

Implications of Applied P-Sources with Calcium Super Phosphate, Phosphoric Acid and Rock Phosphate, and Phosphate Dissolving Bacteria on Snap Bean Grown Under Greenhouses Conditions

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Abstract

Two field experiment were carried out during the two successive winter seasons of 2017-2018 and 2018-2019 in a private sector farm at Damallo Village, Qalubia Governorate, to investigate the effect of different sources of phosphorus as a soil application i.e., Calcium superphosphate (15.5% P₂O₅) at 50g/m², Rock phosphate (26.3% P₂O₅) at 27g/m², Phosphoric acid (56%P₂O₅) at 14.3mg/m² at recommended dose with/ without bio fertilizer *Bacillus megaterium* var. *phosphaticum* "phosphate dissolving bacteria "PDB" as well as their interaction on vegetative growth, chemical composition and productivity as well as pod quality of snap bean (*Phaseolus vulgaris* L.) cv. moraleda. Results showed that using Phosphoric acid (56%P₂O₅) fertilizer at the recommended dose of mineral fertilizer reflected significantly highest values in all measured vegetative growth aspects, chemical constituents of plant foliage, pod yield and its quality of bean plants compared with rock phosphate at the recommended dose of mineral fertilizer which gave the lowest values in the two seasons of study. In addition, fertilizing snap bean plants with Bio-Phosphorus fertilizer contained phosphate dissolving bacteria (PDB) (*Bacillus megaterium* var *phosphaticum*) at rate of 4 L/greenhouse applied alone at soil subsurface near the plant roots at two time started after two weeks from transplantation with one month interval at 2 l/360m² increased all measured parameters compared with the treatment without addition in the two seasons of study. Moreover, fertilizing the plants with different sources (p) plus (PDB) gave the highest values in most measure under study, fertilizing plants with phosphoric acid plus PDB gave the highest values in all vegetative growth aspects, fruit pod yield and the best quality compared with other treatments during both seasons of study.

Key words : Snap bean-Calcium super phosphate- Rock phosphate- Phosphoric acid- Phosphateen (*Bacillus megaterium* var. *phosphaticum*)- phosphate dissolving bacteria – PDB – bio- fertilizer- Vegetative growth-Yield- Pod quality- Green house.

Introduction

Snap bean (*Phaseolus vulgaris* L.) is one of the most important cash leguminous vegetable crops grown in Egypt for local consumption and exportation. Snap bean characterized by its high content of protein, starch, and dietary fiber and considered as an excellent source of potassium, molybdenum, selenium, thiamine B1, niacin B6, and folic acid (Maiti and Singh., 2007). In Egypt, snap bean production area was 42108 fed produced 175,898 tons with an average yield of about 4.2 tons /fed. Cultivated area under greenhouse are 1196370 m²(2586 greenhouses) and total production of 7914 tons with an average productivity of 6.615 kg/ m². (Bulletin of the Agric. Statistics.2017Ministry of Agric. and land Reclamation, Economic Affairs Sector). Moreover, the quantity of exported pods in 2018 reached 23,761 tons, mostly to England, Belgium, Germany, Italy and the Netherlands (Central Administration of Agricultural Quarantine - General Union of Producers and Exporters of Horticultural Crops).

Phosphorus (P) is one of the major plant nutrients which constitutes about 0.2% of plant dry weight (Schachtman *et al.*, 1998). Phosphorus is considered as an integral part of the cellular activities of living organisms and contributes to several vital functions in the plant, such as early root and seedling growth,

improving winter hardiness, promotion of early heading and uniform maturity, increasing seed formation and quality, and increasing water-use efficiency. Moreover, it is involved in several key plant functions including cell division, photosynthesis, storing and transfer of energy, regulation of some enzymes, transformation of sugars and nutrients within the plant, as well as, the transfer of genetic characteristics from one generation to another (Taiz *et al.*, 2015). Phosphorus deficiency affects not only plant growth and development and crop yield, but also the quality of the fruit and the formation of seeds (Njira and Nabwami., 2015). Availability, absorption and effectiveness of phosphorus to plants depends on many factors like pH, physicochemical properties of the soil, dominant climate and soil organic matter content and P fertilizer sources (Gupta *et al.* 1985 and Ghoname *et al.* 2012).

In Egypt, superphosphates and rock phosphate constitute the main sources of P fertilizers used for agricultural production for a long time but recently other alternatives became available such as phosphoric acid that usually used to produce P fertilizers which is a costly and energy consuming process. However, its direct use has been found effective when it was applied through irrigation water after the emergence of maize and wheat grown under alkaline and calcareous soil conditions. Half

dose of P as phosphoric acid produced as much maize yield was produced by the full dose of P as single super phosphate "SSP"(Niab., 2002). Some Australian scientists also confirmed the superiority of fluid P fertilizers over the granular P-fertilizers and produced 31% more wheat yield (Holloway et al., 2001). Also, superphosphate was the first commercial mineral fertilizer, and it led to the development of the modern plant nutrient industry. This material was once the most commonly used fertilizer, but other phosphorus (P) fertilizers have largely replaced SSP because of its relatively low P content. are manufactured by reacting insoluble mineral phosphate with acid to create a soluble, readily available form of phosphate. Single super phosphate is about 20 percent phosphate.

