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Response of Faba Bean to Phosphorus Fertilization and Zinc Application under Inoculation with Psb

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ABSTRACT

Throughout two successive years (2018-2019 and 2019-2020), field experiments in split-split plot design with three replicates by combining three phosphorus levels (0, 50 and 100% from recommended doses) and two addition ways of zinc (soil and foliar) half of treatments inoculated with PSB and the other half without inoculation. P fertilization individually comparing with the control (non-fertilized) on faba bean increased significantly all of vegetative growth parameters (plant height, fresh and dry weight), chlorophyll content. P and Zn content increased in shoots and decreased in roots as well as yield and its components (seed index, weight of pods, total yield, total carbohydrates and protein) were increased and recorded the highest values at 100% RD. The results in this study showed that, foliar application with Zn-EDTA was the most suitable form significantly affected in all mentioned parameters. Also, in the same experiment found an increase in all studied parameters in inoculated plants with PSB.

Keywords: phosphorus fertilization, zinc, PSB and faba bean

INTRODUCTION

Egypt is considered one of the most producers of rain season legumes (Kasem, 2012). Among legumes food, a faba bean (*Vicia faba* L.) is highly favored by Egyptian farmers due its quick developing attributes that enable families to get money needed required to buy food and other family needs when different yield have not yet developed. It's seed not only provide a cheep source of protein but also source of vitamins, minerals and starch (Heuzé *et al.*, 2018) and a food of high calorific and nutritive value particularly in the diet of low income people. Egyptian Government is squeezing hard to increment the quality and yield of faba bean plant through improving agricultural practices such as fertilization phosphorus and zinc. where, cultivated area reached 37677 ha which produced 134175 ton (FAOSTAT, 2016).

Under Egyptian soil conditions availability of phosphorus is controlled by various factors ($CaCO_3$, organic matter, pH and clay contents) so; the availability of phosphorus for plant is low. Available phosphorus content in the incorporated fertilizer is rapidly switched to unavailable compounds to the plants such as tri-calcium phosphate (Ghazi, 2017). Most of P detention in alkaline soils happen in calcareous soils, calcium ions keep P by precipitating P on surface of calcium carbonate , also it generates low soluble salt of calcium phosphate (Shen *et al.*, 2011). Efficiency of phosphorus recovery is not more than 20 % of utilized P in the world soils on account of P ion complexes precipitate about 80 % of applied P fertilizer. Thus, the supply of phosphorus is required for the primary target is beneficent food security by increasing sustainable productivity of yield. The environmental pollution could be reduced by over use the large quantities of fertilizers. Thus, for plants the available fraction is very low. Phosphorus is fundamental element for improving photosynthetic assimilation, root growth, phosphor-lipids, phosphor-proteins and ADP, ATP formation (El-Sobky and Yasin 2017). Various authors reported that with increase of P level, a significant increase found of seed yield and yield attributes as resulted by (Hashemabadi, 2013; Mousa and El Sayed, 2016 and El-Sobky and Yasin, 2017)

Increasing calcium carbonate content and soil pH reduce the availability of phosphorus and zinc (Ye *et al.*, 2015). Phosphorus and zinc are critical and fundamental elements which limit plant growth and production specially for legumes (El-Agrodi *et al.* 2017; Fouda, 2017). The deficiency of these elements turns out to be significantly more genuine in alkaline calcareous dry soils. In these soils, phosphorus and zinc are mostly found as insoluble or unavailable forms for plant, phosphorus fixed in apatite calcium minerals and zinc existing as insoluble zinc hydroxides and adsorbed firmly to carbonate minerals, such as dolomite and calcite (Weldua *et al.*, 2012).

Foliar spraying of zinc was positively effective on yield and yield components of faba bean (Bozorgi *et al.*, 2011). Zinc plays an beneficial part as enzymes metal component (alcohol dehydrogenase, superoxide dismutase, carbonic anhydrase, alcohol dehydrogenase, and RNA polymerase) or as a structural, functional, or regulator cofactor of a great number of enzymes (El-Gizawy and Mehasen, 2009). Zn is a component of a number of proteinases and dehydrogenases enzymes consequently Krebs cycle and affecting electron transfer reaction and energy production (Srivastava, 2006).

