.522**	13.732**
Err.(a)	10	7.281	0.019	0.764	11.806	0.86
Zn foli.	3	203.611**	1.462**	8.333**	120.907**	28.786**
PxZn	15	16.944	0.058*	0.467	4.441	0.358
Err.(b)	36	9.333	0.028	0.653	5.199	1.677
C.V.,		3.7	5.62	5.41	3.34	4.84
2007/2008 season						
Rep.	2	5.014	0.059	1.681	4.389	0.976
P fert.	5	822.981**	1.475**	12.614**	505.389**	59.382**
Err.(a)	10	17.681	0.04	1.064	24.106	0.88
Zn foli.	3	294.051**	0.388**	10.940**	121.389**	39.822**
PxZn	15	12.573	0.063	0.606	18.678	1.442**
Err.(b)	36	9.514	0.043	0.759	14.06	0.556
C.V.		3.55	6.84	5.57	5.41	2.74
Combined analysis						
Years	1	680.340**	0.284**	18.063**	44.444	5.800*
YxRep.	4	4.639	0.086*	0.889	8.222	0.968
P fert.	5	1266.21**	2.050**	31.624**	1028.05**	64.571**
YxP	5	66.024**	0.145**	1.479	23.861	8.542**
Err.(a)	20	12.481	0.029	0.914	17.956	0.87
Zn foli.	3	489.840**	1.647**	18.748**	228.611**	67.770**
YxZn	3	7.822	0.203**	0.525	13.685	0.838
PxZn	15	18.301*	0.085**	0.464	12.328	0.641
YxPxZn	15	11.216	0.036	0.609	10.791	1.16
Err.(b)	72	9.424	0.036	0.706	9.63	1.116
C.V.,		3.62	6.28	5.49	4.51	3.92

Table 1: Continued

S.O.V.	Seed yield / fed ton	Straw yield / fed ton	Protein %	N %	P %	N Uptake kg/fed	P Uptake kg/fed
2006/2007 season							
Rep.	0.005	0.018*	1.861	0.048	0.001	3.43	0.490*
P fert.	0.369**	0.278**	50.305**	1.288**	0.010**	1993.826**	14.795**
Err.(a)	0.004	0.004	1.711	0.044	0.0004	17.039	0.089
Zn foli.	0.120**	0.103**	33.180**	0.849**	0.005**	886.690**	5.766**
PxZn	0.006**	0.002	0.970*	0.025*	0.001**	17.976**	0.114*
Err.(b)	0.001	0.002	0.485	0.012	0.0001	3.445	0.051
C.V.,	1.86	2.27	2.34	2.34	2.53	2.68	3.6
2007/2008 season							
Rep.	0.003	0.009*	0.347	0.009	0.001*	2.832	0.374*
P fert.	0.256**	0.296**	48.326**	1.237**	0.011**	1671.873**	12.582**
Err.(a)	0.002	0.002	1.395	0.036	0.0002	7.965	0.089
Zn foli.	0.151**	0.119**	11.522**	0.295**	0.003**	727.273**	5.971**
PxZn	0.003*	0.003	1.161	0.03	0.0001**	16.046	0.083*
Err.(b)	0.001	0.002	1.033	0.026	0.0001	12.7	0.035
C.V.	2.22	2.36	3.29	3.29	1.79	4.77	2.81
Combined analysi							
Years	0.125**	0.016*	47.266**	1.210**	0.002*	1073.084**	4.558**
YxRep.	0.004	0.014**	1.104	0.028	0.001*	3.131	0.432**
P fert.	0.615**	0.561**	96.651**	2.474**	0.021**	3630.575**	27.124**
YxP	0.010*	0.013**	1.979	0.051	0.0004	35.124*	0.252*
Err.(a)	0.003	0.003	1.553	0.04	0.0003	12.502	0.089
Zn foli.	0.269**	0.220**	41.366**	1.059**	0.007**	1607.130**	11.685**
YxZn	0.003*	0.002	3.335**	0.085**	0.0003	6.833	0.052
PxZn	0.007**	0.002	1.167	0.03	0.001**	26.378**	0.121**
YxPxZn	0.002**	0.003*	0.965	0.025	0.0002**	7.645	0.077
Err.(b)	0.001	0.002	0.759	0.019	0.0001	8.073	0.043
C.V.,	2.06	2.32	2.88	2.88	2.18	3.95	3.21

* and ** significant at 5% and 1% level of probability, respectively.

