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Enhances Soil Health and Improving mineral phosphorous Fertilizer use Efficiency for Faba Bean Plants (*Vicia faba* L.) using Organic and Bio-Fertilizers

Ghada F. H. El-Sheref [1*] ; A. M. Mansour[1] and R. A. Ibrahim[2]

[1]Soil, Water and Environment Res., Inst. ARC, Giza, Egypt
[2] Field Crops Res., Food Legumes Crop Research Department, Inst. ARC, Giza, Egypt

ABSTRACT

Using management practices that improve soil health and increase productivity and profitability an important think. Two field experiments were conducted in the Experimental Farm of Sids Agricultural Research Station, (ARC) Beni-Suif Governorate, Egypt during 2020/2021 and 2021/2022 seasons to study how to enhances soil health and increase use efficiency of mineral phosphorous fertilizer (0, 50 and 100% recommended rate of phosphorous fertilizer, RRP) by using organic fertilizer (5 t ha-1 compost) and/or bio-fertilizer (phosphorine inoculation) and its effects on growth parameters, yield components, yield and its components, nutrients status and phosphorous use efficiency for mineral phosphorous fertilizer. The results indicate that increasing phosphorous levels up to 100 % RRP increased all studied growth parameters, and improved yield and its components as well as nutritional values. Also, application of organic manure and bio-fertilizer solely or in combination enhanced all studied characters of faba bean. Using organic manure mixed with phosphorine inoculation beside 50% RRP of mineral phosphorous fertilizer resulted in increased yield quantity and quality statistically equal to these produced under 100 % RRP, which means that it can be save about 50% of mineral phosphorous fertilizer to reduce the production cost, minimize the environmental pollution and Improve soil health. Also, it can be concluded that using organic fertilizer and bio- fertilizer improved phosphorous use efficiency when applied with 50 % reduction in RRP, which resulted in faba bean production equal to 100% RRP and enhanced soil health through increasing OC content, beneficial microbial population and nutrients availability.

Keywords: Faba Bean, mineral P fertilizer, organic manure, bio-fertilizer and P use efficiency.

INTRODUCTION

Faba bean (*Vicia faba* L.) is one of the most principle winter foods in Egypt as a cheaper source of protein as well as considers a food with high calorific and nutritive value, particularly in the diet of low income people. It is a major crop in several countries such as China, Ethiopia, and Egypt, and is grown for human and animal feed in the Mediterranean region and Latin America. In developing countries, faba bean is used as human food and animal nutrition, especially for horses, poultry and pigs as well as pigeons in industrialized countries. It is used as a vegetative, green or dried, beside fresh or canned. It is an excellent crop for cropping system due to its lowest production costs and its unique ability to fix atmospheric N_2 symbiotically from soil or atmosphere (Singh et al, 2013). Followed to nitrogen, phosphorus is the most important macro nutrient for plant growth, especially legume plants. It is an integral part of several biochemical processes such as nucleic acids, phospholipids, phosphor-protein and nucleotides. The energy currency in plants is mostly refer to phosphate compounds. Phosphorus abundant in soil in inorganic and organic forms. Many soils all over the world are suffering from P- deficiency due to low free P- availability (Raheem et al., 2022). Etemadi et al. (2019) stated that legume plants needed to large amounts of phosphorus not only as a promoting growth, but also to its specific role in nitrogen fixation, nodule number/ plant and growth and development of plants.

Beside the high cost of mineral fertilizers, it has negative environmental effect (Chandimi et al., 2019). Fuda et al. (2021) indicated that organic manure improve soil properties, enhance root growth and soil microbial activity. Mohamed et al. (2023) illustrated that compost application enhance and regulate plant growth and improve stress tolerance and resilience. Bio-fertilizers are most promising fertilizers for plant nutrition and soil fertility, as alternative for chemical fertilizer which its using affecting human health and environmental pollution (El-Naqma et al., 2024). Seed inoculation with phosphate solubilizing bacteria (PSB) as a biofertilizer is alternative source instead of mineral phosphorus fertilizer (Shakori and Sharifi, 2016). Keneni et al. (2010) stated that faba bean plants have a potential to form association with phosphate solubilizing bacteria. The bio-fertilizer can positively affected growth parameters, yield and its components, P uptake by faba bean plants, P uptake by releasing P from unsoluble tri-calcium phosphate (Nik farjam and Amin panuh, 2015). Mekki (2016) and Fuda et al (2021) indicated that PSB improved growth, seed and straw yields and nutrient uptake of faba bean plants).

Soil health is the continuing ability of soil to function as a vital living ecosystem that supports plants, animals and humans. Healthy soil gives us clean air and water, abundant crops and forests, diverse wildlife, productive pastures, and beautiful landscapes.