Chemical fertilizers have several negative impacts on environment and sustainable agriculture. Therefore, bio fertilizers are recommended in these conditions and growth prompting bacteria have been used as a replacement of chemical fertilizers (Wu et al., 2005). The use of phosphate solubilizing bacteria as inoculants simultaneously increases P uptake by the plant and crop yield. Strains from the genera *Pseudomonas*, *Bacillus* and *Rhizobium* are the most powerful phosphate solubilizers (Rodríguez and Fraga., 1999). (Keneni et al., 2010) indicated that faba bean have a potential to form association with phosphate solubilizing bacteria. Potent PSB including *Pseudomonas* sp., *Rhizobium* sp. and *Bacillus* sp. are mainly solubilized phosphate pool by production of organic acid which is easily uptake by the plant. These microorganisms can play an important role in improving yield and its components, phosphate uptake efficiency and plant growth by releasing phosphorus from soil (Awasthi et al., 2011).

Rock phosphate (RP) is one of the indigenous phosphate sources in many countries. The phosphorus content in the rock ranged from 25 to 31 % P₂O₅ with low solubility (Adetunji., 2005).

Application of rock phosphate has been proved to be beneficial to plant growth and productivity (Akande et al., 2008). The methods of enhancing the quality of rock phosphate and its agronomic efficiency included composting RP.

Current study aimed to determine the effect different sources of phosphorus such as a soil application i.e., Calcium superphosphate, Rock phosphate and Phosphoric acid (with or without bio fertilizer *Bacillus megaterium* var. *phosphaticum* "phosphate dissolving bacteria "PDB" as well as their interaction on vegetative growth, chemical composition and productivity as well as pod quality of snap bean .

Materials and Methods.

Two field experiments were carried out during the two winter successive seasons of 2017-2018 and 2018-2019 in private sector farm at Damallo Village, Benha, Qalubia Governorate to investigate the effect of different sources of phosphorus as a soil application i.e., Calcium super phosphate (15.5% P₂O₅) at 50g/m², Rock phosphate (26.3% P₂O₅) at 27g/m² , Phosphoric acid (56%P₂O₅) at 14.3mg/m² at recommended dose with/ without bio fertilizer *Bacillus megaterium* var. *phosphaticum* "phosphate dissolving bacteria "PDB" as well as their interaction on vegetative growth, chemical composition and productivity as well as pod quality of snap bean (*Phaseolus vulgaris* L.) cv. Moraleda grown under greenhouses conditions (18*18*3.5meter). Soil samples were taken at 30 cm from soil surface and soil physical and chemical properties were determined according to Jackson (1973) and Black (1982) and were illustrated at Table (1). Moreover, maximum and minimum air temperature (c⁰) and relative humidity % under plastic house in the first and second season are shown in Table (2).

Table 1. Physical and chemical properties of the experimental soil during the two seasons of study.

Item	Unit	2017-2018 Season	2018-2019 Season
Coarse sand	%	5.66	4.98
Fine sand	%	16.75	15.50
Silt	%	22.87	26.02
Clay	%	54.72	53.5
Textural class		Clay	Clay
Bulk density	kg/m ³	950	950
pH	(1:2.5)	7.02	7.18
E.C (1:2.5)	ds/m	6.52	6.63
Total nitrogen	ppm.	399	350
Total phosphate	ppm	9.9	9.5
Total potassium	ppm	506.68	505
Total Fe	ppm	5.10	5.25
Total Mn	ppm	1.33	1.76
Total Zn	ppm	3.09	2.88
Total Cu	ppm	4.78	4.01
Ca ⁺⁺	(meq/l)	60	60
Mg ⁺⁺)meq/l(	23	22

Na+	)meq/l(	11	11.5
K+	)meq/l(	2.4	2.5
Cl-	)meq/l(	7.7	7.4
HCO ³⁻)meq/l(	2.5	2.4

Table 2. Maximum and minimum air temperature (c⁰) and relative humidity% under plastic house in the first and second season.

Months	First season (2017-2018)				Second season (2017-2018)			
	Temperature C ⁰		Relative humidity		Temperature C ⁰		Relative humidity	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
October	38	21	90	40.3	39	22.3	91	39.9
November	37	22.2	91	44.5	38.7	23	92	41
December	36.9	14.2	90	36.5	37.5	14.5	90	37
January	33.4	14.1	89	24.6	34.5	13.9	89	40.2
February	35.5	14.5	90	25.3	35.7	14.1	89.5	40.1
March	36.3	16.7	90.3	39.1	35.8	18	91.5	41.9

The experimental design was a randomized complete block, factorial, in 3 replicates. Factors of the experiment and their treatments were as follows: (A) P-addition: three treatments of : (1) Super Phosphate (16% P₂O₅), (2) Rock Phosphate (26.3% P₂O₅), (3) Phosphoric acid (56% P₂O₅) (designated as P₁, P₂, P₃ respectively), the full dose of P 7.84 g P/m², (B) Bio fertilization two treatments: (1) no addition of bio fertilizer (B₀) and (2) addition of bio fertilizer (B₁). The bio fertilizer is P-dissolving bacteria (*Bacillus megaterium*).

Bacterial strain of P-dissolving bacteria (*Bacillus megaterium* var *phosphaticum*) was obtained from the Unit of Bio-fertilizers, Faculty of Agriculture, Ain Shams University, Egypt. The bio fertilizer suspension was given through the soil in two doses: the first was with seed sowing and the second was

added to soil 14 days after seeding at 2 l/360 m² per once.

