Assessing Faba Bean Yield and Quality as Affected by Various Phosphorus Sources and Lithovit Levels

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Abstract

Two field experiments were conducted at the Experimental Research Station, Faculty of Agriculture, Moshtohor, Benha University, Qalyoubia Governorate, Egypt, during 2016/17 and 2017/18 winter seasons this study is to evaluate the effectiveness of four treatments: phosphate fertilization sources as soil addition (super phosphate (SP), rock phosphate (RP) + phosphate dissolving bacteria (PDB), sulphur (S) + phosphate dissolving bacteria (PDB) and RP + S+ PDB) with three spraying levels of lithovit (0 , as tap water, 0.5 and 1.0)g/L), to increase the availability of phosphorus from rock phosphate and their effects on vegetative growth parameters, chemical composition, yield and yield attributes of faba bean plants cv. Sakha 4. Experiments were designed and carried out as split plot design where lithovit as foliar application levels randomly distributed in the main plots and phosphorus fertilization sources were in the split plots of three replicates. Results determined as follows: Application of different phosphate fertilization sources induced significant increases growth characteristics, yield, its components, and chemical constituents of faba bean (Sakha 4). In addition, Fertilizer application of RP + S + PDB formed the tallest plant heights, No. of branches / plant, chlorophyll content, yield and its components and seed index as well in the two respective seasons with variable significant magnitudes. Also, Nitrogen (%), Phosphorus (%) and Potassium (%) were increased in the 1st season where fertilized with RP + S + PDB. Foliar application of lithovit, 1.0 g/L level exerted the highest values of growth characteristics, yield, its components, and chemical constituents of faba bean (Sakha 4) as well in each of the two growing seasons with different significant magnitudes.

Keywords: Faba bean, rock phosphate, phosphate dissolving bacteria, sulphur, Lithovit.

Introduction

Faba bean *(Vicia faba* L.*)* is an annual legume which botanically known as the broad bean, fava bean, faba bean, field bean, bell bean, or tic bean. Its seeds are used for human consumption. Grain legumes are belonging to the family Fabaceae which are cultivated for their mature seeds or immature green pods. Seeds contain 35% protein, 45% carbohydrate and 2% fat. Broad bean seeds are rich in amino acids, vitamins, carbohydrates, fiber, chlorophyll pigments and minerals and contain anti-nutritional compounds, including tannins, protease inhibitors, phytates and glycosides **Crépon *et al.,* (2010).**

Faba bean has four main functions in agro-ecosystems: (1) providing food and feed which are rich in protein; (2) increasing soil fertility by supplying the agro-ecosystems by symbiotic N_2 fixation with Rhizobium; (3) expanding the crop system to decrease growth constraints and yield by the other crops in rotations; and (4) reducing fossil energy consumption for crop production **Nikfarjam and Aminpanah (2015).** It represents a popular breakfast food and also used as green or fresh vegetable. Also, it is an important crop for soil improvement which between cereal rotation to keep the soil fertility and production through nitrogen fixation.

Lithovit compound containing silica (5%), magnesium carbonate (4%) and calcium carbonate (75%) particles, extremely small, which gives them the ability to interoperate the stomata of leaves for plants when foliar sprayed. The positive effect of such compound of being contains magnesium, which is the central element in chlorophyll molecule as that silica plays an important role in plants exposed to drought stress which mainly water relations and photosynthesis **(Raven, 2003).**

Phosphorus is one of the most important elements that is a significantly affecting on plant growth and metabolism. Legumes require high amounts of P due to the involvement of P in energy transfer rate that must take place in its nodule reported by **Kandil *et al.,* (2013).** Phosphorus has also an enhancing impact on plant growth and biological yield through its importance as an energy storage and transfer necessary for metabolic processes **(Singh *et al.,* 2014).** Phosphorus addition increased the efficiency of photosynthesis, enhances the activity of rhizobia and increases the number of branches and pods/plant, and greater yield of pea, faba bean **(Lal *et al.,* 2016).**

In spite of the extensive addition of phosphorus to soil, the available amount of phosphorus for plants is usually low since its availability to plants is limited by different chemical reactions especially in arid and semiarid soils by **El-Gizawy and Mehasen (2009).** Phosphorus plays an important role in numerous physiological and biochemical processes like photosynthesis, it is the transformation of sugar to starch and transporting of the genetic traits by **Zaki *et al.,* (2012).** Also, Phosphorus has helpful effects on nodule creation and nitrogen fixation in legume crops and plays a vital role in the structure of nucleus and cell membrane **Raghothama and Karthikeyan (2005).**

Rock phosphate is the main basis for producing phosphate fertilizers. It is considered the cheapest P fertilizer. Phosphate rock sources may be of fiery of sedimentary origin **Hellal *et al.*, (2019).** However, using acidic resources such as sulphur and sulphuric acid, or using rock phosphate combined with phosphate dissolving bacteria (PDB) such as *Pseudomonas, Azospirillum, Burkholderia, Bacillus, Enterobacter, Rhizobium, Erwinia, Serratia, Alcaligenes, Arthrobacter, Acinetobacter, and Flavobacterium* which can produce some organic acids will release phosphorous from rock phosphate and can replace P-fertilizers.

Phosphate - dissolving microorganisms represent one of the biofertilizers and play an important role in supplying plants with phosphorus. They take about a number of revolutions increasing the solubility of inorganic phosphorus. Some bacteria such as *Bacillus megaterium* provide plants with growth promoting materials and plays a major role in phosphate solubilization.

El-Kamony *et al.*, (2000) observed that using of phosphate dissolving microorganisms which include phosphate dissolving bacteria (phosphorein or microbein) may have an additional benefit such as mobilizing of phosphate and micronutrients when the production of organic acids such as formic acid, lactic acid and propionic acids. These acids decrease the pH and bring about the dissolution of bounds forms of phosphate and reduce than offered for growing plants.

Bio-fertilizers are included to different kinds of free-living microorganisms which have ability to convert nutrients from unavailable to available form and biostimulats plant growth stimulating factors by biological processes **Chen (2006).**

Biological phosphate fertilizers containing beneficial bacteria and fungi they increased phosphate solutions by increasing soil acidity or transform it to alkaline by phosphatase enzyme, which can be absorbed by plants easily.