Table 2: Effect of seasonal on yield and its components as well as seed quality of faba bean

Season	Plant height cm	No. of branch/plant	No. of pods/plant	100-seed weight g	Seed yield/plant g	Seed yield/fed ton
2006/2007	82.639	2.960	14.944	68.194	26.779	1.445
2007/2008	86.986	3.049	15.653	69.306	27.181	1.503
F test	**	**	**	N.S	*	**
Season	Straw/yield fedTon	Protein %	N %	P %	N Uptake kg/fed	P uptake kg/fed
2006/2007	1.728	29.696	4.751	0.431	69.196	6.264
2007/2008	1.749	30.842	4.935	0.438	74.656	6.620
F test	*	**	**	*	**	**

traits in both seasons as well as the combined data. Also, the foliar application with zinc mean squares was highly significant for all traits in both seasons as well as the combined analysis. The interaction between P fertilizer and foliar application mean squares were significant for all of the studied characters except plant height, No. of branches/plant,100-seed weight, seed yield/plant and straw yield/fed in the first season while, in the second season were significant for seed yield/plant and seed yield/fed, P% and P uptake as well as plant height, No. of branches/plant, seed yield/fed, P%, N and P uptake in the combined analysis. The interaction between years and P fertilizer treatments mean squares was significant for all of the studied characters except No. of pods/plant, 100-seed weight, protein%, N% and P%. The interaction between years and foliar application with zinc mean squares was not significant for all of the studied characters except No. of branches/plant, seed yield/fed, protein% and N%. The interaction between years, P fertilizer and foliar application mean squares were not significant for all of the studied characters except seed and straw yields/fed and P%.

Effect of growing seasons: Data in Table 2 show that significant seasonal effects (P<0.05) existed for all characters studied except 100-seed weight. Higher mean values for all characters were detected in the second season. It could be concluded that the increase in seed yield/fed in the second season may be due to the significant increase in the No. of branches and pods/plantand seed yield/plant.

Effect of Bio and mineral P fertilizers: Phosphorus fertilizer levels mixed with PDB significantly affected *(P<0.05*) all studied characters (Table 3). The results showed that adding 30 kg P_2O_5/fed mixed with PDB markedly increased plant height, No. of branches/plant, No. of pods/plant, 100-seed weight, seed yield/plant, seed and straw yields/fed, protein%, N%, P%, N and P uptake by 28.55, 32.92, 23.56, 25.02, 19.44, 36.13, 29.10, 20.13, 20.14, 20.41, 63.55 and 63.71%, respectively as compared with zero phosphorus treatment.

Thus, adding 30 kg P_2O_5/fed mixed with PDB might be the recommended for faba bean production, where phosphorus is an essential element for cell division, root development and seed formation. This might be due to combined stimulating effect of phosphate dissolving bacteria and P fertilizer levels in supplying the growing plants with their phosphorus requirements. The increase in seed yield might be associated with high No. of pods/plant, 100-seed weight and seed yield/plant. The results are in accordance with those obtained by El-Moursy [1], Said [2], Ahmed and El-Abagy [3], El-Habbasha *et al.* [4], Mokhtar [5], Tageldin and Mehasen [6], Mekail *et al.* [7], Al-Fageh and Mehasen [8], Yilmaz [9], Hamed [10], Saber and Kabesh [11] and Abo El-Nour *et al.*[12].

Effect of foliar application with zinc: Results in Table 3 indicate clearly that there were significant differences *(P<0.05*) in all studied traits for yield and yield components as well as seed chemical contents of faba bean(combined analysis of both seasons). The maximum values of 100-seed weight, seed yield/plantand seed yield/fedwere 71.86 g, 28.10 g and 1.657 ton, respectively, when plants received 0.04% zinc EDTA (14% Zn). Straw yield/fed, protein%, N%, P%, N and P uptake significantly increased by increasing zinc level from 0.0 to 0.04%. The increase in seed yield/fed, N and P uptake were 14.28, 24.47 and 22.65 %, respectively when faba bean plants were sprayed by 0.04% zinc EDTA, relative to control. From these results it could be concluded that zinc played an important role in metabolic processes and in turn affected the plant growth. Also the increase zinc more than 0.04% may increase plant growth, whereas this treatment gave the highest values for all traits under study. The same results were previously obtained by

Table 3: Mean values of faba bean characters as affected by P fertilizer, PDB and foliar with zinc (combined analysis of 2006/2007 and 2007/2008 seasons)

Treatments	Plant height cm	No. of branch. /plant	No. of pods/plant	100-seed weight g	Seed yield/plant g	Seed yield/fed ton
P fert. & PDB						
Zero	74.25	2.43	13.62	62.45	24.48	1.217
15 kg P_2O_5/fed	81.33	2.96	14.50	64.83	26.17	1.416
30 kg P_2O_5/fed	85.25	3.13	15.12	65.33	26.68	1.522
PDB	82.95	3.08	15.58	65.83	27.14	1.416
15 kg P_2O_5+PDB	89.62	3.16	16.12	75.95	28.14	1.615
30 kg P_2O_5+PDB	95.45	3.23	16.83	78.08	29.24	1.657
L.S.D at 5%	2.10	0.10	0.57	2.55	0.56	0.032
Zn. Spray						
Tap water	80.05	2.70	14.30	65.77	25.16	1.365
0.02%	83.83	2.98	15.25	68.16	26.67	1.448
0.04%	88.30	3.16	15.94	71.86	28.10	1.560
0.06%	87.05	3.15	15.69	69.19	27.97	1.523
L.S.D at 5%	1.43	0.08	0.39	1.45	0.49	0.014