Therefore, the purpose of this research was to investigate criteria of enhance soil health and efficiency of applying mineral phosphorus fertilizer, bio-phosphorus fertilizer and compost as organic fertilizer alone or in combination on improving soil health and faba bean plants growth, yield and yield components as well as nutrients status.

[*] **Corresponding author.**
E-mail address: d.ghadaelsheref116@gmail.com
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MATERIALS AND METHODS

Experimental location and design

Two field experiments were performed in clay alluvial soil at Sids Agricultural research farm, ARC, Beni-Suef government, Egypt during two successive winter growing seasons of 2020/2021 and 2021/2022 to investigate criteria of enhance soil health and the possibility of improving phosphorus fertilizer use efficiency by using some organic and bio-fertilizers and its effects on quality and quantity of faba bean plants. The experimental site is located at latitude of 29 04˚ N, Longitude of 31 05˚ E and Elevation of 30-40m above sea level. The physical and chemical characteristics of the experimental soil (0- 30 cm depth, according to A.O.A.C, 2000) are listed in Table 1.

Table 1. Physical and chemical characteristics of the experimental site soil in both growing seasons.

Properties	2020/2021	2021/2022
Soil texture	Clay	Clay
pH, (in 1:2.5 soil- water suspension)	8.0	8.1
EC, dSm^{-1}	1.3	1.5
Organic matter, %	1.4	1.1
Soil mineral N, mg kg^{-1}	25.1	22.7
Soil available P, mg kg^{-1}	12.3	11.7
Soil available K, mg kg^{-1}	121	110

The experiment was planted with faba bean cultivar (Giza 843) on 3rd and 7th November in both growing seasons and arranged at a split plot design in complete randomized blocks in using four replicates. Each plot consisted of five ridges 3.5 m length and 0.6 m apart and 20 cm distance between plants (plot area was 10.5 m^2 = about 1/650 ha). The preceding crop was Zea maize and other cultural practices were done as recommended for faba bean cultivation.

Study treatments:

I. Main plots: mineral phosphorus fertilizer (A), using three levels were studded:

1- Zero (without MPF application)
2- 21 kg P ha^{-1} (50% recommended rat of P, RRP)
3- 42 kg P ha^{-1} (100% recommended rate of P, RRP)

II. Sup main plots: organic and bio-fertilizer (B), four treatments.

1-Zero (without organic or bio-fertilizer)
2-12 Mg ha^{-1} compost
3-Seed inoculation with phosphorine (Bacillus Megatherium phosphaticum bacteria as phosphate solubilizing bacteria)
4-12 Mgha^{-1} compost + Seed inoculation with phosphorine.

Mineral phosphorus fertilizer was added as triple superphosphate 15.5 % P_2O_5) and well fermented compost were incorporated in the soil surface before sowing during land preparation.

The chemical characteristics of the used compost (according to A.O.A.C, 2000) are shown in Table (2). The faba bean seeds were mixed with phosphorine inoculation (SWERI P- obtained from Bio-fertilizers Production Unit Microbiology Dept., Soils, Water and Environment Res Int., ARC) using Arabic gum as sticker just before planting. All plots fertilized with 100kg N ha^{-1} as ammonium nitrate (33.5% N) in two equal doses, before the first and second irrigations, while 144 kg K_2O as potassium sulphate fertilizer (48% K_2O) was fertilized before the first irrigation.

Table 2. Average of some chemical characteristics of the compost used in both growing seasons.

Properties	Seasons	
	2020/21	2021/22
N, g kg^{-1}	21.1	23.1
P, g kg^{-1}	7.5	7.9
K, g kg^{-1}	16.9	17.2
C:N ratio	15:1	14.1
Organic matter (OM), g kg^{-1}	550	561
pH, in 1:10 compost- water suspension	6.62	6.50
EC, dSm^{-1} , in 1:10 compost- water extraction	3.91	3.82
Bulk density, kg m^{-3}	670	665

Plant growth characters

Five plants were randomly taken at 90 days after sowing to estimate some growth parameters, i.e. plant height (cm), number of branches/ plant and number of leaves/plant. Also at harvesting time, five plants were randomly collected from the central ridge to determine some yield and yield components parameters (number of pods /plant, number of seeds /pod, 100-seed weight (g) and seed yield/plant (g). Two central rows were handily harvested to determine yields [seed, straw and biological yield, kg/ha]. In addition, seed and straw samples were taken to determine NPK concentration and uptake. Phosphorus use efficiency was calculated according to **Caswell and Godwin. (1984)** as follow:

$$\text{PFUE} = \frac{(\text{Yield of fertilized plants} - \text{yield of unfertilized plants})}{\text{rate of applied fertilizer}}$$

Statistical analysis

The obtained data were statistically analyzed according to method described by Snedecor and Cochrom (1980). Least significant difference (L. S. D.) at 5% level was used to compare between means.