Phosphate solubilizing bacteria (PSB) are a group of beneficial bacteria capable hydrolysis of organic and inorganic phosphorus from insoluble compound. Using biofertilizers alone, without stimulative rates from mineral fertilizers was less effective than the recommended rates of chemical fertilizers **(Awad, 1998).** These effects through the ability of the microorganisms to enhance some growth regulator substances, which it may play an important role in plant growth through promoting photosynthesis, translocation, and accumulation of dry matter within different plant organs. It may also be related to the role of the more available phosphorus produced by phosphorus releasing bacteria in plant growth. These results are also in agreement with those obtained by **Abd El-Hady and Abbas (2005) and El Banna *et al.*, (2009).**

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 **(Abo El-Nour *et al.*, 1996).**

Therefore, this study amid to evaluating the efficiency of foliar applications of lithovit under different sources of phosphorus fertilization combined with super phosphate as a control, phosphate dissolving bacteria (PDB) bio-inoculation with *Bacillus megaterium*, rock phosphate (RP) and sulphur (S) on vegetative growth, yield, its component and chemical composition of faba bean plants.

Materials and Methods

Two field experiments were carried out at the Experimental Research Station, Faculty of Agriculture, Moshtohor, Benha University, Qalyoubia Governorate, Egypt, during 2016/17 and 2017/18 winter seasons this is to evaluate the efficiency of rock phosphate (RP), sulphur (S), phosphate dissolving bacteria (PDB), as well as foliar application of lithovit to enhance the availability of phosphorus from rock phosphate and their effects on vegetative growth parameters, chemical composition, yield and yield components of Sakha 4 faba bean seeds.

The treatments were as follows:

A. **Phosphate fertilization sources:**

Super Phosphate calcium (SP) (15.5% P_2O_5) as a control.

Rock phosphate (RP) + Bacteria dissolving phosphate (BDP).

Sulphur (S) + Bacteria dissolving phosphate (BDP).

Rock phosphate (RP) + Sulphur (S) + Bacteria dissolving phosphate (BDP).

B. **Lithovit levels:**

Foliage spraying in liquid solution of 0, 0.5 and 1.0 g/L.

Seeds of faba bean (cv. Sakha 4) were planted on 6th and 14th November in first and second seasons, respectively. For all treatments, two phosphorus sources (super phosphate and rock phosphate) and sulphur were applied during seed sowing preparation. Split plot design with three replicates were used in the two seasons.

The lithovit spraying foliar application levels were randomly assigned to the main plots and the phosphorus fertilization sources in the sub-plots. Each plot was included 5 ridges; 3.5 m long and 60 cm wide, the plot's area was 10.5 m^2. Seeding rate was 50 kg/fed. The recommended dose for faba bean (31 kg P_2O_5/fed) was added before sowing in the form of calcium super phosphate (SP); 15.5 % P_2O_5.

Rock phosphate (RP); 30% P_2O_5 applied as soil addition before sowing at the rate of 31 kg P_2O_5/fed.

Sulphur was added before sowing at the rate of 200 kg S /fed. Cell suspension of (*Bacillus megaterium* var. phosphaticum) was obtained from unit of biofertilizers, Fac. of Agric., Ain Shams Univ. Cairo. Egypt. This suspension of cell is containing about 108 colony farming unit (CFU). Seeds of faba bean were soaked with the liquid suspension of (PDB) before sowing.

Faba bean plants were sprayed three times by using hand sprayer with the aqueous solution of lithovit levels at 40, 60 and 80 days after planting, while control treatments were sprayed with tap- water. All other practical treatments were done according to the recommended doses of Ministry of Agricultural and soil reclamation for faba bean plant.

The soil type of the experimental unit was clay with pH 8.0. Organic matter, EC, pH, available N, P and K were determined according to the methods described by **Jackson (1973)**. The physical and chemical properties of the experimental soil units of Moshtohor Exp. Station are recorded in **Table (1)** for each of the two growing winter seasons.

Table 1. Physical and chemical properties of the experimental soil units at Moshtohor Agric. Exp. Station during each of the two growing winter seasons.

Properties	Seasons	
	2016/17	2017/18
Mechanical analysis		
Coarse sand %	5.96	4.79
Find sand %	**19.15**	**16.08**
Silt %	29.65	32.63
Clay %	45.24	46.50
Texture grade	clay	clay
Chemical analysis		
pH (1: 2.5)	8.2	8.0
E.C. (ds/m) (1:20)	0.16	0.2
$CaCO_3$ (%)	**3.15**	**2.1**
HCO_3 (meq/L)	1.25	1.25
Cl^- (meq/L)	0.55	0.55
Ca^{++} (meq/L)	0.8	0.9
Na^+ (meq/L)	0.78	0.83
K^+ (meq/L)	0.23	0.18
Mg^{++} (meq/L)	0.2	0.2
N available(mg/kg)	**252**	**155**
P available (mg/kg)	**13**	**7.0**
K available(mg/kg)	**1350**	**1080**

At flowering stage (90 days after sowing) randomly plant samples were taken from all treatments to determine: plant height (cm), Num. of branches plant^{-1} and total chlorophyll contents in faba bean leaves it was measured by chlorophyll meter (SPAD) Model SPAD 402 according to **Mielke and Schaffer (2010).**

At harvest, ten plants were taken at random from the central ridges to estimate: number of pods plant^{-1}, number of seeds pod^{-1}, number of seeds plant^{-1}, and weight of pods plant^{-1} (g), weight of seeds plant^{-1} (g) and 100-seed weight (g). Moreover, the whole plot was harvested to determine seed yield (kg fed^{-1}) for the three central ridges of each experimental unit.

From each plot, samples of faba bean seeds were dried in oven at (70ºC) tell constant weight and digested by a sulphoric- perchloric acid mixture as described by **Peterburgski, (1968)** to determine N, P and K in faba bean seeds. Nitrogen and potassium contents were determined using Kjeldahl digestion and flame photometer procedure in the digested product (according to the methods of **Chapman and Pratt (1961).** Phosphorus content of faba bean seeds was determined by using colorimetric method **Olsen *et al*., (1954).**

Moreover, protein percentage in faba bean seeds were calculated by multiplying nitrogen percentage x 6.25 **A.O.A.C. (1990).** Statistical analysis: The analysis of variance for data of each of the two growing seasons were carried out according to **Snedecor and Cochran (1990).** The L.S.D. test at the 5% level was used in means comparison.