Calcium superphosphate (15.5% P₂O₅) was obtained from Abu Zaabal fertilizer and chemical Co., Egypt, added at 50g/m² (18kg/ greenhouse 360m²) before the planting.

Rock phosphate (26.3% P₂O₅) was obtained from Abu Zaabal fertilizer and chemical Co., Egypt, added at 27g/m² (9.7kg/ greenhouse 360m²) before the planting. Analysis of rock phosphate are shown in Table (3).

Phosphoric acid (56%P₂O₅) was applied at 14.3 mg/m² (5.15 l per greenhouse 360 m²). It was added with drip irrigation at three times started after one month from planting, with one month interval, during the two growing seasons.

Table 3. Chemical analysis of the experimental soil. of rock phosphate

	Unit	
pH		7.51
EC(1:5)	(dS/m)	2.73
Moisture content	%	4.6
Dry matter	%	95.4
Total N	%	0.015
SiO ₂	%	3.83
Al ₂ O ₃	%	0.28
Fe ₂ O ₃	%	0.22
TiO ₂	%	0.02
CaO	%	51.23
MgO	%	0.68
MnO	%	0.06
K ₂ O	%	0.04
Na ₂ O	%	0.61
P ₂ O ₅	%	26.3
SO ₃	%	1.32
Cd	Mg/g	7.32
Na	Mg/g	952.8

Data recorded: -

1- Vegetative growth characteristics

At full blooming stage (60 days from sowing) three plants from each experimental plot were taken and the following data were recorded.

Plant height, number of leaves/plants, number of branches/plants, fresh and dry weight/ plant

2- Photosynthetic pigments: - the chlorophyll a,b and carotenoids from the fifth mature leaf from top was measured at 60 days from seed sowing were determined calorimetrically as described in **A.O.A.C (1990)**.

Chemical constituents of plant foliage: - were determined in the dry weight of plant foliage at 60 days from seed sowing and then used to the following chemical constituents, total nitrogen, phosphorous, potassium, calcium and Magnesium percentages were determined according to **ADAS/MAFF (1987),Watanabe and Olsen (1965) and Chapman and Pratt (1961)**, respectively.

3- Yield measurements: - at harvest, 70 days after seed sowing, green pods from each experiential unit were picked, weighed and the following yield components were estimated.

a- Early bods yield :- the yield which was collected from the first four harvests was expressed as early yield (early yield/ plant and m²).

b- Total pods yield :- included all the green pods which were picked all over the harvesting periods (total yield / plant and m²).

c- Marketable yield%: (marketable yield/ total yield)100

4- Chemical pods quality was determined as follow: -

✓ Total nitrogen:- it was assayed according to **Pregl (1945)**, using the micro- kjeldahl apparatus. A factor of 6.25 was used for conversion of total nitrogen to protein percentage.

✓ Phosphorus and potassium concentration as mentioned before in chemical constituents of leaves.

✓ Fibers:- it was determined as g/100 g dry weight sample according to **(A.O.A.C.,1990)**.

✓ Total carbohydrate:- it was determined in dry weight sample according to **Mgnetskietal. (1959)**.

Statistical analysis: All collected data in both season of study were subjected to analysis of variance as factorial experiments in design was a randomized complete block, Duncan's analysis was used to differentiate means according to **Snedecor and Cochran (1991)**.

Results and Discussions

1. Vegetative growth characteristics.

Data presented in table (4) show the effect of different sources of phosphors as a soil application i.e Calcium super phosphate (15.5% P₂O₅) at 50g/m₂, Rock phosphate (26.3% P₂O₅) at 27g/m₂, Phosphoric acid (56%P₂O₅) at 14.3mg/m² at recommended dose with/ without bio fertilizer *Bacillus megaterium var. phosphaticum* "phosphate

dissolving bacteria "PDB" as well as their interaction on vegetative growth parameters of snap bean plants growing under greenhouses during the two seasons of study.

It is evident from data in Table (4) that, there were significant differences in most studied morphological vegetative growth parameters of snap bean plants among the used different sources of phosphor fertilizing. In addition, using Phosphoric acid (56%P₂O₅) fertilizer at the recommended dose of mineral fertilizer reflected significantly highest values in all measured vegetative growth aspects (plant height, number of leaves, number of branches, total fresh and dry weight/plant as well as leaf area) of bean plants compared with rock phosphate at the recommended dose of mineral fertilizer which gave the lowest values in the two seasons of study. On the contrary , such differences did not reach the level of significance between phosphoric acid and calcium super phosphate in case of number of branches per plant in the two season.

As for the effect of bio fertilizer treatments, the same data in Table (4) indicate that fertilizing snap bean plants with Bio-Phosphorus fertilizer contained phosphate dissolving bacteria (PDB) (*Bacillus megaterium var phosphaticum*) at rate of 4 L/greenhouse applied alone at soil subsurface near the plant roots at two time started after two weeks from transplantation with one month interval at 2 l/360m² increased all measured growth aspects expressed as plant height, number of leaves and branches/plant, fresh and dry weight of plant and leaf area per plant compared with the treatment without addition in the two seasons of study.