RESULTS AND DISCUSSION

Vegetative growth

The results in Table 3 show that, irrespective of organic and bio fertilizers, increasing mineral phosphorus fertilizer levels had a positive effect on faba bean growth parameters expressed as plant height, number of branches /plant and number of leaves /plant. Comparing with unfertilized plants mineral phosphorus application, added application of 50 or 100 % RPR increased plant height, number of branches /plant and number of leaves /plant by about 9.55 and 15.26, 5.20 and 14.64 , and 17.86 and 26.91% respectively in the first growing season. The same trends of data were obtained in the second growing season. The promoted effect of phosphorus on faba bean growth may be due to the availability of P is limited under alkaline soil condition, so application of phosphorus is directly improve plant growth which P is needed for plants in relatively large amount. Jasim and Al-Amiri (2020) added that phosphorus has specific role in nitrogen fixation, nodule formation, number of nodule, growth and development of legume plant.

With regard to the main effect of organic and bio-fertilizer, the results clearly show that, faba bean growth parameters were positively responded to organic and/or bio-fertilizers. It is obvious to notice that organic manure application surpassed biofertilizer in its activity and their effect on growth parameters. The highest value of growth parameters (117.44 cm, 5.89 and 131.05 in the first growing season and 118.79 cm, 6.09 and 138.59 in the second growing season, respectively) were achieved under mixed organic manure with biofertilizer. Meanwhile, the lowest values were obtained for plants without both organic and bio-fertilizer.

The positive effect of organic manure could be explained by the fact that organic manure consider as a source of multiple nutrients as well as it improving physical and chemical soil properties (Ge et al., 2018). These results are in line with those obtained by Afifi et al. (2017) for organic manure, Maghraoui et al. (2016) for phosphorus bio-fertilizer, and Mekki (2016) for combined organic with bio fertilizers. The results of the interaction reveal that the studied vegetative growth parameters of faba bean plants were significantly affected by the interaction between chemical P and organic and/or bio-fertilizers. In the presence of organic and/or bio-fertilizers, added 50% RRP exhibited values of growth parameters statistically equal to those under 100% RPR, which means the possibility to reduce mineral phosphorus fertilizer to 50% from its recommended rate, which may be due the promoted effect of both organic and bio-fertilizer on improving the efficiency of P fertilizers. These results ore in harmony with those obtained by Foda et al. (2021).

Table 3. Effect of mineral and bio-phosphorus fertilizers and compost on faba bean growth parameters

Treatments		Plant height (cm)		No. of branches/plant		No. of leaves /plant	
Mineral P(A)	**Organic and bio- fertilizer (B)**	**2020/21**	**2021/22**	**2020/21**	**2021/22**	**2020/21**	**2021/22**
Zero	Zero	98.20	102.76	4.63	4.96	91.32	97.16
	Compost	106.33	111.32	5.26	5.77	110.53	116.51
	Biofertilizer	102.51	107.55	5.20	5.51	109.70	113.24
	Compost+ biofertilizer	110.73	112.17	5.61	5.88	1119.54	123.55
	mean	104.44	108.46	5.19	5.53	107.78	112.62
50% RRP	Zero	109.34	111.37	5.12	5.37	119.24	121.23
	Compost	115.15	119.62	5.41	5.76	126.65	129.02
	Biofertilizer	112.82	115.01	5.32	5.54	125.03	127.31
	Compost+ biofertilizer	120.34	122.14	5.95	6.22	137.20	146.16
	mean	114.41	117.04	5.46	5.72	127.03	130.93
100 % RRP	Zero	119.61	121.13	5.95	6.08	136.19	145.98
	Compost	120.51	122.33	5.94	6.13	136.32	146.09
	Biofertilizer	120.01	121.62	5.83	6.11	136.22	146.00
	Compost+ biofertilizer	121.36	122.07	6.96	6.17	136.40	146.05
	mean	120.38	121.79	5.95	6.12	136.78	146.02
mean of activator	Zero	109.06	111.75	5.23	5.47	115.58	121.46
	Compost	114.10	117.76	5.54	5.89	124.50	130.52
	Biofertilizer	111.78	114.75	5.45	5.72	123.65	128.85
	Compost+ biofertilizer	117.44	118.79	5.89	6.09	131.05	138.59
	L.S.D at 0.5%						
	A	3.90	3.62	0.25	0.26	6.32	6.63
	B	2.75	2.42	0.13	0.15	4.05	4.37
	A× B	4.31	4.15	0.30	0.33	7.11	7.52