Results and Discussion

1- Effect on different applied treatments on vegetative growth characteristics and total chlorophyll:

A- Effect of foliar spraying of lithovit levels with phosphorus fertilization on growth characteristics and total chlorophyll:

Data recorded in **Table (2)** illustrate the effect of foliar applications of lithovit at (0, 0.5 and 1.0 g/L) under different forms of phosphorus fertilization combined with 31 kg P_2O_5/fed. Super phosphate (SP), as a control, (rock phosphate (RP) + phosphate dissolving bacteria (PDB)), (sulphur (S) + PDB), (RP + S + PDB) on faba bean plants as well as morphological plant growth measurements and total chlorophylls in the two growing seasons

(2016/17&2017/18). The statistical analysis of the obtained data shows that in **Table (2)**, the most suitable treatment which realized the highest mean values of all the studied parameters of faba bean plants on morphological plant growth and total chlorophyll under the foliar spraying with lithovit at (1.0 g/L) under different sources of phosphorus fertilization combined with (RP+PDB), (S+PDB), (RP+S+PDB) in the two seasons (2016/17&2017/18) were significantly increased when compared with the control (31 kg P_2O_5/fed.) expressed as; plant height (96.83, 94.33 cm), number of branches/plant (2.83, 2.42) and total chlorophyll (46.6,42.9) in the two seasons, respectively with significant variable magnitudes.

In this regard, in the first season on plant heights (96.83 cm) was of no significantly differences when compared with the control (SP) and other treatments, whereas, in the second season, number of branches/ plant (2.42) without significant differences among them when compared with the control (31 kg P_2O_5/fed.).

Byan (2014) reported that using lithovit (a natural intensified CO_2 foliar fertilizer) as foliar spray on snap bean plants cv. Poulista improved the values of green pod characters as well as the vegetative growth compared with the control (distilled water).

The obtained results are in agreement with those finding by **Rouhollah *et al.*, (2016),** who noticed that faba bean leaf chlorophyll content was significantly affected by nitrogen and phosphorus application fertilizer to the soil.

On the contrast, **Kole and Hajra (1999)** reported that no significant differences between Ca superphosphate or rock phosphate were detected on growth and yield of a broad bean plant. **Rakha and El-Said (2013)** found that applications of phosphorus fertilizers in two forms generally had a non-significant effect on the most plant growth characters of broad bean.

These results are in harmony with those obtained by **Yirga *et al.*, (2012)** and **Rouhollah *et al.*, (2016)** they found that the chemical fertilizer at a rate of 50 kg urea ha^{-1} and 150 kg ha^{-1} of triple super phosphate had a significant effect on plant height of faba bean. The high availability of nutrients, especially nitrogen, affects the growth and increase the length of internodes of plant height. While such results are not matching with the results of **Nikfarjam and Aminpanah (2015)** where they found that the P application had no significant effect on plant height.

B- Effect of different sources of phosphorus fertilization on growth characteristics:

Results presented in **Table (2)** showed that the effect of different sources of phosphorus fertilization combined with 31 kg/fed. (P_2O_5 as a control), (RP+PDB), (S+PDB) and (RP+S+PDB) on faba bean plants on morphological plant growth and total chlorophyll in the two seasons (2016/17& 2017/18) as presented in plant height (100.78, 102.44 cm), number of branches /plant (3.00, 2.56) and total chlorophyll (48.7, 44.7) in the two respective seasons, with significant differences.

The treatment of tricombination of (RP+S+PDB) gave the highest values for all traits under study and significantly increased with such treatment of tricombination of (RP+S+PDB) when compared with the control (SP) and other treatment of (RP+PDB) and (S+PDB).

Rafat and Sharifi (2015) reported that application of phosphorus at the rate of 50 kg P ha^{-1} lead to supreme values of plant height, pod length, number of pods per plant and pod yield in common bean. **Adhami and Ronaghi (1999)** indicated that dry weight of broad bean improved by application of phosphorus.

They reported that by increasing P uptake, plant nutrition development and possibly further rooted in the soil can be reason of increasing weight of dry organs. Also, **Turk and Al-Tawaha (2002)** found that the significant increase of plant height and branches $plant^{-1}$ with P application. Also, **Cazzato *et al.*, (2012)** observed the increase in the weight of broad bean leaves and stems when sulphur was applied.

Applying sulfur may be considered an effective method to lower the high pH values in the soil and, hence, improving the availability and uptake of phosphorus micronutrients by the plants **Abdel-Samad *et al.*, (1990)** reported that sulfur plays a vital role in chlorophyll biosynthesis and in the activities of certain enzymes.

Also, similar effect of elemental sulphur application and inoculation with the dissolving agent PDB in the presence of RP on yield and its components was observed. This could be attributed to the vigorous role of combined treatments in dropping soil pH, increasing nutrient uptake, chlorophyll contents, and photosynthetic rate which affected the growth and plant characteristics **(Ali, 2002).**

C- Interaction effect between foliar spraying of the dissolving agent lithovit and different sources of phosphorus fertilization on vegetative growth characteristics and total chlorophyll:

Data recorded in **Table (2)** illustrate the interaction effect between foliar spraying of the dissolving agent lithovit at (0, 0.5 and 1.0 g/L) under different sources of phosphorus applications combined with 31 kg P_2O_5/fed. Super phosphate (SP) as a control, (RP+PDB), (S+PDB), (RP+S+PDB) on faba bean plants on morphological plant growth measurements and total chlorophyll in the two seasons (2016/17& 2017/18). Results in **Table (2)** showed the effect of interaction between the foliar applications of lithovit at (1.0 g/L) combined with tricombination of (RP+S+PDB) when compared with the control (SP) in the two seasons (2016/17& 2017/18) gave the highest values with such treatment without significant differences among them when compared with the control in each of two seasons (2016/17& 2017/18) expressed in plant height (103.67, 107.0 cm), number of branches/plant (3.33, 3.00) and total chlorophyll (49.5, 46.7) in two seasons (2016/17& 2017/18), respectively.