With regard to the effect of the interaction between (p) soil addition fertilizers and bio fertilizer(PDB), the same data in Table(4) indicate that fertilizing the plants with different sources (p) plus (PDB) gave the highest values in most measure under study, fertilizing plants with phosphoric acid plus PDB gave the highest values in all growth aspects compared with other treatments during both seasons of study. The enhancing effect of phosphoric acid on vegetative growth may be due to the main role in reducing soil pH , which can improve the availability of mineral elements and make them more soluble and available for absorption by plants and in turn increase the vegetative growth. Obtained results are in agreement with those reported by **El-bassiony (2003), El-zeiny (2007), Gharib et al. (2009) and Massoud et al. (2009)**.

2. Chemical composition of plant foliage

Data recorded in Table (5) show the effect of different sources of phosphor as a soil application i.e Calcium super phosphate (15.5% P₂O₅) at 50g/m₂, Rock phosphate (26.3% P₂O₅) at 27g/m₂, Phosphoric acid (56%P₂O₅) at 14.3mg/m² at recommended dose with/ without bio fertilizer *Bacillus megaterium var. phosphaticum* "phosphate dissolving bacteria "PDB"

as well as their interaction on chemical constituents of plant foliage during the two seasons of growth. Concerning to the effect of fertilization treatments, it's clear from such data that fertilizing snap bean plants with calcium super phosphate, rock phosphate and phosphoric acid of recommended dose show no significant differences in some determined chemical constituent of chlorophyll a+b, nitrogen, magnesium percentage in the both season and chlorophyll a, carotenoids and calcium in the first one. In this regard, fertilizer plants with phosphoric acid improved significantly phosphor, potassium percentage in both season and carotenoids and calcium percentage in second one followed by calcium super phosphate in both seasons of study.

Concerning the effect bio fertilizer treatments the same data in Table (5) indicate that, fertilizing snap bean plants with Bio-Phosphorus fertilizer contained phosphate dissolving bacteria (PDB) (*Bacillus megaterium var phosphaticum*) at rate of 4 L/greenhouse applied alone at soil subsurface near the plant roots at two time started after two weeks from transplanted with one month interval at 2 l/360m² per increased all studied chemical constituents of plants that reached the level of significance during both seasons, without significant in case calcium and magnesium percentage in first season and nitrogen and magnesium percentage in second one **Obtained results are in agreement with those reported by Massoud *et al.* (2009) , Ahmed *et al.* (2013) and Sabry *et al.* (2017)**

As for the effect of the interaction the same data in Table(5) indicate that fertilizing the plants with phosphoric acid plus PDB reflected the highest values in most measure i.e the photosynthetic pigments and phosphor percentage in both season of study as well as no significant in case of nitrogen, potassium, calcium and magnesium percentage in both season, On the other hand, fertilizing snap bean with rock phosphate of recommended dose without bio fertilizer gave the lowest values in all assayed aspects during both seasons of study. The stimulative effect of P on N and P contents may be attributed to the high amount of available phosphorous and/ or the increase in absorbing efficiency of plant roots. . In this connection, the superiority of PDB and phosphoric acid in increasing the determined macro-elements and total carbohydrate may be due to their role in fixing atmospheric nitrogen, reducing soil pH and increasing solubility of phosphors and potassium in root rizosphere and consequently increased nutrient uptake and accumulation by plants and also increased the photosynthetic pigments assimilation and their content in plant foliage Obtained results are in agreement with those reported by **Ahmed *et al.* (2013), Elbassiony (2003) and Sabry *et al.* (2017)**

3. Green pods yield and its components.

Data in Table (6) indicate that there were a differences in all measure Green pods yield and its

components of snap bean plants as a result of using different studied sources of phosphor fertilizer except early yield in both season and pod yield /plant in first one. Fertilizer plants by phosphoric acid gave the highest values in marketable yield and total yield /m² followed by fertilizing with calcium super phosphate. In this connection, using rock phosphate from recommended dose reflected the lowest values in produced green pods yield.

As for the effect of bio fertilizer treatments on total produced pods yield and its components, such data in Table (6) show that, fertilizing snap bean plants with Bio-Phosphorus fertilizer contained phosphate dissolving bacteria (PDB) significantly increased total produced pods yield and its components in both season compared with another treatments without (PDB).

As for the effect of the interaction the same data in Table (6) indicate that fertilizing the plants with phosphoric acid plus PDB reflected the highest values in total produced green pods yield and its components in all measure i.e early yield, marketable yield and total pod yield in both season of study followed by fertilizing plants with calcium super phosphate plus (PDB) in both season. On the other hand, fertilizing snap bean with rock phosphate of recommended dose without bio fertilizer gave the lowest values in all assayed aspects during both seasons of study. In this connection, such increment effect of bio-phosphorus and phosphoric acid may be attributed to their positive effect on vegetative growth parameter (Table 4) and chemical constituents (Table5) which in turn reflected on number of flower formation and consequently increased the produced yield. **Obtained results are in agreement with those reported by Elbassiony (2003), Elkatib *et al.* (2009), Massoud *et al.* (2009), Salem and midan (2012), Ahmed *et al.* (2013) and Meseretturuko *et al.* (2014).**

4. Chemical pods quality.

Physical pods quality

Data in Table (7) show the effect of mineral fertilizer(p) sources as a soil application i.e Calcium super phosphate (15.5% P₂O₅) at 50g/m², Rock phosphate (26.3% P₂O₅) at 27g/m² , Phosphoric acid (56%P₂O₅) at 14.3mg/m² at recommended dose with/ without bio fertilizer *Bacillus megaterium var. phosphaticum* "phosphate dissolving bacteria "PDB" as well as their interaction on physical pods parameters expressed as average pod length, diameter, fresh and dry weight of pod and dry matter during the two seasons of study

Data in Table (7) indicate that there were a differences in all measured physical pods trails of snap bean plants as a result of using different studied sources of phosphor fertilizer. In this regards, such difference did not reach the level of significant in case of pod length, pod diameter in both season, also pod fresh and dry weight in first one season only.