Yield and Yield components

Concerning the main effect of mineral phosphorus fertilizer, the results presented in Table 4 reveal that, yield components of faba bean plant namely, number of pods/plant, number of seeds/pod and 100 hundred seed weight were significantly affected by mineral P treatments. Application of 100 % RRP resulted in highest values of yield components (17.7, 3.13 and 61.24 g in the first growing season and 18.32, 3.17 and 63.32 g in the second growing season one, respectively). Whereas, the lowest values were obtained for plants treated without P application. The number of pods/ plant, number of seeds/ pod and 100-seed weight are the significant constituents that directly affect faba been yield (Devi, et al., 2012). These results are in accordance to results obtained by Raheem et al. (2024).

Table 4. Effect of mineral and bio- phosphorus fertilizers and compost on faba bean yield components.

Treatments		No of pods/plant		No of seed /pod		100- seed weight (g)	
Mineral P (A)	**Organic and bio- fertilizer (B)**	**2020/21**	**2021/22**	**2020/21**	**2021/22**	**2020/21**	**2021/22**
Zero	Zero	13.30	14.65	2.25	2..31	44.51	45.36
	Compost	15.95	17.04	2.63	2.67	48.325	49.17
	Biofertilizer	15.83	16.71	2.61	2.61	46.37	46.98
	Compost+ biofertilizer	16.62	17.47	2.94	2.94	55.26	57.25
	mean	15.43	16.47	2.60	2.63	48.60	49.69
50%RRP	Zero	15.33	15.725	2.53	2.55	49.17	51.32
	Compost	16.16	17.06	2.71	2.76	56.56	57.17
	Biofertilizer	15.96	16.83	2.63	2.68	55.03	55.78
	Compost+ biofertilizer	17.71	18.34	3.11	3.18	61.25	63.32
	mean	16.29	17.00	2.75	2.79	55.50	56.90
100% RRP	Zero	17.70	18.29	3.12	3.16	61.22	63.30
	Compost	17.70	18.34	3.11	3.17	61.24	63.32
	Biofertilizer	17.69	18.32	3.13	3.17	61.23	63.32
	Compost+ biofertilizer	17.71	18.34	3.14	3.18	61.25	63.33
	mean	17.70	18.32	3.13	3.17	61.24	63.32
Mean of activator	Zero	15.44	16.55	2.63	2.63	51.63	53.33
	Compost	16.60	17.48	2.83	2.87	55.35	56.55
	Biofertilizer	16.49	17.29	2.79	2.82	54.21	55.36
	Compost+ biofertilizer	17.35	18.05	3.05	3.10	59.25	61.30
	L.S.D at 0.5%						
	A	0.53	0.56	0.06	0.07	2.63	2.91
	B	0.31	0.37	0.05	0.06	2.16	2.56
	A× B	0.75	0.80	0.08	0.10	3.75	4.11

As for the organic and/or bio-fertilizer, the results showed that the studied yield component parameters were positively responded to the tested treatments. The effect of bio-organic treatments on yield components could be

arranged as the following descending order: organic manure + BF biofertilizer > organic fertilizer > biofertilizer > without bio or organic application. It is worthy to notice that the difference between organic fertilizer alone and biofertilizer alone did not reach the significant values differences between treatments. These effects of organic and/or bio-fertilizer may be due to its effects on vegetative growth of faba bean plants as discussed in Table (3). These results are in agreement with results those obtained by Afifi et al. (2017) for organic manure, Salim and Abou El-Yazied (2015) for bio-fertilizer, and Fufa and Amdemariom (2021) for combined effect of organic and bio-fertilizers.

The results of the interaction reveal that yield components of faba bean were affected by the interaction between mineral phosphorus fertilizer and organic-bio fertilizers, where in presence of compost plus phosphorine, added application of 50% RRP of mineral phosphorus fertilizer resulted in values of yield components, has no significant difference to those under 100% RRP in both growing seasons. In general, the highest values of yield and yield components recorded from the treatments of 100% RRP with or without organic-bio-fertilization, or 50% RRP + organic fertilizer + phosphorine inoculation. On the other hand, the lowest values were obtained under the control treatments (without mineral P, organic and bio-fertilization). The stimulating effect of bio-fertilizers such as phosphorine inoculant which mainly contain microrgamsms such as pseudomomus can belong to plant growth-promoting rhizobacteria and known for its ability to solubilize insoluble phosphate material which enhances plant growth and yield through cycling and availabity of nutrients and improved root activities, in turn increased water and nutrients absorption, especially phosphorus (Shams El-Deen et al., 2020). Farid et al. (2023) and El Shaboury et al. (2024) found that applying organic or phosphorus bio-fertilizer as sole or in combination with chemical P fertilizer enhanced the yield components of faba been plants.