Phosphorus 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, contain significant amounts of Zn like super phosphate fertilizer, as impurities. When super phosphate is substitute with "high analysis" forms of P-fertilizers, Zn deficiency increased, like mono-ammonium phosphate and diammonium phosphate. Zinc is an active nutrient in biochemical processes and has a chemical and biological interaction with some other elements such as P (El-Agrodi *et al.* 2017). Baddour *et al.* (2004) stated that

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the bad effects of P fertilization at high rates could be corrected by foliar application of Zn and inoculation of phosphorus dissolving bacteria. Where, corrected the dismal effect of heavy phosphorus application by P fertilization either in mineral or bio form with foliar application of Zn- EDTA has been. Then, all parameters of snap bean increasing due to of P/Zn ratio, which tented to be constant in parts of snap bean plant. Mineral phosphorus combined with PSB increased seed yield, quality and yield components of sunflower crop except Zn content in seed decreased with mineral P application but increased with phosphorus solubilizing bacteria application. The above mentioned parameters increased with foliar application of chelated zinc except seed P content (Hammad *et al*., 2012).

So, soil inoculation with phosphate dissolving bacteria improved soil fertility and plant productivity, these symbiotic microorganisms were appeared to influence positively plant growth under phosphorus-deficient conditions by making complex phosphorus sources available to the plant (Srinivasan *et al.*, 2012). In this way, utilizing such rhizobia, chosen for their phosphate-solubilizing limit as bio-inoculants to crops would result in the double beneficial nutritional impact from P mobilization (Maghraoui *et al*. 2016).

The objective of this study was to evaluate the ability of phosphorus solubilize bacteria to solubilize phosphate, comparing with no-inoculation effect of these bacteria on growth and phosphorus uptake by *Vicia faba* plants in the presence of Zn-fertilization and its ability to realize P element from P fertilization and their effects on vegetative growth parameters, chemical composition, and yield of faba bean plants.

MATERIALS AND METHODS

To accomplish the objective of this investigation, two-field experiment were conducted at privet farm, El-Mansoura Dakahlia Governorate, Egypt, during the rain seasons of 2018-2019 and 2019-2020 to investigate the state of zinc under phosphorus fertilization in absence and presence of phosphorus soluble bacteria on faba bean plant using split-split plot design with three replicates by combining three phosphorus levels (0, 50 and 100% from recommended doses) and two addition ways of zinc (soil and foliar) half of treatments inoculated with PSB and the other half without inoculation.

Soil samples (0-30 cm) were collected from the surface of experimental area. The acuired soil samples were air dried, squashed and passed through a 2-mm sieve. Soil analysis was determined using the standard methods as follows; particle size distribution determined according to the methods of (Haluschak, 2006) which was loamy. Soil properties described as; pH 7.91, EC/dsm^{-1} 2.63 in soil past, $CaCO_3$ 3.08% and organic matter1.18% as well as 48.6, 4.61, 286 and 0.83 mg.kg $^{-1}$ for available N, P, K and Zn, respectively (Reeuwijk, 2002) at the start of experiment.

Before planting, faba bean seeds were washed with water, air dried and soaked in cell suspension of *Bacillus megatherium* var. Phosphaticum for 30 min, which was kindly provided by unit of bio-fertilizers, Fac. of Agric., Ain Shams Univ. Cairo. Egypt. This suspension of cell is containing about 108 colony farming unit (CFU). 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.

The plot area was 10.5 m^2 (3x 3.5m) with five rows. Planting date of faba bean seeds was the 1st week of November during both seasons, after 20 days from sown, hills were thinned to one seedling per hill.

Nitrogen fertilizer at rate of 20 kg/fed in form of urea (46% N) and potassium fertilization; as 50 kg/fed was added from potassium sulfate (48% K_2O) in one dose (with the N-addition) were applied together 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 (0, 50 and 100% from RD); using ordinary super phosphate (15.5% P_2O_5) at (0. 50 and 100 kg.fed^{-1}, respectively). Zinc fertilization; as Zn-EDTA [6% Zn] at rate 150 ppm was added by foliar after 50 days from planting and the another form was $ZnSO_4$ at rate 5 kg.fed^{-1} as soil addition.

Some samples were randomly chosen from each plot of faba bean plants after 65 days from planting at flowering stage to determine the vegetative growth parameters as (plant length, fresh and dry weight) as well as chlorophyll content (mg. g^{-1} fresh weight) in faba bean leaves according to the method of (Gavrilenko and Zigalova 2003), P% and Zn mg kg^{-1} in shoot and root were estimated in the digested samples on dry weight basis as described by (Mertens, 2005 and Agrilasa, 2002) respectively. Also, data of flowering in expression of number of flowers, number of pods as well as; fruit setting % = No. of pods. plant^{-1}/No. of flowers. plant^{-1} x 100 was calculated.