Table 2. The impact of phosphate fertilization sources and lithovit levels on vegetative growth characteristics and total chlorophyll of faba bean during two seasons (2016/17 &2017/18).

Lithovit levels (L) (g/L)	Fertilization (F)	First season (2016/17)			Second season (2017/18)		
		No. of branches/plant	Plant height (Cm)	Total chlorophyll	No. of branches/ plant	Plant height (Cm)	Total chlorophyll
Without (Control)	SP (Control)	1.67	84.67	40.7	1.33	74.67	35.6
	BDP + RP	2.33	95.00	45.1	2.00	95.33	39.2
	BDP + S	2.00	89.67	44.1	2.00	87.33	35.6
	BDP + RP+ S	2.67	97.33	48.5	2.33	98.33	41.7
Mean		**2.17**	**91.67**	**44.6**	**1.92**	**88.92**	**38.0**
0.5	SP (Control)	2.00	86.67	43.8	1.67	77.00	36.3
	BDP + RP	2.67	95.67	46.2	2.33	94.67	40.4
	BDP + S	2.33	91.00	45.2	2.33	90.67	41.5
	BDP + RP+ S	3.00	101.33	48.1	2.33	102.00	45.6
Mean		**2.50**	**93.67**	**45.8**	**2.17**	**91.08**	**40.9**
1.0	SP (Control)	2.33	90.33	44.5	2.00	80.33	39.5
	BDP + RP	3.00	96.67	46.9	2.33	96.33	41.5
	BDP + S	2.67	96.67	45.5	2.33	93.67	43.7
	BDP + RP+ S	3.33	103.67	49.5	3.00	107.00	46.7
Mean		**2.83**	**96.83**	**46.6**	**2.42**	**94.33**	**42.9**
SP (Control)		2.00	87.22	43.0	1.67	77.33	37.1
BDP + RP		2.67	95.78	46.1	2.22	95.44	40.4
BDP + S		2.33	92.44	44.9	2.22	90.56	40.3
BDP + RP+ S		3.00	100.78	48.7	2.56	102.44	44.7
Mean		**2.50**	**94.06**	**45.67**	**2.17**	**91.44**	**40.63**
L.S.D at 5 % for:		L=0.36 F= 0.33 LF= N.S	L= N.S F=3.54 LF= N.S	L=0.96 F= 1.24 LF= N.S	L=N.S F= 0.40 LF= N.S	L=2.42 F= 4.18 LF= N.S	L=0.15 F= 1.37 LF= N.S

SP = super phosphate, RP = rock phosphate, PDB = phosphate dissolving bacteria, S = sulphur and L= lithovit.

1-Effect of different applied treatments on yield and its components:

A- Effect of foliar spraying of lithovit levels with phosphorus fertilization on yield and its components:

Data recorded in **Tables (3,4 and 5)** showed that the effect of foliar application with lithovit at (0, 0.5 and 1.0 g/L) under different sources of phosphorus applications combined with SP as a control, (RP+PDB), (S+PDB) and (RP+S+PDB) on faba bean plant in the two seasons (2016/17& 2017/18) on yield and its components.

Results presented in **Tables (3, 4 and 5)** showed the effect of foliar spraying with lithovit at 1.0 g/L under different sources of phosphorus fertilization combined with SP as a control, (RP+PDB), (S+PDB) and (RP+S+PDB) on faba bean plant in the two seasons (2016/17& 2017/18) on yield and its components gave the highest values which were associated such treatment expressed as; weight of plant (g) (94.5, 91.8), pods (35.8, 32.2), seeds/ plant (g) (28.2, 22.3), number of pods /plant (11.5, 9.6), seeds/ pod (3.6, 3.2), seeds/ plant (32.3, 27.7), seed yield (2115.6, 1669.4 kg/ fed.), biological yield (4800.0, 3433.3 kg/ fed.) and seed index (96.1, 80.5), in the two seasons respectively.

In the first season some of the studied characters did not show significant differences when compared with the control in two seasons (2016/17& 2017/18) which expressed as; number of pods/plant (11.5), weight of seeds/plant (28.2 g) and number of seeds/ plant (32.3 g), respectively in the two seasons. Also, weight of pods (32.2 g) did not show significant differences as showed in the second season (2017/18). **Singh *et al.,***

(2015) reported that the grain and straw yields of cowpea increased significantly by all the levels of phosphorus over control. Application of 90 kg P_2O_5 ha^{-1} recorded significantly higher yields of grain and straw. The increases in grain and straw yields with 90 kg P_2O_5 ha^{-1} over control were 29.0 and 27.0 %, respectively. The increases in yield may be attributed to the effective metabolic activities coupled with the increased rate of photosynthesis leading to better translocation of nutrients in sink. Similar results were reported by **Singh *et al.,* (2014), Singh *et al.,* (2016)** in lentil.

B-Effect of different sources of phosphorus fertilization on yield and its components:

Results presented in **Tables (3,4 and 5)** showed that the effect of different sources of phosphorus fertilization combined with 31 kg P_2O_5/fed. as a control, (RP+PDB), (S+PDB) and (RP+S+PDB) on yield and its components on faba bean plants in the two growing seasons (2016/17& 2017/18), However, the highest values were associated with the tri combination of (PDB+ RP+S) were significant increase with the treatment of tricombination of (PDB+ RP+S) when compared with the untreated one (SP) in the two growing seasons (2016/17&2017/18) expressed as; weight of plant (g) (89.4, 88.7), weight of pods (40.3, 38.6), weight of seeds/ plant (g) (34.6, 26.5), number of pods /plant (12.6, 11.5), number of seeds/ pod (3.7, 3.3), number of seeds/ plant (36.7, 34.1 g), seed yield (2597.5, 3600.0 kg/ fed.), seed index (96.0, 83.9), biological yield (4933.3, 3600 kg/ fed.), in the two seasons respectively.