Yield and yield components:

Results in Table 5 represent effect of mineral phosphorous levels and organic manure and/or bio fertilizer and their interaction on yield measurements and yield components of faba bean plants namely, seed; straw and biological yields (t ha^{-1}). As for the main effect of chemical phosphorus, the results reveal that all studied yield parameters were gradually increased as phosphorus level increased up to 100% RRP. The relative increasing in seed yield due to application of 100 % RRP reached to 28.25 and 66.65% when compared to added 50% RRP and without phosphorus application in first season, respectively Similar trends were obtained for straw and biological yields as well as in the second season. The increment in faba bean seeds yield due to increasing phosphorus levels might be attributed to its positive effect of number of pods/plant, number of seeds/pod and the weight of hundred seed as the aforementioned discussed in Table 4. In this concern, Raheem et al. (2024) reported that phosphorus plays an important role in flower initiation, fruit set as well as sugar and starch utilization, cell division and elongation and biomass accumulation, consequently increased seed and straw yields.

Table 5. Effect of mineral and bio-phosphorus fertilizers and compost on yield of faba bean.

Treatments		Biological yield (t ha-1)		Straw yield (t ha-1)		Biological yield (t ha-1)	
Mineral P (A)	**Organic and bio- fertilizer (B)**	**2020/21**	**2021/22**	**2020/21**	**2021/22**	**2020/21**	**2021/22**
Zero	Zero	1.96	1.96	2.66	2..69	4.57	4.65
	Compost	3.15	3.15	3.79	3.82	6.82	6.97
	Biofertilizer	2.83	2.83	3.70	3.78	6.39	6.61
	Compost+ biofertilizer	3.67	3.67	3.95	4.06	7.43	7.73
	mean	2.78	2.90	3.53	3.59	6.31	6.49
50%RRP	Zero	2.64	2.75	3.82	3.89	6.46	6.64
	Compost	3.72	3.79	4.17	4.30	7.89	6.09
	Biofertilizer	3.42	3.54	4.05	4.20	7.47	7.74
	Compost+ biofertilizer	4.65	4.81	4.56	4.71	9.21	9.52
	mean	3.61	3.72	4.15	4.28	7.76	8.00
100% RRP	Zero	4.60	4.76	4.50	4.63	9.10	9.39
	Compost	4.58	4.80	4.55	4.69	9.13	9.49
	Biofertilizer	4.65	4.79	4.52	4.67	9.17	9.46
	Compost+ biofertilizer	4.68	4.82	4.57	4.72	9.25	9.54
	mean	4.63	4.79	4.54	4.68	9.17	9.47
Mean of activator	Zero	2.05	2.82	3.66	3.74	5.71	6.56
	Compost	3.78	3.91	4.17	4.27	7.95	8.18
	Biofertilizer	3.59	3.72	4.09	4.22	7.68	7.94
	Compost+ biofertilizer	4.27	4.43	4.36	4.50	8.63	8.93
L.S.D at 0.5%							
A		0.45	0.98	0.20	0.25	0.72	0.76
B		0.37	0.42	0.15	0.16	0.61	0.64
A× B		0.68	0.72	0.43	0.51	1.15	1.20

As for main the effects of bio-organic fertilizer, the results show that faba bean yield were significantly affected by application of organic manure or biofertilizer application as in sole or in combination. The highest seed, straw and biological yields were obtained under application of organic manure in combination with biofertilizer (4.27, 4.36 and 8.63 t ha-1 in the first growing season and 4.43, 4.50 and 8.93 t ha-1 in the second one, respectively) followed by application of organic manure alone, and biofertilizer alone. While the lowest values were achieved under control (2.05, 3.66 and 5.71 t ha^{-1} in the first growing season and 2.82, 3.74 and 6.56 t ha^{-1} in the second one respectively). This synergistic effect of organic manure and/or bio-fertilizer on yield measuments of faba been plants could be explained by its effect on

vegetative growth and yield components as mentioned before in Tables 3 and 4. Fufa and Amdemarin (2021) mentioned that Faba bean yields increased as a result of physiological and morphological processes occurring though crop growth and development increased by organic manure application. Shams El-Deen et al. (2020) illustrated that phosphate - solubilizing bacteria is markedly enhanced plant growth, which is mostly present near the roots and improved nutrient uptake as well as increased phosphorus avilability. These results are in line with these obtained by Mikael et el. (2021) for organic manure, Fuda et al. (2021) for phosphorus bio-fertilizer, and Mikki (2016) for mixed organic manure with bio-fertilizer.