After 130 days from sowing, at harvesting stage representative plant samples were taken from each plot and these parameters were determined; weight of pods (g. plant^{-1}), seed index and seed yield (kg.fed^{-1}). From each plot, samples of faba bean seeds were oven dried at (70 oC) till constant weight and digested by a sulphoric-perchloric acid mixture as described by (Peterburgski, 1968) to determine, total carbohydrates% according to (Sadasivam and Manickam, 1996) and N in faba bean seeds to calculate protein percentage in faba bean seeds, which calculated by multiplying nitrogen percentage X 6.25 (A.O.A.C. 2000).

Analysis was done for the data of variance (ANOVA) by means of COSTATE software program. Means of treatments were considered significantly when they were more than the least significant differences (LSD) at significance of ($p \leq 0.05$) difference at according to (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant growth parameters and flowering data:

Plant growth parameters as plant height, fresh and dry weight as well as flowering data as no. of flower.plant^{-1}, no. of pods.plant^{-1} and fruit setting% were significantly affected by P levels in both seasons except no. of flowers and fruit setting as indicated in Table (1). So, all traits are increased with increasing P levels up to 100% P from recommended doses during both seasons of the experiment comparing with the non-application. The most suitable treatment, which realized the highest mean values of all parameters of faba bean plants (101.55 & 105.29) for plant height cm, (219.54 & 228.65) for fresh weight g/plant, (29.82 & 30.87) for dry weight g/plant and (10.83 & 12.58) for no. of pods/plant were recorded with the treatment of 100% P. The previous results revealed that phosphorus is required in large quantities in shoot tips where metabolism is high and cell division is rapid (Ndakidemi and Dakora, 2007). Thus, an indication that the faba bean plant used the mineral phosphorus applied prudently in growth and development processes. Phosphorus play a beneficial role for the growth of the root system epidermal osmotic adjustment and essential part in the number of enzimatic reaction that depends on phosphorelation. Fouda, (2017) resulted an increase in all parameters growth and flowring data during P-fertilization. These results are in agreement with those obtained by (Shakori and Sharif, 2016; Ghazi, 2017 and Sarkar *et al.*, 2017).

Data given in Table (1) revealed that growth parameters and flowering date had no significant effect with addition of Zn forms except with plant height in the 1st season and dry weight during both seasons. The highest values for both plant height and dry weight were recorded with foliar application than soil addition. Such effect of micronutrient fertilization with zinc indicate the importance of Zn to plants, being involved in many enzymatic reactions and consequently for better growth and development. Zinc is required for the synthesis of auxin, which is a growth-regulating compound (indole acetic acid) (El Habbasha *et al.* 2015). Similar findings were reported by (El-Sobky and Yasin, 2017 and Ghazi, 2017)

The statistical analysis of the data presented in Table (1) indicate that plants inoculated with PSB significantly increased in growth parameters and flowering data comparing with the un-inoculated plant except no. of flowers/plant and fruit setting % during both seasons of the experiment. Increasing plant growth parameters by inoculation of PSB along with P_2O_5 may be due to the inoculation-induced increase in gibberellic acid and indole acetic acid production, which subsequently increased the cell division and cell elongation (Afzal *et al.,* 2010). Besides, apparently PSB increases plant traits by increasing phosphorus solubility and its availability to plants. These results are consistent with those of other researchers. A similar positive effect was observed by (Rakha and El-Said 2013; Nikfarjam and Aminpanah, 2015 and Akl and Abdel-Fattah, 2019).

The interaction among previous treatments indicated in the same Table, The application of P significantly increased all the mentioned traits up to 100 % from recommended doses with inoculation with PSB under foliar application with zinc except no. of flower/plant and fruit setting% during both seasons. Similar results were also reported by (El-Agrodi *et al.* 2017 and Ghazi, 2017).

Table 1. Effect of phosphorus fertilization, inoculation with PSB and Zn application forms as well as their interactions on plant growth parameters and flowering data during 2018-2019 and 2019-2020.