However, using super phosphate at the recommended dose reflected the highest values of pod fresh and dry weight in second season. As for the effect of bio fertilizer treatments on physical pod quality parameters, the same data in Table (7) indicate that, fertilizing snap bean plants with Bio-Phosphorus fertilizer contained phosphate dissolving bacteria (PDB) significantly increased all measured pod parameters with significantly in case of pod fresh and dry weight in first season and pod length, pod diameter and pod fresh weight in second one .

With regard to the effect of the interaction, the same data in Table(7) indicate that average all measured pod traits significantly affected by interaction treatments except pod length in both season and pod diameter in first season. In this respect, fertilizing of snap bean plants with phosphoric acid as soil application from recommended dose plus PDB gave the highest value of all measure physical quality compared with others interaction treatments, followed by using calcium super phosphate plus PDB and phosphoric acid without (PDB). The increment effect of bio-phosphorus and phosphoric acid fertilizer on physical pod quality traits may be attributed to increasing nitrogen, phosphorus, potassium uptake and total carbohydrates assimilation which affect the increasing anabolic assimilation products which consequently reflected on green pod parameters. **Obtained results are in agreement with those reported by El-zeiny (2007), Salem (2012) and Ahmed et al. (2013).**

Chemical pods constituent's quality.

With regards to the effect of fertilization treatments, data in Table(8) showed that there were a differences among the fertilization treatments in all measured chemical pods quality expressed as fertilizer plants with phosphoric acid gave the highest values of all measure quality parameters i.e. carbohydrate, protein, phosphor, potassium and T.s.s.

Data in Table (8) revealed that the effect of bio fertilizer treatments on increased all measured of as carbohydrate, protein, fiber, phosphor, potassium and T.s.s percentages during both seasons of study without significant in case of fiber in both season and potassium in second one. Compared with the other treatment.

As for the effect of the interaction the same date in Table (8) indicate that fertilizing bean plants with phosphoric acid as soil application from recommended dose plus PDB reflected the highest values of carbohydrate, protein, phosphor, potassium and T.s.s percentages during both seasons except potassium percentage in both season followed by fertilizing bean plant with calcium super phosphate plus PDB in two season. while the lowest fiber percentage was recorded as a result of using phosphoric acid plus PDB during the two seasons of growth. Bio phosphorus with chemical phosphorus fertilizer increased pods protein, because nutrients absorption capability and plant absorption balance increased by phosphate-solubilizing microorganisms. Obtained results are in agreement with those reported by **Elbassiony(2003), El-zeiny (2007), Massoud et al. (2009) , Elkatib et al. (2009) and Salem (2012).**

Table 4. Effect of mineral (P) fertilizers sources bio fertilizer treatments as well as their interactions on vegetative growth of plant foliage of snap bean plants during the two seasons 2017- 2018 and 2018 -2019

Treatments	First season						Second season						
	Plant height (cm)	NO. of leaves/plant	No. of branches/plant	Total fresh weight (g/plant)	Total dry weight (g/plant)	Leaf area/plant (cm ²)	Plant height (cm)	NO. of leaves/plant	No. of branches/plant	Total fresh weight (g/plant)	Total dry weight (g/plant)	Leaf area/plant (cm ²)	
Soil application of P-sources													
Super Phosphate	289.2 ab	14.835 b	3.54 a	221.3 b	43.005 b	77.735 ab	276.1 b	15.5 a	2.725 a	205.05 a	33.055 a	68.915 ab	
Rock Phosphate	286.1 b	15.535 b	2.995 b	212 c	43.555 b	74.415 b	276.15 b	14.33b	2.61 b	185.35 b	30.11 b	65.135 b	
Phosphoric acid	295 a	16.12 a	3.76 a	217.85 a	45.445 a	93.1 a	290.35 a	15.83 a	2.945 a	201.5 a	33.055 a	79.915 a	
Inoculation with P-dissolving bacteria (<i>Bacillus megaterium</i>)													
Without bio fertilizer	278.93 b	15.28 b	3.02 b	205.23 b	41.33 b	75.38 b	273.7 b	14.7 b	2.48 b	188.1 b	30.26 b	67.27 b	
With bio fertilizer	301.3 a	15.71 a	3.85 a	228.87 a	46.67 a	88.12 a	288.03 a	15.74 a	3.04 a	206.5 a	33.89 a	75.38 a	
Soil application of P-sources X Inoculation with P-dissolving bacteria (<i>Bacillus megaterium</i>)													
Bio fertilize (P-dissolving bacteria)	bio Super Phosphate	276.3 c	15.67 b	3.31 ab	218.2 ab	42.45 b	76.3 b	274.4 bc	15.67 ab	2.56 b	197.3 ab	32.33 bc	67.13 bc
	Without Rock Phosphate	274.4 c	15.5 bc	2.44 b	193.6 c	39.33 c	68.63 c	266.7 c	13.9 c	2.33 b	179 b	27.89 d	65.57 bc
	fertilizer Phosphoric acid	286.1 bc	14.67 cd	3.3 ab	203.9 bc	42.22 b	81.2 b	280 bc	14.53 bc	2.56 b	188 b	30.55 cd	69.1 bc
	Super Phosphate	302.2 ab	14 d	3.77 ab	224.4 a	43.56 b	79.17 b	277.8 bc	15.33 bc	2.89 ab	212.8 a	33.78 ab	70.7 b
	Rock Phosphate	297.8 ab	15.57 bc	3.55 ab	230.4 a	47.78 a	80.2 b	285.6 ab	14.77 bc	2.89 ab	191.7 ab	32.33 bc	64.7 c
acid	303.9 a	17.57 a	4.22 a	231.8 a	48.67 a	105 a	300.7 a	17.13 a	3.33 a	215 a	35.56 a	90.73 a	