These increases in yield and its components of broad bean plants may be attributed to the increases in both cell division and cell elongation it means cell growth. As reported earlier, phosphorus plays a major role in protein biosynthesis and protoplasm formation. It may increase the proportion or protoplasm to cell wall, and it is a part of the molecular structure for nucleic acids DNA and RNA resulting in an increment in vegetative growth characters as the increase in cell size **(Mengel and Kirkby (1987)** In addition, phosphorus plays an vital role in photosynthesis and respiration, and it is also essential for division and development of meristematic tissues. Similar results were previously reported by **Abdul-Galil *et al.,* (2003) and Abdo (2003).** Seed inoculation with the PDB caused a remarkable increase in most of the studied parameters as compared with rock phosphate fertilizer only. Some of researchers indicated beneficial effect of phosphorus fertilizer on increasing of faba bean yield. **El-Gizawy and Mehasen (2009)** revealed that the application of chemical phosphorus fertilizer produced significant effect on seed yield, yield components and content of nitrogen, phosphorus and zinc in the seed of faba bean.

Soil inoculation with phosphate dissolving bacteria (phosphorein) improved soil fertility and plant productivity **(Dubey, 2000) and Mohammed, (2004)** on bean plant proving the utilizing of P bio fertilizer (phosphorein) with or instead of mineral markedly increased the available phosphorus concentrate ions in soil and plants, and hence increased plant growth and yields. **Eman *et al., (*1993)** found that inoculation of faba bean plants with phosphate solubilizing bacteria significantly increased weight of plants as compared with the unfertilized treatment. **Saber *et al.,* (1983)** showed that the use of phosphate dissolving bacteria led to increasing Phosphorus uptake and yield of faba bean cultivated in a calcareous soil.

Phosphorus is a vital element for cell division, root development and seed formation. This might be due to 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 and seed yield/plant. Such results are in accordance with those obtained by **El-Habbasha *et al.,* (2007) and Yilmaz (2008).**

C-The interaction effect between foliar spraying with lithovit and different sources of phosphorus fertilization on yield and its components:

Data recorded in **Tables (3,4 and 5)** showed the effect of interaction between foliar spraying of lithovit at (0, 0.5 and 1.0 g/L) under different sources of phosphorus fapplications combined with 31 kg/fed. Super phosphate (SP) as a control, (RP+PDB), (S+PDB) and (RP+S+PDB) on faba bean plants during the two seasons (2016/17& 2017/18). Results in **Tables (3,4 and 5)** showed that the interaction effect between foliar application of lithovit at (1.0 g/L) combined with tricombination of (RP+ S+PDB) when compared with the control (SP) on faba bean plants during the two seasons (2016/17& 2017/18) which produced the highest values of yield and its components. In this respect, all of the studied characters of significant differences when compared with the control in each of the two seasons (2016/17& 2017/18) except for the number of seeds /pod which were 3.9, 3.4 in the two seasons, respectively. Also, during the first seasons, weight of seeds/plant (37.3 g) and seed yield (2797.5 kg/ fed.) were significant increased **(Tables 3,4 and 5).** Significant response of broad bean plants to phosphate fertilization was recorded by **Ahmed *et al.,* (2002).** Moreover, **Abo El-Soud *et al.,* (2003) and Mohammed (2004)** showed that the phosphorus application which gave a highly significant increase in dry weight of shoots, number of pods per plant, number of seeds per pod, pod length and weight as well as NPK contents of cowpea and broad bean plants when compared to those obtained by rock phosphate by **Hamed (2003). Alipour *et al.,* (2014)** showed that biological phosphorus fertilizers significantly enhanced seed and biological yield, harvested index and plant height. Moreover, **Kole and Hajra (1999)** reported no significant differences between Ca super phosphate or rock phosphate were detected on growth and yield of broad bean plant. On the other hand, **El-Gizawy and Mahasen (2009)** found that plant observed more phosphorus in presence of phosphate dissolving microorganisms.

These increases may be due to the inoculation with phosphate dissolving bacteria which solubilized unavailable forms of calcium certain phosphate by expelling organic acids such as gluconic acid, formic, acetic, lactic, propionic, fumaric, and succinic acids, those acids decreasing the pH which directly change insoluble phosphates in the soil into soluble forms (as well as the displacement of phosphorous on surfaces reported by **Nassar *et al.*, (2000)** and **Ewais**

(2006). Sulphur is a vital element for a good vegetative growth particularly the chlorophyll formation as well as leading to a high yield. Seed inoculation with the dissolving agent (PDB) produces organic acids and may also produce growth promoting substances such as auxins, gibberellins and cytokinins. Such substances could influence the plant growth and alter phosphate ions to be chemically liberated from the P- source. These results were in agreement with the previously mentioned results of **El-Habbasha *et al.*, (2007)** and **El-Gizawy and Mehasen (2009)** who noticed that plant height, 100-seed weight, number of pods/plants, seed yield/plant, seed and straw yields/fed. were increased when adding 30 kg P_2O_5 mixed with the dissolving agent (PDB) to soil markedly.

Table 3. The impact of phosphate fertilization sources and lithovit levels on biological yield, seed yield and seed index of faba bean during two seasons (2016/17 &2017/18).