Treatments			Plant height, cm		Fresh weight, g/plant		Dry weight, g/plant		No. of flowers/plant		No. of pods /plant		Fruit setting%	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Phosphorus fertilization rates														
0% P			85.66	90.10	192.09	200.80	24.91	27.29	11.75	12.33	7.67	9.25	66.64	76.44
50% P			97.83	101.61	215.24	222.21	28.69	30.06	14.17	15.67	9.92	11.75	71.39	76.39
100% P			101.55	105.29	219.54	228.65	29.82	30.87	14.67	16.25	10.83	12.58	75.66	78.59
LSD at 5%			1.33	1.05	3.60	2.45	0.26	0.09	n.s	n.s	0.99	0.55	n.s	n.s
Forms of zinc application														
$ZnSO_4$ (soil)			94.58	98.72	208.35	216.35	27.66	29.30	13.50	14.67	9.44	11.11	71.57	77.33
$ZnSO_4$ (foliar)			95.44	99.27	209.57	218.10	27.95	29.51	13.56	14.83	9.50	11.28	70.89	76.96
LSD at 5%			0.56	n.s	n.s	n.s	0.21	0.08	n.s	n.s	n.s	n.s	n.s	n.s
Phosphorus Soluble bacteria inoculation														
Without			91.17	95.24	202.80	210.62	26.59	28.47	12.78	13.83	8.72	10.50	69.25	77.09
PSB			98.86	102.75	215.12	223.83	29.03	30.34	14.28	15.67	10.22	11.89	73.21	77.19
LSD at 5%			0.74	0.73	0.65	1.27	0.05	0.12	n.s	n.s	0.43	0.56	n.s	n.s
Interaction														
0% P	$ZnSO_4$ (soil)	Without	84.68	88.64	186.22	198.84	24.39	27.09	11.67	12.00	7.33	8.67	64.81	74.14
		PSB	86.66	91.47	194.16	203.25	25.24	27.52	12.00	12.67	8.00	9.33	67.53	74.21
	$ZnSO_4$ (foliar)	Without	82.79	86.62	190.44	195.00	23.96	26.44	11.00	11.33	7.00	9.00	63.74	81.12
		PSB	88.53	93.65	197.55	206.09	26.06	28.12	12.33	13.33	8.33	10.00	70.48	76.31
50%P	$ZnSO_4$ (soil)	Without	91.51	95.67	210.05	210.18	26.73	28.65	13.00	14.33	8.67	10.67	68.10	75.69
		PSB	100.48	104.66	218.34	227.17	29.68	30.66	14.67	16.00	10.67	12.33	76.62	80.69
	$ZnSO_4$ (foliar)	Without	93.77	97.48	205.83	216.02	27.35	29.08	13.33	14.67	9.00	11.00	68.15	75.22
		PSB	105.53	108.61	226.74	235.49	30.99	31.85	15.67	17.67	11.33	13.00	72.68	73.95
100% P	$ZnSO_4$ (soil)	Without	95.81	100.53	210.17	219.02	28.25	29.45	13.67	15.00	10.00	11.67	75.28	79.71
		PSB	108.34	111.36	231.15	239.61	31.64	32.45	16.00	18.00	12.00	14.00	77.10	79.52
	$ZnSO_4$ (foliar)	Without	98.44	102.52	214.05	224.65	28.83	30.13	14.00	15.67	10.33	12.00	75.44	76.68
		PSB	103.60	106.74	222.79	231.33	30.54	31.44	15.00	16.33	11.00	12.67	74.81	78.46
LSD at 5%			1.82	1.78	2.39	3.11	0.12	0.30	n.s	n.s	1.06	1.39	n.s	n.s

Chlorophyll content:

As shown in Table (2), it could be observed that; a stimulation effect was happened on the mean values of chlorophyll a , b and total due to application of phosphorus fertilization. With increasing P-fertilization, it was found an increase in chlorophyll content. In other words; the highest values recorded (0.670, 0.469 and 1.139 and 0.707, 0.495 and 1.202) for chlorophyll (a, b, total chlorophyll), respectively in the 1st and 2nd seasons were realized for the 100% P-application from the recommended dose. Nyoki and Ndakidemi, (2014) on effect of P on cowpea, mentioned that supplementation of phosphorus at all levels significantly increased the chlorophyll content of cowpea plants measured at 5 and 7 WAP compared with the control. The results are in accordance with those obtained by (Fouda, 2017; Ghazi, 2017 and El-Agrody *et al.*, 2017).

Regarding the effect of Zn forms on chlorophyll content at the same Table found that, both forms of Zn significantly effected on chlorophyll content. On the same line, data revealed that bthe highest mean values of chlorophyll indicated with foliar application Zn-EDTA comparing with soil application of $ZnSO_4$. The same trend was happened during both seasons. In this concern, application of Zn was reported to increase the contents of chlorophyll a, b and total chlorophyll of *Vicia faba* (Sharaf *et al.*, 2009 and Reda *et al*., 2014).