The results of the interaction show that faba bean yields were significantly responded to the interaction between the two studied parameters. Combination of organic and biofertilizer with 50%. RRP resulted in faba bean yields, statistically equal to those produced under 100%. RRP, which mainly due to the synergistic effect of organic or biofertilizer on enhancing phosphorus availability in soil (Attia et al., 2023). However, the plants without mineral P fertilizer, organic manure or biofertilizer exhibited the lowest faba bean yield and yield components.

NPK Nutrient status

Results given in Tables 6, 7, 8, 9 and 10 show the effect of mineral phosphorus fertilizer in combined with organic and/or bio-fertilizer on NPK concentrations status of faba bean expressed, as N, P and K content and uptake in seeds and/or straw. The result reveal that increasing the level of mineral fertilizer led to significantly increases in N, P and K content and uptake in faba bean seeds and straw. Fertilized faba bean plants with 100% RRP gave highest values of N, P and K content in seeds (3.72, 0.51 and 2,38 %), wears values in the straw (1.55, 0.34 and 1.82 %), as well as N, P and K uptake in seeds (172.02, 23.33 and 110.13), wears values in the straw (70.18, 15.29 and 82.29 kg h-1), and total N, P and K uptake (242.2, 38.64 and 195.53 kg ha-1, respectively in first growing season). The Same trends of data were obtained in the second growing season. El- Gizawy and Mehasen (2009) indicated that the positive effect of mineral phosphorus in nutrient stratus in seeds and straw of faba bean plant is mainly due to adding mineral P supplied the plants with their phosphorus requirements. The reported agreed with those obtained by Mousa and El-Sayed (2016).

Considering the main effect of organic and bio-fertilizer, the results show that organic manure solely or in combination with bio-fertilizer significantly increased NPK nutrients content in both seeds and straw. It is obvious to observe that NPK nutrients concentration and uptake due to organic manure significantly surpassed that due to phosphorine inoculation, except phosphorus content in both seeds and straw, which seem to give the same trend. In general, the highest values of NPK nutrients content and Considering the main effect of organic and bio-fertilizer, the results show that organic manure solely or in combination with bio-fertilizer significantly increased NPK nutrients content in both seeds and straw. It is obvious to observe that NPK nutrients concentration and uptake due to organic manure significantly surpassed that due to phosphorine inoculation, except phosphorus content in both seeds and straw, which seem to give the same trend. In general, the highest values of NPK nutrients content and uptake were recorded under organic and/or bio-fertilizer as compared to control. In this concern, Attia et al. (2023) and Mohamed et al. (2023) indicted that the promoted effect of organic and /or bio-fertilizer may be attributed to the recycling nutrients, improving nutrients availability especially phosphorus and potassium, decomposition of organic manure and improved soil properties and soil health.

Table 6. Effect of mineral and bio- phosphorus fertilizers and compost on N, P and K concentration in seed of faba bean.

Treatments		N (%)		P (%)		K (%)	
Mineral P(A)	**Organic and bio- fertilizer (B)**	**2020/21**	**2021/22**	**2020/21**	**2021/22**	**2020/21**	**2021/22**
Zero	Zero	2.73	2.75	0.27	0.26	2.05	2.07
	Compost	3.11	3.16	0.35	0.32	2.21	2.24
	Biofertilizer	3.00	3.03	0.37	0.35	2.07	2.09
	Compost+ biofertilizer	3.35	3.37	0.42	0.40	2.25	2.29
	mean	3.05	3.08	0.35	0.23	2.14	2.17
50% RRP	Zero	3.20	3.76	0.36	0.34	2.22	2.25
	Compost	3.50	3.55	0.41	0.40	2.39	2.42
	Biofertilizer	3.31	3.37	0.47	0.44	2.25	2.27
	Compost+ biofertilizer	3.82	3.83	0.51	0.49	2.39	2.44
	mean	3.46	3.50	0.44	0.31	2.31	2.35
100% RRP	Zero	3.62	3.64	0.50	0.48	2.37	2.42
	Compost	3.81	3.84	0.51	0.49	2.39	2.43
	Biofertilizer	3.64	3.65	0.51	0.49	2.37	2.42
	Compost+ biofertilizer	3.82	3.85	0.52	0.50	2.39	2.44
	mean	3.72	3.75	0.51	0.49	2.38	2.43
Mean of activator	Zero	3.18	3.22	0.38	0.36	2.21	2.25
	Compost	3.47	3.52	0.42	0.40	2.33	2.36
	Biofertilizer	3.32	3.35	0.54	0.43	2.23	2.26
	Compost+ biofertilizer	3.66	3.65	0.48	0.46	2.35	2.39
	L.S.D at 0.5%						
	A	0.11	0.12	0.05	0.04	0.10	0.12
	B	0.09	0.10	0.03	0.03	0.07	0.07
	A× B	0.23	0.25	0.08	0.07	0.20	0.21

Table 7. Effect of mineral and bio- phosphorus fertilizers and compost on N, P and K concentration in straw of faba bean.