Lithovit levels (L) (g/L)	Fertilization (F)	First season (2016/17)			Second season (2017/18)		
		Biological yield (kg/fed.)	Seed yield (kg/fed.)	Seed index	Biological yield (kg/fed.)	Seed yield (kg/fed.)	Seed index
Without (Control)	**SP (Control)**	3066.7	1022.5	82.0	2666.7	830.0	62.0
	BDP + RP	4400.0	1932.5	89.0	2933.3	1540.0	76.7
	BDP + S	4400.0	1860.0	91.0	3333.3	1452.5	73.3
	BDP + RP+ S	4666.7	2352.5	92.0	3466.7	1907.5	81.7
Mean		**4133.3**	**1791.9**	**88.5**	**3100.0**	**1432.5**	**73.4**
0.5	**SP (Control)**	3733.3	1712.5	90.3	2800.0	1167.5	68.0
	BDP + RP	4666.7	1907.5	96.7	3333.3	1647.5	80.0
	BDP + S	4666.7	1822.5	93.0	3333.3	1657.5	77.0
	BDP + RP+ S	4933.3	2642.5	97.7	3600.0	2017.5	83.7
Mean		**4500.0**	**2021.3**	**94.4**	**3266.7**	**1622.5**	**77.2**
1.0	**SP (Control)**	4133.3	1842.5	91.3	2933.3	1215.0	72.7
	BDP + RP	4933.3	2060.0	98.0	3333.3	1715.0	83.3
	BDP + S	4933.3	1762.5	96.7	3733.3	1705.0	79.7
	BDP + RP+ S	5200.0	2797.5	98.3	3733.3	2042.5	86.3
Mean		**4800.0**	**2115.6**	**96.1**	**3433.3**	**1669.4**	**80.5**
SP (Control)		3644.4	1525.8	87.9	2800.0	1070.8	67.5
BDP + RP		4666.7	1966.7	94.6	3200.0	1634.2	80.0
BDP + S		4666.7	1815.0	93.6	3466.7	1605.0	76.7
BDP + RP+ S		4933.3	2597.5	96.0	3600.0	1989.2	83.9
Mean		**4477.8**	**1976.3**	**93.0**	**3266.7**	**1207.3**	**82.0**
L.S.D at 5 % for:		L= 223.5 F= 258.6 LF= N.S	L= 190.8 F=150.2 LF= 260.2	L=3.48 F= 3.09 LF= N.S	L=173.1 F= 254.3 LF= N.S	L=77.6 F= 63.0 LF= N.S	L= 2.25 F= 2.03 LF= N.S

SP = super phosphate, RP = rock phosphate, PDB = phosphate dissolving bacteria, S = sulphur and L= lithovit

Table 4. The impact of phosphate fertilization sources and lithovit levels on Weight of plant, Weight of pods/plant and Weight of seeds/plant of faba bean during two seasons (2016/17 &2017/18).

Lithovit levels (L) (g/L)	Fertilization (F)	First season (2016/17)			Second season (2017/18)		
		Weight of plant (g)	Weight of pods/plant (g)	Weight of seeds/plant (g)	Weight of plant (g)	Weight of pods/plant (g)	Weight of seeds/plant (g)
Without (Control)	SP (Control)	69.6	20.7	13.6	68.6	14.9	11.1
	BDP + RP	82.1	35.8	25.8	76.4	33.0	20.5
	BDP + S	72.2	33.4	24.8	84.4	32.2	19.4
	BDP + RP+ S	86.0	38.5	31.4	85.2	36.8	25.4
Mean		**77.5**	**32.1**	**23.9**	**78.7**	**29.2**	**19.1**
0.5	SP (Control)	71.1	24.7	22.8	73.1	16.2	15.6
	BDP + RP	88.5	30.8	25.4	81.1	34.8	22.0
	BDP + S	76.9	33.3	24.3	83.4	34.4	22.1
	BDP + RP+ S	87.8	37.2	35.2	89.1	39.1	26.9
Mean		**81.1**	**31.5**	**26.9**	**81.7**	**31.2**	**21.6**
1.0	SP (Control)	82.5	28.7	24.6	76.3	17.2	16.2
	BDP + RP	91.6	33.2	27.5	84.7	36.3	22.9
	BDP + S	82.3	36.3	23.5	88.4	35.3	22.7
	BDP + RP+ S	94.5	45.1	37.3	91.8	39.9	27.2
Mean		**87.7**	**35.8**	**28.2**	**85.3**	**32.2**	**22.3**
SP (Control)		74.4	24.7	20.3	72.7	16.1	14.3
BDP + RP		87.4	33.3	26.2	80.7	34.7	21.8
BDP + S		77.1	34.3	24.2	85.4	34.0	21.4
BDP + RP+ S		89.4	40.3	34.6	88.7	38.6	26.5
Mean		**82.1**	**33.2**	**26.3**	**81.9**	**30.8**	**21.0**
L.S.D at 5 % for:		L= 4.22 F= 5.00 LF= N.S	L= 1.74 F= 2.82 LF= N.S	L= N.S F=1.60 LF= 2.77	L=N.S F=4.38 LF= N.S	L= N.S F=1.88 LF= N.S	L= 1.03 F= 0.84 LF= N.S

SP = super phosphate, RP = rock phosphate, PDB = phosphate dissolving bacteria, S = sulphur and L= lithovit

Many investigators reported that, phosphate dissolving bacteria enhance improve seed and straw yields **(Ahmed and El-Abagy, 2007 and El-Habbasha *et al.*, 2007).**

Such results are in agreement with those obtained by **Rugheim and Abdelgani (2012),** where they reported that Rhizobium and phosphate solubilizing bacteria significantly increased yield and seed quality of faba bean plant.

Similar results were obtained by **El-Gizawy and Mehasen (2009),** who reported that adding phosphate dissolving bacteria in combination with mineral fertilizer of phosphorus increased number of pods per plant, seed yield per plants. 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 number of pods and yield / plant

3-Effect of foliar spraying of lithovit and different sources of phosphorus fertilization and their interaction on the chemical composition:

Regarding the effect of dissolving agent, data presented in **Table (6)** showed that the effect of foliar spraying with lithovit at (0, 0.5 and 1.0 g/L) under different sources of phosphorus fertilization combined with 31 kg P_2O_5/fed. (SP) as a control, (RP+PDB), (S+PDB) and (RP+S+PDB) on chemical composition of N, P, K and CP content on faba bean plants in the two seasons. It is clear in **Table (6)** that, spraying lithovit application levels when increased from 0 to 0.5 and up to 1.0 g/L, N, P, K and CP (%) content exerted slight insignificant increase in the two seasons. The highest values of means for N, P, K and CP (%) content were produced when spraying of lithovit concentration at (1.0 g/L) which were 4.47, 0.46, 14.18 and 27.92 % in the first season corresponding to 4.73, 0.24, 12.76 and 29.58% in the second season.

Concerning application of phosphate fertilization sources, generally, data in **Table (6)** did not exert significant differences on N, P, K and CP (%) especially in the first season. Whereas the greatest values of N, P, K and CP (%) were cleared as application of (PDB+RP+S) were 4.78, 0.43, 14.93 and 29.88 % in the first season. Other trend was observed during the second season where the same treatment gave less value without significant differences magnitudes.