Results in Table (2) indicated that plots receiving seeds treated with PSB giving the highest increase in chlorophyll a, b and total comparing with plots with untreated plants during both 2018-2019 and 2019-2020 seasons. A similar positive effect was observed by Ghazi, 2017 and El-Agrody *et al*., 2017.

The different comparisons among the mean values of chlorophyll (a, b & a+b) mg.g-1 as affected by the combination soil application of P levels, Zn forms with bio-P are presented in Table (2). Data clearly showed that; soil application of P with all other treatments has been recorded a stimulation effect on the average values of all the aforementioned traits. In addition, the highest mean values are (0.702 & 0.741) for chlorophyll a, (0.498 & 0.521) for chlorophyll b and (1.200 & 1.261) for total chlorophyll, respectively in 2018-2019 and 2019-2020.

Table 2. Effect of phosphorus fertilization, inoculation with PSB and Zn application forms as well as their interactions on chlorophyll content during 2018-2019 and 2019-2020.

Treatments			Chlorophyll a, mg/g FW		Chlorophyl l b, mg/g FW		Total chlorophyll mg/g FW	
			1st	2nd	1st	2nd	1st	2nd
Phosphorus fertilization rates								
0% P			0.591	0.623	0.393	0.429	0.984	1.052
50% P			0.652	0.688	0.452	0.481	1.104	1.169
100% P			0.670	0.707	0.469	0.495	1.139	1.202
LSD at 5%			0.002	0.002	0.002	0.002	0.001	0.003
Forms of zinc application								
$ZnSO_4$ (soil)			0.632	0.667	0.433	0.464	1.065	1.130
$ZnSO_4$ (foliar)			0.643	0.679	0.443	0.473	1.087	1.152
LSD at 5%			0.003	0.002	0.002	0.003	0.004	0.003
Phosphorus Soluble bacteria inoculation								
Without			0.618	0.652	0.420	0.453	1.039	1.105
With Phosphorus Soluble bacteria			0.657	0.693	0.456	0.484	1.113	1.177
LSD at 5%			0.004	0.002	0.003	0.003	0.006	0.004
Interaction								
0% P	$ZnSO_4$ (soil)	Without	0.585	0.618	0.385	0.427	0.970	1.045
		PSB	0.597	0.628	0.400	0.433	0.997	1.061
	$ZnSO_4$ (foliar)	Without	0.573	0.605	0.380	0.414	0.953	1.018
		PSB	0.608	0.642	0.407	0.443	1.016	1.085
50%P	$ZnSO_4$ (soil)	Without	0.622	0.654	0.423	0.453	1.046	1.107
		PSB	0.666	0.704	0.465	0.494	1.131	1.198
	$ZnSO_4$ (foliar)	Without	0.630	0.667	0.432	0.465	1.062	1.132
		PSB	0.691	0.726	0.487	0.511	1.178	1.237
100% P	$ZnSO_4$ (soil)	Without	0.644	0.677	0.445	0.474	1.089	1.151
		PSB	0.679	0.719	0.478	0.501	1.158	1.219
	$ZnSO_4$ (foliar)	Without	0.656	0.693	0.455	0.484	1.111	1.178
		PSB	0.702	0.741	0.498	0.521	1.200	1.261
LSD at 5%			0.009	0.006	0.007	0.006	0.015	0.010

Phosphorus and Zn in faba bean shoot and root:

Data illustrated in Fig (1 & 2) show the effect of P-fertilization rates and Zn application forms in presence or absence of PSB on P and Zn concentration of faba bean shoot and roots. Data in Fig (1) indicated that due to application of P-fertilization, there are a significant increases in P concentration of shoot until 100%P, and significant decrease in root. While, Fig (2) showed that the application of P-fertilization revealed a significant increase in Zn- content in shoots until 50% then decreased with 100%, while Zn-content in roots decreased with increasing P-fertilization rate to 50% then a small increase was found with 100%.