Table 5. Effect of mineral(P) fertilizers sources bio fertilizer treatments as well as their interactions on chemical constituents of plant foliage of snap bean plants during the two seasons 2017- 2018 and 2018 -2019.

Treatments	First season									Second season															
	Chlorophyll (a)	Chlorophyll(b)	Chlorophyll (a+b)	Carotenoids	N%	P%	K%	Ca%	Mg%	Chlorophyll (a)	Chlorophyll(b)	Chlorophyll (a+b)	Carotenoids	N%	P%	K%	Ca%	Mg%							
Soil application of P-sources																									
Super Phosphate	8.08 a	5.53 ab	13.61 a	2.59 a	2.82 a	0.575 a	1.61 ab	0.66 a	0.285 a	8.96 b	6.155 a	15.34 a	2.6 ab	2.76 a	0.545 b	1.61 ab	0.75 ab	0.295 a							
Rock Phosphate	8.98 a	5.38 b	14.36 a	2.44 a	2.85 a	0.53 b	1.57 b	0.83 a	0.355 a	10.84 a	4.77 a	15.61a	2.145 b	2.94 a	0.55 ab	1.595 b	0.72 b	0.345 a							
Phosphoric acid	8.135 a	5.71 a	13.84a	2.895 a	2.935 a	0.59 a	1.695 a	0.76 a	0.345 a	10.34 a	5.36 a	15.47 a	2.915 a	2.965 a	0.61 a	1.7 a	0.805 a	0.34 a							
Inoculation with P-dissolving bacteria (<i>Bacillus megaterium</i>)																									
Without fertilizer	bio 7.18 b	4.86 b	12.04 b	2.38 b	2.87 a	0.55 b	1.55 b	0.75 a	0.33 a	9.49 b	4.51 b	14 b	2.17 b	2.85 a	0.55 b	1.55 b	0.74 b	0.33 a							
With fertilizer	bio 9.61 a	6.22 a	15.84 a	2.9 a	2.86 a	0.58 a	1.71 a	0.75 a	0.33 a	10.61 a	6.35 a	16.95 a	2.94 a	2.93 a	0.59 a	1.72 a	0.78 a	0.33 a							
Soil application of P-sources X Inoculation with P-dissolving bacteria (<i>Bacillus megaterium</i>)																									
Bio fertilize (P-dissolving bacteria)	Without fertilizer	bio Super Phosphate	6.88 c	4.8 c	11.68 d	b	2.28	2.77 a	ab	1.52	0.66 a	0.3 a	8.78	c	6.1 a	bc	14.88	2.32	2.76	0.56	ab	1.52 a	0.67 a	0.3 a	
		Rock Phosphate	8.95 b	4.97 bc	13.92 c	b	2.24	2.98 a	0.53 b	a	1.48	0.84 a	0.37 a	10.54	b	3.38 b	cd	13.92	1.63 b	2.88	a	0.52 b	1.5 a	0.77 a	a
		Phosphoric acid	5.72 d	4.8 c	10.52 d	ab	2.62	2.87 a	0.57	1.65	1.65	0.75 a	0.32 a	9.15	c	4.05 b	13.2 d	13.2 d	2.56	2.91	0.57	ab	1.64 a	0.78 a	a
		Super Phosphate	9.28 b	6.26 a	15.54 b	ab	2.9	2.87 a	0.59	1.71	1.71	0.66 a	0.27 a	9.14	c	6.21 a	15.81 b	15.81 b	2.88 a	2.76	a	0.53 b	1.71 a	0.83 a	a
Bio fertilize (P-dissolving bacteria)	Without fertilizer	Rock Phosphate	9.01 b	5.79 ab	14.8 bc	ab	2.64	2.72 a	0.53 b	a	1.67	0.82 a	0.34 a	11.15 al	6.16 a	17.31 a	17.31 a	2.66	3 a	0.58	ab	1.69 a	0.67 a	a	
		Phosphoric acid	10.55 a	6.62 a	17.17 a	a	3.17	3 a	1.74	1.74	1.74	0.77 a	0.37 a	0.77 a	0.37 a	11.53 a	6.67 a	17.74 a	3.02	3.02	a	0.65 a	1.76 a	0.83 a	a
		Super Phosphate	6.88 c	4.8 c	11.68 d	b	2.28	2.77 a	ab	1.52	0.66 a	0.3 a	8.78	c	6.1 a	bc	14.88	2.32	2.76	0.56	ab	1.52 a	0.67 a	0.3 a	

Table 6. Effect of mineral(P) fertilizers sources bio fertilizer treatments as well as their interactions on green pods yield and its components of plant foliage of snap bean plants during the two seasons 2017- 2018 and 2018 -2019.