It is also clear that the interaction effect of the applied treatment (lithovit levels x phosphate fertilization sources) did not exert significant differences magnitudes on N, P, K and CP (%). This is because of the fluctuation of the obtained results with no specific direction as it clears from **Table (6).** **Singh *et al.*, (2015)** found that application of phosphorus level significantly increased the protein content in cowpea grain and straw and maximum values in gram (20.00%) and straw (6.69%) were recorded with 90 kg P_2O_5 ha^{-1}. **Richards *et al.*, (2011)** pointed out that the increase in solubility of phosphorus in soil solution causes an increase in iron uptake by the plant which contributes in increasing nitrogen fixation by legumes then increase in protein content and seed quality as well.

El-Sayed (1999) reported that PDB as a dissolving agent plays an important role in releasing P from rock, tri-calcium, or other difficult of P-forms through the production of organic and inorganic acids, as well as CO_2. These substances convert the insoluble forms of P into soluble forms. The dissolving agent of PDB also affects other nutrients in addition to phosphorus.

These results strength be due to the beneficial effect of phosphorus application on leguminous crops due to its role in activation the microbial population in nodules to fix more N_2 that used by plants in protein synthesis **(Bhadoria *et al.*, 1997).** These results are in accordance with those obtained by **El-Habbasha *et al.*, (2007).**

Table 5. The impact of phosphate fertilization sources and lithovit levels on No. of pods / plant, No.of seeds /pod and No. of seeds / plant of faba bean during two seasons (2016/17 &2017/18).

Lithovit levels (L) (g/L)	Fertilization (F)	First season (2016/17) No. of pods / plant	No. of seeds /pod	No. of seeds / plant	Second season (2017/18) No. of pods / plant	No. of seeds /pod	No. of seeds / plant
Without (Control)	SP (Control)	8.2	3.1	21.6	6.5	2.9	18.7
	BDP + RP	9.9	3.4	31.7	8.3	3.1	25.2
	BDP + S	11.6	3.4	31.8	8.9	3.1	25.9
	BDP + RP+ S	12.4	3.5	36.5	11.0	3.2	33.1
Mean		**10.5**	**3.4**	**30.4**	**8.7**	**3.1**	**25.7**
0.5	SP (Control)	8.7	3.2	24.0	6.9	3.0	19.5
	BDP + RP	10.4	3.5	29.6	8.9	3.2	26.4
	BDP + S	12.1	3.4	32.5	9.4	3.2	26.3
	BDP + RP+ S	12.7	3.6	36.7	11.4	3.3	34.3
Mean		**11.0**	**3.4**	**30.6**	**9.2**	**3.2**	**26.6**
1.0	SP (Control)	10.1	3.4	26.3	7.6	3.0	20.7
	BDP + RP	10.6	3.5	32.9	9.1	3.2	27.4
	BDP + S	12.3	3.5	32.6	9.7	3.3	27.7
	BDP + RP+ S	12.8	3.9	37.2	12.0	3.4	34.9
Mean		**11.5**	**3.6**	**32.3**	**9.6**	**3.2**	**27.7**
SP (Control)		9.0	3.3	24.0	7.0	3.0	19.6
BDP + RP		10.3	3.5	31.4	8.8	3.2	26.3
BDP + S		12.0	3.5	32.3	9.3	3.2	26.6
BDP + RP+ S		12.6	3.7	36.7	11.5	3.3	34.1
Mean		**11.0**	**3.5**	**31.1**	**9.2**	**3.2**	**26.7**
L.S.D at 5 % for:		L=N.S F= 0.63 LF= N.S	L=0.09 F= 0.08 LF=N.S	L= N.S F=1.55 LF= N.S	L= 0.33 F= 0.35 LF= N.S	L=0.04 F= 0.07 LF=N.S	L=0.53 F= 1.36 LF=N.S

SP = super phosphate, RP = rock phosphate, PDB = phosphate dissolving bacteria, S = sulphur and L= lithovit

Phosphate solubilizing bacteria has the ability to increase available Phosphorus for plants through creation of organic acids **(Mehana and Farag, 2000)**, The microorganisms involved in P solubilization can enhance plant growth by increasing the efficiency of biological nitrogen fixation, enhancing the availability of other trace elements and by production of plant growth promoting substances which revealed by **Gyaneshwar *et al.*, (2002).**

Many investigators reported that phosphate dissolving bacteria enhanced nutrient uptake of faba bean **(El-Habbasha *et al.*, (2007)** and **Demissie *et al.*, 2013)** indicated plant height, root length, phosphorus content, P uptake and nodule number and weight were enhanced due to inoculation with phosphate solubilizing bacteria.

Using of microorganisms as environment friendly biofertilizer helps to reduce the much expensive phosphatic fertilizers. Phosphatic biofertilizer could help to increase the availability of accumulated phosphate by solubilization efficiency of biological nitrogen fixation and the increasing availability of Fe, Zn. through production of plant growth promoting substances **(Kucey *et al.*, 1989).**

On the other hands, **Rakha and El-Said (2013)** reported that N and P were significantly increased by using bio-fertilizers as compared with the control, whereas the mixture of microbein and phosphorein caused an increase in N and P uptake, plants received mixture of phosphorein and microbein gained the best nutritional values resulted in the content of N, protein, P, Fe, Mn and Zn contents.

Application of phosphate dissolving bacteria (PDB) increased the uptake of N and K for building new tissues **Nassar *et al.*, (2000).** The positive effect of P application on N contents in different parts of broad bean plants can be attributed to increase of the nodular number, size, and mass, which in turn increases N_2-fixation by bacteria **(El-Koumey *et al.*, 1993).**

Ahmed and El-Abagy (2007) reported that, phosphate dissolving bacteria enhance improve seed and straw yields and increase nutrient uptake. Phosphate dissolving bacteria and soil microorganisms can play an important role in phosphate uptake efficiency by releasing phosphorus from rock or tri-calcium phosphate. Also, **El-Gizawy and Mehasen (2009)** showed that adding phosphate dissolving bacteria in combination with mineral fertilizer of phosphorus increased protein, N and P percentages in faba bean seeds. Many investigators reported that, phosphate dissolving bacteria increase nutrient uptake **(Ahmed and El-Abagy, 2007 and El-Habbasha *et al.*, 2007).**

Table 6. The impact of phosphate fertilization sources and lithovit levels on nitrogen, phosphorus potassium and protein content of faba bean during two seasons (2016/17 &2017/18).