Treatments	Straw yield /fed. ton	Protein %	N %	P %	N Uptake kg/fed	P uptake kg/fed
P fert. & PDB						
Zero	1.481	27.552	4.408	0.382	53.742	4.660
15 kg P_2O_5/fed	1.672	29.401	4.704	0.440	66.744	6.234
30 kg P_2O_5/fed	1.754	31.224	4.996	0.460	76.108	7.007
PDB	1.746	28.932	4.629	0.421	65.750	5.982
15 kg P_2O_5+PDB	1.865	31.406	5.025	0.442	81.312	7.142
30 kg P_2O_5+PDB	1.912	33.099	5.296	0.460	87.899	7.629
L.S.D at 5%	0.031	0.750	0.120	0.010	2.129	0.179
Zn. Spray						
Tap water	1.639	28.819	4.611	0.417	63.303	5.730
0.02%	1.717	30.226	4.836	0.430	70.472	6.266
0.04%	1.819	31.354	5.017	0.448	78.795	7.028
0.06%	1.779	30.677	4.908	0.441	75.133	6.745
L.S.D at 5%	0.018	0.408	0.065	0.004	1.330	0.096

Table 4: Effect of the interaction between P and zinc fertilizers on some faba bean characters (combined analysis of 2006/2007 and 2007/2008 seasons)

Treatments		Plant height cm	No. of branch./plant	Seed yield/fed ton	P %	N uptake kg/fed	P uptake kg/fed
Zero	Tap water	70.50	2.11	1.152	0.347	48.425	4.001
	0.02%	73.50	2.36	1.212	0.365	52.325	4.420
	0.04%	76.50	2.65	1.266	0.405	57.376	5.121
	0.06%	76.50	2.61	1.240	0.412	56.841	5.096
15 kg P_2O_5/fed	Tap water	77.16	2.76	1.310	0.422	58.063	5.526
	0.02%	82.16	3.03	1.403	0.440	65.715	6.174
	0.04%	83.33	2.95	1.480	0.455	72.029	6.737
	0.06%	82.66	3.10	1.472	0.442	71.171	6.498
30 kg P_2O_5/fed	Tap water	80.16	2.66	1.444	0.450	69.311	6.500
	0.02%	85.16	3.05	1.488	0.462	75.188	6.870
	0.04%	88.33	3.43	1.599	0.470	82.641	7.518
	0.06%	87.33	3.40	1.558	0.458	77.293	7.142
PDB	Tap water	79.83	2.93	1.325	0.398	57.019	5.282
	0.02%	81.83	3.03	1.387	0.415	64.550	5.761
	0.04%	85.00	3.21	1.485	0.435	72.385	6.465
	0.06%	85.16	3.16	1.467	0.437	69.045	6.418
15 kg P_2O_5+PDB	Tap water	84.66	2.78	1.467	0.428	70.223	6.289
	0.02%	88.16	3.08	1.581	0.438	79.053	6.931
	0.04%	95.00	3.46	1.723	0.457	89.916	7.869
	0.06%	90.66	3.31	1.687	0.443	86.056	7.480
30 kg P_2O_5+PDB	Tap water	88.00	2.98	1.491	0.455	76.779	6.780
	0.02%	92.16	3.35	1.617	0.460	86.002	7.440
	0.04%	101.66	3.35	1.806	0.468	98.422	8.461
	0.06%	100.00	3.31	1.715	0.457	90.391	7.834
L.S.D at 5%		3.52	0.21	0.036	0.010	3.259	0.236

Hamed [10], Marschner [13], Mahady [14], Gomaa [15], El-Hosary and Mehasen [16], Abd-Alrahman *et al.* [17] and El-Masri *et al.* [18].

Effect of the interaction: The interaction between Phosphorus treatments and zinc spraying was significantly affected *(P<0.05*) on plant height, No. of branches/plant, seed yield/fed, P%, N and P uptake (Table 4). The highest values of plant height, No. of branches/plant, seed yield/fed, P%, N uptake and P uptake were obtained with adding 30 kg P_2O_5/fed+PDB under sprayed by 0.04% zinc EDTA, 14% Zn. Meanwhile, the lowest values were recorded by zero P fertilizer and sprayed by tap water.

CONCLUSION

On the light of the obtained results, it could be concluded that under the conditions during this investigation, enrichment of faba bean plants with spraying by 0.04% zinc EDTA and P fertilizer level up to 30 kg P_2O_5/fed combined with phosphate dissolving bacteria (PDB) gave a considerable increase in yield and yield components as well as seed chemical contents of faba bean plants.

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