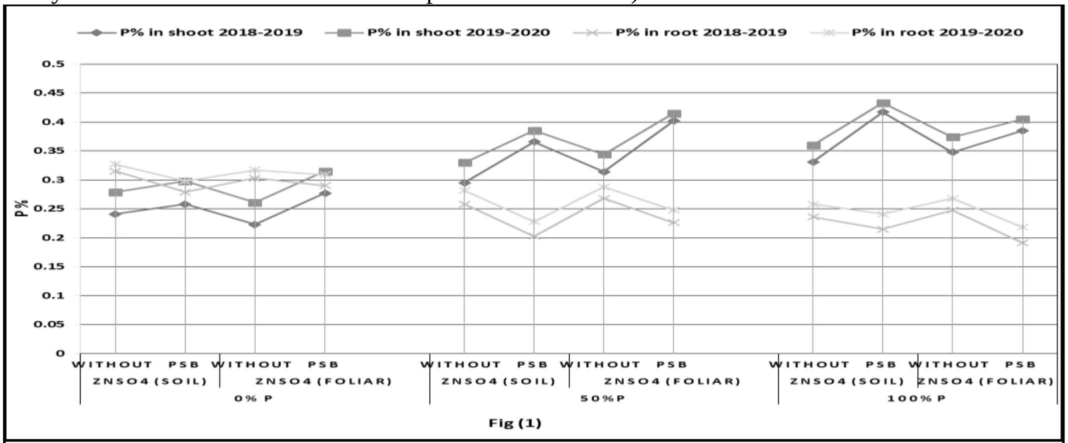
Also, data in Fig (1 & 2) show that with addition of Zn application forms a significant effect was happened in both P and Zn content in shoot and root and the increase in P and Zn content is due to the foliar application with Zn-EDTA, while P and Zn concentration in root recorded low values with Zn-foliar and recorded the highest values with soil application of Zn in form of $ZnSO_4$ with no-significant effect. At the same Figs data reveal that the average values of both P content in shoots and roots and Zn content in shoots recorded the highest values with inoculation of seeds by PSB, but the Zn content in roots decreased with the inoculated plants.

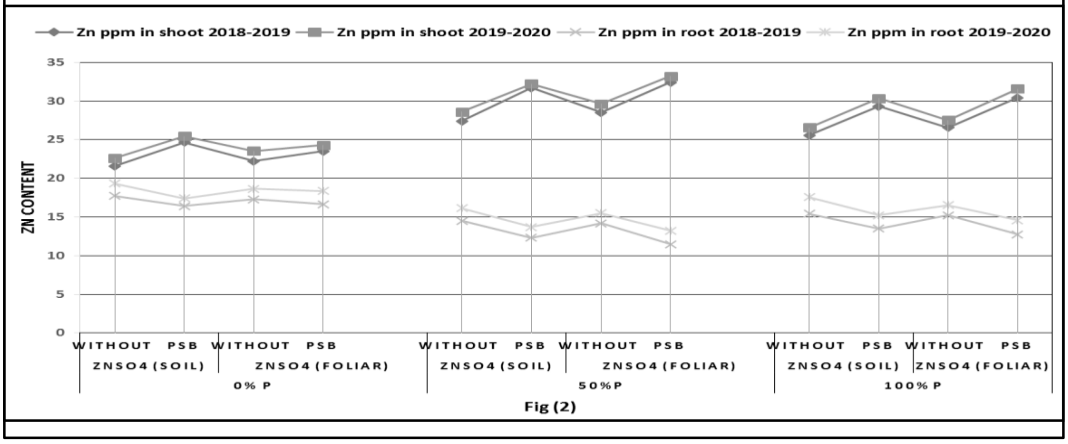
These outcomes lead to the decision that there is a mutual antagonism or interaction between phosphorus and zinc, which principally influenced the movement of these supplements whenever either nutrient exceeded some threshold value. The primary purposes for effect of increment of P content on Zn deficiency can highlighted to the following: zinc transmission of plant roots to shoots decreased with increase concentrations of phosphorus , so Zn gather in roots or its uptake reduces by roots. Content of Zinc in shoots of plants reduces by effect of induced growth response (dilution impact); that means increase in plant growth lea to increases amount of zinc uptake in plant but its concentration decreases in plant tissues. These results were supported by (Ghazi, 2017 and El-Agrody *et al*., 2017).

Yield and its components:

Data of yield and its components are given in Table (3) which revealed that seed index, weight of pods, total yield, total carbohydrates and protein significantly affected by the application of P-fertilization at ($p \leq 0.05$) during both seasons of the experiment. With increasing rate of P-fertilization, the mean values of all mentioned traits are increased. The corresponding relative increments were accounted to be (9.63, 12.45%) for seed index, (17.27, 22.15%) for weight of pods, (13.09, 16.88%) for total yield, (6.26, 8.04%) for total carbohydrates and (14.67, 18.79%) for protein, respectively in 2018-2019 for 50% and 100% compared to the control. The highest values were recorded when faba bean plants were treated with 100% P-fertilization, the positive effect of P-fertilization on production of faba bean might be attributed to the merit of the nutrient in promoting of both vegetative and reproductive, thereby improving photosynthetic efficiency also the physiological role of P on the meristematic activity of plant tissues and consequently increasing plant growth, and subsequently its function as a part of enzyme system having a vital role of the synthesis of other foods from carbohydrate. The results of this study are in harmony with those of Foda, 2017; Ghazi, 2017; Al-Agrody *et al.,* 2017 and Alemayehu and Shumi, 2018.