Treatments		N (%)		P (%)		K (%)	
Mineral P(A)	**Organic and biofertilizer (B)**	**2020/21**	**2021/22**	**2020/21**	**2021/22**	**2020/21**	**2021/22**
zero	Zero	1.11	1.23	0.20	0.18	1.63	1.66
	Compost	1.31	1.39	0.22	0.21	1.74	1.78
	Biofertilizer	1.13	1.24	0.25	0.24	1.65	1.67
	Compost+ biofertilizer	1.35	1.41	0.28	0.26	1.77	1.80
	mean	1.23	1.32	0.24	0.22	1.70	1.73
50% RRP	Zero	1.35	1.37	0.26	0.25	1.70	1.72
	Compost	1.51	1.57	0.28	0.26	1.80	1.80
	Biofertilizer	1.37	1.38	0.31	0.30	1.73	1.74
	Compost+ biofertilizer	1.55	1.58	0.34	0.32	1.83	1.85
	mean	1.45	1.48	0.30	0.28	1.77	1.78
100% RR P	Zero	1.54	1.56	0.33	0.33	1.81	1.83
	Compost	1.56	1.58	0.34	0.32	1.82	1.84
	Biofertilizer	1.54	1.56	0.34	0.33	1.82	1.83
	Compost+ biofertilizer	1.56	1.58	0.34	0.33	1.83	1.85
	mean	1.55	1.57	0.34	0.33	1.82	1.84
Mean of activator	Zero	1.33	1.39	0.26	0.25	1.71	1.74
	Compost	1.46	1.51	0.28	0.26	1.79	1.81
	Biofertilizer	1.35	1.39	0.30	0.29	1.73	1.75
	Compost+ biofertilizer	1.49	1.52	0.32	0.30	1.81	1.83
	L. S. D at 0.05						
	A	0.08	0.09	0.02	0.02	0.05	0.05
	B	0.05	0.06	0.01	0.01	0.04	0.03
	A×B	0.14	0.14	0.05	0.04	0.09	0.08

Table8. Effect of mineral and bio- phosphorus fertilizers and compost on N, P and K uptake in seed of faba bean

Treatments		N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})	
Mineral P(A)	**Organic and biofertilizer (B)**	**2020/21**	**2021/22**	**2020/21**	**2021/22**	**2020/21**	**2021/22**
Zero	Zero	52.14	57.90	5.18	5.10	39.10	40.57
	Compost	94.23	99.54	10.61	10.08	66.96	70.56
	Biofertilizer	81.51	85.75	9.95	9.91	55.68	58.15
	Compost+ biofertilizer	116.58	123.68	14.62	14.68	78.30	84.04
	mean	86.11	107.56	10.09	9.94	60.01	63.33
50% RRP	Zero	84.48	88.65	9.50	9.35	58.61	61.88
	Compost	130.20	134.55	15.25	15.16	88.91	91.72
	Biofertilizer	113.20	119.30	16.07	15.58	76.95	80.36
	Compost+ biofertilizer	177.63	184.22	23.72	23.52	111.14	117.36
	mean	126.38	131.68	16.13	15.90	83.90	87.83
100% RR P	Zero	166.52	173.26	23.00	22.26	109.02	115.19
	Compost	174.50	184.32	23.36	23.52	109.46	116.64
	Biofertilizer	168.28	174.84	22.72	23.42	110.21	115.92
	Compost+ biofertilizer	178.78	185.57	24.34	24.10	111.85	117.61
	mean	172.02	179.50	23.35	23.32	110.13	116.34
Mean of activator	Zero	101.05	105.27	12.56	12.24	68.91	72.54
	Compost	132.98	139.48	15.41	16.25	88.44	92.97
	Biofertilizer	121.00	126.63	16.25	16.32	80.95	84.87
	Compost+ biofertilizer	157.66	164.49	20.89	20.78	100.43	105.33
	L. S. D at 0.05						
	A	12.15	15.25	2.33	2.12	10.17	10.29
	B	10.33	12.47	2.30	2.05	9.05	9.58
	A×B	14.92	16.33	2.95	2.71	12.16	12.38

Table 9. Effect of mineral and bio- phosphorus fertilizers and compost on N, P and K uptake in straw of faba bean.