Treatments	First season				Second season				
	Early yield (g/m ²)	Marketable yield/m ²	Total Pod yield (g/m ²)	Pod yields (g/plant)	Early yield (g/m ²)	Marketable yield/m ²	Total yield (g/m ²)	Pod yields (g/plant)	
Soil application of P-sources									
Super Phosphate	819 a	5281 a	6515a	1319.15 a	809.35 a	4868.5 a	5962.5 ab	1209.5 ab	
Rock Phosphate	703.15 a	4860 b	6043.5b	1203.35 a	830.5 a	4564.5 b	5760 b	1149.2 b	
Phosphoric acid	810.5 a	5251 a	6602.5 a	1310.85 a	852.35 a	4886.5 a	6295 a	1245 a	
Inoculation with P-dissolving bacteria (<i>Bacillus megaterium</i>)									
Without bio fertilizer	716.2 b	4907.3 b	6080.6 b	1216.4 b	756.43 b	4472.3 b	5581.67b	1116.47 b	
With bio fertilizer	838.9 a	5354 a	6693.3 a	1339.1 a	905.03 a	5074 a	6430 a	1286 a	
Soil application of P-sources X Inoculation with P-dissolving bacteria (<i>Bacillus megaterium</i>)									
fertilizer (P-dissolving)	Without bio fertilizer								
	Super Phosphate	767.3 c	5093 ab	5237 c	1267.5 ab	771 c	4665 c	5680 c	1164 c
	Rock Phosphate	634 d	4608 c	6335b	1134.2 b	706.3 d	4181 d	6245 b	1049.4 d
	Phosphoric acid	747.3 c	5021 b	6670a	1247.5 ab	826.7 b	4571 c	5820 c	1136 c
	With bio fertilizer								
	Super Phosphate	870.7 ab	5469 a	6850 a	1370.8 a	954.7 a	5072 ab	5245 d	1255 b
Rock Phosphate	772.3 bc	5112 ab	6360 b	1272.5 ab	792 bc	4948 b	6275 b	1249 b	
Phosphoric acid	873.7 a	5481 a	6870 a	1374.2 a	933.7 a	5202 a	6770 a	1354 a	

Table 7. Effect of mineral (P) fertilizers sources bio fertilizer treatments as well as their interactions on physical fruit quality of plant foliage of snap bean plants during the two seasons 2017- 2018 and 2018 -2019.

Treatments	First season				Second season				
	Pod length (cm)	Pod diameter (cm)	Pod fresh weight(g)	Pod dry weight (g)	Pod length (cm)	Pod diameter (cm)	Pod fresh weight(g)	Pod dry weight(g)	
Soil application of P-sources									
Super Phosphate	14.69a	0.845 a	8.93 a	0.885 a	13.79 a	0.72a	9.365 a	0.725 a	
Rock Phosphate	14.60a	0.835 a	8.595 a	0.855b	13.94 a	0.71 a	8.7 b	0.715 b	
Phosphoric acid	14.86 a	0.855 a	8.78 a	0.85 b	14.115 a	0.72a	8.695 b	0.73 a	
Inoculation with P-dissolving bacteria (<i>Bacillus megaterium</i>)									
Without bio fertilizer	14.63 a	0.84 a	8.45 b	0.83 b	13.64 b	0.69 b	8.55 b	0.7 a	
With bio fertilizer	14.81 a	0.85 a	9.08 a	0.89 a	14.26 a	0.75 a	9.29 a	0.75 a	
Soil application of P-sources X Inoculation with P-dissolving bacteria (<i>Bacillus megaterium</i>)									
Without bio fertilizer	Super Phosphate	14.72 a	0.84 a	8.8 ab	0.82 c	13.69 a	0.69 bc	8.4 c	0.69 c
	Rock Phosphate	14.55 a	0.85 a	8.23 b	0.85 bc	13.47 a	0.68 c	8.56 bc	0.7 bc
	Phosphoric acid	14.61 a	0.82 a	8.33 b	0.83 c	13.76 a	0.69 bc	8.7 bc	0.7 bc
	Super Phosphate	14.67 a	0.85 a	9.06 a	0.89 ab	13.89 a	0.76 a	9 b	0.74 abc
Bio fertilize (P-dissolving bacteria)	Rock Phosphate	14.66 a	0.82 b	8.96 a	0.85 bc	14.41 a	0.74 ab	8.83 bc	0.75 ab
	Phosphoric acid	15.11 a	0.89 a	9.23 a	0.94 a	14.47 a	0.76 a	10.03 a	0.76 a

Table 8. Effect of mineral(P) fertilizers sources bio fertilizer treatments as well as their interactions on physical fruit quality of plant foliage of snap bean plants during the two seasons 2017- 2018 and 2018 -2019.