Statistical analysis of the data presented in Table (3) indicated that, both form of Zn application significantly affected seed index, weight of pods, total yield, total carbohydrates and protein during both seasons of the experiment. The highest mean values were recorded with foliar application with Zn-EDTA comparing with the soil application $ZnSO_4$ as (60.38, 37.44, 3683.45, 51.45 and 14.90), respectively for seed index, weight of pods, total yield, total carbohydrates and protein in 2018-2019. The same trend was happened in 2019-2020. The increase due to Zn fertilization might be attributed to the fact that Zn plays an essential part in initiation of primodia and biosynthesis of the IAA for reproductive parts and a result of favorable impact of zinc on the metabolic reactions within the plants. The results are in close conformity with findings of Reda *et al.* (2014). As for the effect of Zn on carbohydrates and protein, this indicates that there is value to Zn application forms for obtaining high total carbohydrate and protein of seeds. This might be due to Zn contribution in photosynthesis, chlorophyll, digestion of starch arrangement and enzyme carbonic anhydrase accelerating carbohydrate formation, the maximum requirements of zinc were enough to accumulate suitable carbohydrate contents. Additionally, activate glutamic dehydrogenase enzyme, synthesis of DNA and RNA enhancing glutenin and gliadin content, which are main protein components of gluten accumulated in the later stages of seeds filling. The faba beans quality as (total carbohydrate and protein content) consist on their inherent chemical compositions, which have a response function in various enzymatic activities in seed. The results are in conformity with the findings of Reda *et al.* (2014). Generally, foliar fertilization is more economical than root application due to the higher degree of applied nutrient utilization, which makes the nutrients more efficient. It is a quick and efficient method of supplying microelements in particular. It can however, also be used to satisfy acute needs of macro-elements. Additionally, foliar application can solved some of soil fertilization problems. Foliar application may also overcome the block of nutrient uptake and enrich the target organs directly with appropriate amount of nutrients (El-Sawy 2011). In addition, the obtained results with Zn foliar nutrition agree with those of (Ghazi, 2017 and Al-Agrody *et al.* 2017).





Figs. 1&2. Interaction effect of P-fertilization and Zn application forms in absence and presence of PSB

Table 3. Effect of phosphorus fertilization, inoculation with PSB and Zn application forms as well as their interactions on yield and its components during 2018-2019 and 2019-2020.

Treatments			Seed index,		Weight of pods, g/plant		Total yield, kg/fed		Total carbohydrates %		Protein%	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Phosphorus fertilization rats												
0% P			56.07	58.19	32.95	35.92	3336.01	3808.90	49.03	51.88	13.36	13.91
50% P			61.47	63.75	38.64	41.63	3772.57	4101.79	52.10	54.22	15.32	15.77
100% P			63.05	65.47	40.25	43.34	3898.89	4182.79	52.97	54.87	15.87	16.29
LSD at 5%			0.17	0.49	0.23	0.17	32.47	17.94	0.10	0.16	0.13	0.18
Forms of zinc application												
$ZnSO_4$ (soil)			60.01	62.25	37.12	40.17	3654.87	4023.15	51.28	53.59	14.79	15.25
$ZnSO_4$ (foliar)			60.38	62.68	37.44	40.43	3683.45	4039.17	51.45	53.73	14.90	15.39
LSD at 5%			0.07	0.21	0.06	0.02	32.45	19.53	0.13	0.07	0.16	0.07
Phosphorus Soluble bacteria inoculation												
Without			58.50	60.62	35.53	38.44	3533.14	3937.90	50.46	52.97	14.24	14.74
PSB			61.89	64.32	39.03	42.16	3805.17	4124.43	52.27	54.35	15.46	15.90
LSD at 5%			0.07	0.27	0.06	0.09	14.89	14.29	0.06	0.07	0.13	0.06
Interaction												
0% P	$ZnSO_4$ (soil)	Without	55.64	57.74	32.45	35.46	3303.24	3777.23	48.84	51.75	13.23	13.74
		PSB	56.51	58.59	33.51	36.72	3368.90	3837.40	49.26	52.06	13.54	14.04
	$ZnSO_4$ (foliar)	Without	54.56	56.55	31.37	33.84	3207.77	3729.56	48.18	51.26	12.63	13.44
		PSB	57.56	59.86	34.47	37.66	3464.14	3891.42	49.86	52.45	14.03	14.43
50%P	$ZnSO_4$ (soil)	Without	58.55	60.75	35.75	38.77	3553.00	3959.07	50.55	53.05	14.33	14.83
		PSB	62.73	65.16	39.92	42.86	3869.11	4178.26	52.85	54.75	15.74	16.23
	$ZnSO_4$ (foliar)	Without	59.75	61.86	36.73	39.74	3621.81	3995.52	51.13	53.53	14.75	15.14
		PSB	64.85	67.24	42.13	45.14	4046.37	4274.33	53.85	55.56	16.44	16.86
100% P	$ZnSO_4$ (soil)	Without	60.76	62.95	37.84	40.86	3711.31	4051.68	51.73	53.87	15.07	15.43
		PSB	65.87	68.33	43.25	46.34	4123.66	4335.27	54.45	56.04	16.85	17.23
	$ZnSO_4$ (foliar)	Without	61.76	63.86	39.05	41.95	3801.74	4114.32	52.36	54.35	15.42	15.86
		PSB	63.83	66.74	40.86	44.23	3958.85	4229.88	53.34	55.23	16.13	16.62
LSD at 5%			0.18	0.67	0.14	0.21	36.49	34.78	0.15	0.16	0.31	0.14