Lithovit levels (L) (g/L)	Fertilization (F)	First season (2016/17)				Second season (2017/18)			
		N (%)	P (%)	K (%)	CP (%)	N (%)	P (%)	K (%)	CP (%)
Without (Control)	**SP (Control)**	4.65	0.40	14.25	29.29	4.49	0.21	12.87	28.08
	BDP + RP	3.88	0.39	13.41	24.21	5.20	0.19	12.76	32.50
	BDP + S	4.53	0.41	13.46	28.29	4.37	0.18	12.44	27.29
	BDP + RP+ S	4.79	0.41	14.87	29.58	4.44	0.15	12.37	27.75
Mean		**4.46**	**0.40**	**14.07**	**27.84**	**4.63**	**0.18**	**12.61**	**28.91**
0.5	**SP (Control)**	4.69	0.42	14.30	29.04	4.55	0.24	12.92	28.46
	BDP + RP	3.87	0.42	13.46	24.25	5.21	0.22	12.83	32.54
	BDP + S	4.53	0.44	13.83	28.33	4.44	0.21	12.52	27.75
	BDP + RP+ S	4.73	0.43	14.93	29.92	4.51	0.18	12.43	28.17
Mean		**4.46**	**0.43**	**14.13**	**27.89**	**4.68**	**0.21**	**12.67**	**29.23**
1.0	**SP (Control)**	4.63	0.45	14.33	28.92	4.63	0.27	13.00	28.92
	BDP + RP	3.93	0.46	13.50	24.58	5.23	0.26	12.90	32.67
	BDP + S	4.49	0.47	13.88	28.04	4.51	0.22	12.62	28.17
	BDP + RP+ S	4.82	0.46	15.00	30.12	4.57	0.21	12.50	28.58
Mean		**4.47**	**0.46**	**14.18**	**27.92**	**4.73**	**0.24**	**12.76**	**29.58**
SP (Control)		4.65	0.42	14.29	29.08	4.56	0.24	12.93	28.49
BDP + RP		3.90	0.42	13.46	24.35	5.21	0.22	12.83	32.57
BDP + S		4.52	0.44	13.82	28.22	4.44	0.20	12.53	27.74
BDP + RP+ S		4.78	0.43	14.93	29.88	4.51	0.18	12.43	28.17
Mean		4.46	0.43	14.12	27.88	4.68	0.21	12.68	29.24
L.S.D at 5 % for:		L= N.S F= N.S LF= N.S	L= 0.007 F= N.S LF= N.S	L= 0.007 F= 0.60 LF= N.S	L= N.S F= N.S LF= N.S	L= 0.02 F= 0.26 LF= N.S	L= 0.009 F= 0.013 LF= N.S	L= 0.02 F= 0.26 LF= N.S	L= 0.14 F= 1.62 LF= N.S

SP = super phosphate, RP = rock phosphate, PDB = phosphate dissolving bacteria, S = sulphur and L= lithovit

Sulphur application helps in increasing the plant growth hence increased the uptake of the nutrients at higher levels of sulphur application. These results are in agreement with those obtained by **(El-Gizawy and Mehasen, 2009 and Shirish and Virkar, 2013).**

Such effects of sulphur amendment on nutrients uptake may be due to its important role in reducing the soils' pH, oxidation to sulphuric acid by soil microorganisms. Also, under those experimental conditions, it was concluded that applications of organic manure to sandy loam soil increased the efficiency of P mineral from of the used RP fertilizers. It improves the physical and chemical properties of sandy soil through its ability to adsorb nutrients on active groups or colloidal surfaces and increased the efficiency of nutrients uptake by plants which reflected on growth and productivity. These results agree with those of **Sahu and Jana (2000) and Evans *et al.*, (2006).**

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تقييم إنتاجية وجودة الفول البلدى لمصادر مختلفة من التسميد الفوسفاتى ومستويات الليثوفيت

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أقيمت تجربتان حقليتان بمركز التجارب والبحوث الزراعية بكلية الزراعة بمشتهر – جامعة بنها– محافظة القليوبية– مصر خلال موسمى الزراعة 17/2016 و 18/2017 م لدراسة تأثير الرش بثلاث مستويات من مركب الليثوفيت (صفر – 0.5 – 1 جم/لتر) والتسميد بأربع مصادر من التسميد الفوسفاتى (سوبر فوسفات الكالسيوم (كنترول) – صخر فوسفاتى + بكتريا مذيبة للفوسفور – كبريت + بكتريا مذيبة للفوسفور – صخر فوسفاتى + كبريت + بكتريا مذيبة للفوسفور) على المحصول ومكوناتة وجودة البذور للفول البلدى صنف سخا 4 وإستخدم تصميم قطع منشقة حيث وضعت مستويات الرش بالليثوفيت فى القطع الرئيسية ومصادر التسميد الفوسفاتى فى القطع الشقية فى ثلاث مكررات. وكانت أهم النتائج المتحصل عليها كما يلى:

– أدى الرش بمركب الليثوفيت الى زيادة معنوية فى جميع الصفات المدروسة بالمقارنة بمعاملة الكنترول (بدون معاملة) فى كلا الموسمين بإستثناء النيتروجين % فى الموسم الأول.

– أظهر التسميد بمصادر التسميد الفوسفاتى المختلفة اختلافاً معنوياً فى جميع الصفات المدروسة ماعدا النيتروجين % والفوسفور % والبوتاسيوم% فى الموسم الثانى مقارنة بالكنترول (سوبر فوسفات الكالسيوم).

– تأثير التفاعل كان غير معنوى بين الرش الورقى لمركب الليثوفيت ومصادر التسميد الفوسفاتى المختلفة فى جميع الصفات المدروسة ما عدا وزن بذور/ نبات ومحصول البذور/فدان فى الموسم الاول.

لذا توصى الدراسة بالرش بمركب الليثوفيت بتركيز 1 جم / لتر مع التسميد بالصخر فوسفاتى + الكبريت+ البكتريا مذيبة للفوسفور تحت ظروف جنوب الدلتا.