Treatments		First season					Second season						
		Carbohy drates	Protein	Fiber	P	K	T.s.s	Carbohy drates	Protein	Fiber	P	K	T.s.s
Soil application of P-sources													
Super Phosphate		22.56 a	19.1 a	9.52 a	0.615ab	1.92 a	6.5 ab	22.675 a	18.86a	9.28 a	0.62 a	1.62 a	6.615 a
Rock Phosphate		21.62b	17.55 b	9.68 a	0.575 b	1.655 b	6.05 b	21.725 c	18.13 b	9.28 a	0.645 a	1.75 a	6.37 b
Phosphoric acid		22.24 a	19.38a	9.095 b	0.64 a	1.965 a	6.89 a	22.34 b	18.98 a	9.025 b	0.605 a	2.03 a	6.665 a
Inoculation with P-dissolving bacteria (<i>Bacillus megaterium</i>)													
Without bio fertilizer		21.12 b	18.16 b	9.45 a	0.59 b	1.8 a	6.27 b	21.24 b	17.79 b	9.25a	0.62 a	1.83 a	6.37 b
With bio fertilizer		23.16 a	19.2 a	9.41 a	0.63 a	1.89 a	6.69 a	23.26 a	19.53 a	9.14b	0.62 a	1.77 a	6.73 a
Soil application of P-sources X Inoculation with P-dissolving bacteria (<i>Bacillus megaterium</i>)													
Bio fertilize (P- dissolving bacteria)	bio Super Phosphate	21.08 b	18.43 ab	9.53 ab	0.59 a	1.87 abc	6.3 c	21.19 b	17.93 bc	9.44 a	0.66 a	1.64 a	6.35 b
	Rock Phosphate	21.18 b	17.47 b	9.7 a	0.56 a	1.64 c	5.8 d	21.27 b	17.7 c	9.19 ab	0.6 a	1.83 a	6.32 b
	Phosphoric acid	21.11 b	18.57 ab	9.13 b	0.61 a	1.89 abc	6.7 b	21.25 b	17.73 bc	9.11 ab	0.61 a	2.03 a	6.44 b
	Super Phosphate	24.05 a	19.77 ab	9.51 ab	0.64 a	1.97 ab	6.7 b	24.16 a	19.8 ab	9.12 ab	0.58 a	1.6 a	6.88 a
	Rock Phosphate	22.07 ab	17.63 b	9.66 a	0.59 a	1.67 bc	6.3 c	22.18 ab	18.57 abc	9.37 a	0.69 a	1.67 a	6.42 b
	Phosphoric acid	23.37 ab	20.2 a	9.06 b	0.67 a	2.04 a	7.08 a	23.43 ab	20.23 a	8.94 b	0.6 a	2.03 a	6.89 a

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تأثير استخدام مصادر مختلفة من التسميد الفوسفوري مع التسميد الحيوي الفوسفوري علي نمو وانتاجيه وجوده الفاصوليا الخضراء النامية تحت الصوب

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1-قسم البساتين- كلية الزراعة - جامعة بنها.

2-قسم الزراعات المحمية - معهد البساتين - مركز البحوث الزراعية.

3- قسم تكنولوجيا الحاصلات البستانيه - المركز القومي للبحوث

اجريت تجربة حقلية خلال الموسم النيلي لعامي 2017-2018 و 2018-2019 في مزرعة خاصه بقرية دملو - محافظه القليوبية. لدراسة تأثير مصادر مختلفة من الفوسفور كإضافة ارضيه (سوبر فوسفات الكالسيوم (P₂O₅ % 15.5) 50 جم / م² ، صخر فوسفات (P₂O₅ % 26.3) 27 جم / م² ، و حامض الفوسفوريك (P₂O₅ % 56) 14.3 ملجم / م² بالجرعة الموصي بها مع / بدون السماد الحيوي فوسفاتين . "تحتوي علي بكتيريا مذيبة للفوسفور" وكذلك التفاعل بينهما علي النمو الخضري والتركيب الكيميائي والإنتاجية وكذلك جودة القرنة من الفاصوليا الخضراء النامية تحت الصوب صنف موراليدا. أظهرت النتائج أن استخدام حمض الفوسفوريك (P₂O₅ % 56) بالجرعة الموصي بها من الأسمدة المعدنية الفوسفاتية اعطت أعلى القيم بشكل ملحوظ في جميع جوانب النمو الخضري المقاسة ، والمكونات الكيميائية للنمو الخضري ، ومحصول القرون وجودة النباتات مقارنة مع الفوسفات الصخري بالجرعة الموصي بها من الأسمدة المعدنية الفوسفاتية والتي أعطت أقل القيم . بالإضافة إلى ذلك ، فإن إخصاب نباتات الفاصوليا الخضراء بأسمدة الفوسفور الحيوي والذي يحتوي علي بكتيريا مذيبة للفوسفور بمعدل 4 لترات / الصوبة² 360م² وتم اضافتها بمفردها بالقرب من جذور النباتات علي جرعتين بدأت بعد أسبوعين من الزراعة مع فاصل شهر واحد وقد ادت الي زياده جميع المعاملات المقاسة مقارنة مع الغير معاملة في موسمي الدراسة. علاوة على ذلك ، فإن إخصاب النباتات بالمصادر المختلفة من الأسمدة الفوسفاتية مع التسميد الحيوي اعطى أعلى القيم في معظم المقاييس قيد الدراسة و أعطت إخصاب النباتات مع حامض الفوسفوريك بالإضافة إلي السماد الحيوي أعلى القيم في جميع جوانب النمو الخضري ، وإنتاجية القرون الخضراء وأفضل جودة مقارنة مع المعاملات الأخرى خلال موسمي الدراسة.

الكلمات الدالة:

الفاصوليا الخضراء- سوبر فوسفات الكالسيوم - صخر الفوسفات - حمض الفوسفوريك- فوسفاتين- البكتيريا المذيبة للفوسفور - التسميد الحيوي

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