Yield and its components as affected by PSB are tabulated in Table (3). Data revealed that, above traits were significantly affected by the inoculation with PSB comparing with the un-inoculated plants during both seasons. Comparing with the inoculated plant, it was found that plant treated with PSB recorded the highest values of seed index, weight of pods, total yield, total carbohydrates and protein as (61.89, 39.03, 3805.17, 52.27 and 15.46), respectively in 2018-2019, the same trend was happened in 2019-2020. Phosphate-solubilizing microorganisms had significant part in phosphorus solubility and uptake. The bacteria freed phosphorus from organic and inorganic soils during the mineralization process also the absorption of phosphorus increased from phosphate rock and save a reservoir of phosphorus in the presence of carbon unstable by mineralization process, also increased the seed protein (Alikhan *et al*. 2009). These results are consistent with the view of (Shakori and Sharif, 2016 and Ghazi, 2017).

Moreover, increasing the level of phosphorus significantly increased the mean values of theaforementioned traits less than those obtained for the control treatment until 100% RD. under any form of Zn fertilization in presence of PSB. Thus, it can be observed that the most suitable treatment, which realized the highest mean values of seed index, weight of pods, total yield, total carbohydrates and protein of faba bean plant was connected with the plants treated with 100% from recommended dose of phosphorus fertilization and Zn-EDTA+PSB.

CONCLUSION

It could be deduced from the present results that; foliar application with Zn-EDTA under 100% P in presence of PSB was the most suitable treatments to obtain the highest safe yield quality of faba bean plant.

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استجابه نبات الفول البلدى للتسميد الفوسفاتى واضافه الزنك تحت التلقيح بالبكتريا المذيبه للفوسفات

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تم اجراء تجربتين حقليتين خلال موسمى النمو 2018-2019 و2019-2020 في تجربه منشقه متعامده في 3 مكررات تحتوى على 3 معدلات من التسميد الفوسفاتى (0، 50، 100% من الموصى به) و صورتين من التسميد بالزنك (رش و أرضى) في وجود وعدم وجود بكتريا مذيبه للفوسفات. أوضحت النتائج المتحصل عليها خلال التجربه أنه بزياده معدل اضافه الاسمده الفوسفاتيه يزداد كل من النمو الخضرى (طول النبات، الوزن الطازج و الجاف)، محتوى الكلوروفيل في الأوراق، محتوى النبات من الفوسفور و الزنك و العكس في الجذور، بالاضافه الى المحصول ومكوناته من (وزن الحبوب و القرون و الوزن الكلى للمحصول و محتوى البذور من الكربوهيدرات و البروتين و اعلى القيم سجلت عند اضافه 100% من التسميد الفوسفاتى مقارنه بالكنترول. أوضحت النتائج أن الرش بالزنك المخلبى سجل افضل النتائج للصفات المذكوره كل ذلك في وجود البكتريا المذيبه للفوسفات.