Treatments		N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})	
Mineral P(A)	**Organic and biofertilizer (B)**	**2020/21**	**2021/22**	**2020/21**	**2021/22**	**2020/21**	**2021/22**
Zero	Zero	29.53	33.09	5.32	4.87	43.36	44.65
	Compost	49.65	53.24	8.34	8.04	65.95	68.17
	Biofertilizer	41.81	46.87	9.25	9.07	61.05	63.13
	Compost+ biofertilizer	53.33	57.25	10.67	10.56	69.92	73.08
	mean	43.58	47.61	8.39	8.13	60.07	60.26
50% RRP	Zero	51.57	53.29	9.93	9.73	64.94	66.91
	Compost	62.97	67.51	11.68	11.18	75.06	77.40
	biofertilizer	55.49	57.96	12.56	12.60	70.07	73.08
	Compost+ biofertilizer	70.68	74.42	15.00	15.07	83.45	87.14
	mean	60.18	63.30	12.29	12.14	73.38	76.13
100% RR P	Zero	69.30	72.23	14.85	14.82	81.45	84.73
	Compost	70.51	74.10	15.37	15.01	82.26	86.30
	Biofertilizer	69.61	72.85	15.37	15.41	82.26	85.46
	Compost+ biofertilizer	71.29	74.58	15.54	15.58	83.63	87.32
	mean	70.18	73.44	15.29	15.20	82.40	85.95
Mean of activator	Zero	50.13	52.87	10.03	9.80	63.29	65.43
	Compost	61.04	64.95	11.80	11.41	74.42	77.29
	Biofertilizer	55.64	59.22	12.39	12.36	71.13	73.89
	Compost+ biofertilizer	65.10	68.75	13.74	13.74	79.00	82.51
	L. S. D at 0.05						
	A	8.36	9.25	3.25	3.26	9.25	10.05
	B	7.92	8.05	3.11	3.07	8.62	9.28
	A×B	10.11	11.36	3.78	3.69	10.69	11.35

Table 10. Effect of mineral and bio- phosphorus fertilizers and compost on Total N, P and K uptake by faba bean.

Treatments		N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})	
mineral P (A)	Organic and biofertilizer (B)	2020/21	2021/22	2020/2021	2021/22	2020/21	2021/22
Zero	Zero	81.67	86.99	10.50	9.94	82.46	85.22
	Compost	143.88	152.78	18.95	18.12	132.91	138.73
	Biofertilizer	123.32	132.62	19.20	18.98	116.73	121.28
	Compost+ biofertilizer	169.91	1180.93	25.29	25.24	148.22	157.12
	mean	129.68	138.33	18.48	18.07	120.08	125.59
50% RR P	Zero Compost	136.05	141.94	19.43	19.08	123.55	128.79
	Biofertilizer	193.17	202.06	26.473	26.34	163.97	169.12
	Compost+biofertilizer	168.69	177.26	28.63	28.18	147.02	153.44
		248.31	258.64	38.72	38.59	194.59	209.45
	mean	186.55	194.97	28.43	28.05	157.28	204.45
100% RRP	Zero	235.82	245.49	37.85	37.08	190.47	199.92
	Compost	245.01	258.42	38.73	38.53	191.72	202.94
	Biofertilizer	237.89	247.69	38.09	38.88	192.47	201.38
	Compost+biofertilizer	250.07	265.51	39.88	39.68	1195.48	204.93
	mean	242.20	252.94	38.64	38.54	195.53	202.29
Mean of activator	zero	151.18	158.14	22.59	22.03	132.16	137.98
	Compost	194.02	204.42	28.20	27.66	162.87	170.26
	Bofertilizer	176.63	185.86	28.64	28.68	152.07	158.70
	Compost+biofertilizer	222.76	232.24	34.63	34.50	179.43	188.83
	L. S. D at 0.05						
	A	11.16	12.35	5.23	5.10	11.75	12.18
	B	10.02	11.39	5.04	4.86	11.16	11.12
	A×B	13.23	14.27	7.33	7.14	13.25	14.86

With respect to the interaction, the obtained results showed that incorporated organic and/or biofertilizer have a synergetic effect on improving the application of mineral phosphorus fertilizer on NPK nutrients status of faba bean seeds and straw. In general, the highest values of N, P and K content or uptake were obtained from the treatment of 50 % RRP in combined with both organic manure and phosphorine inoculation or 100% RRP. On the other hand, faba bean plants without phosphorus or both organic and biofertilizer exhibited the lowest values of nutrients status. These results are in similar to those obtained by Rakha and El-Said (2013) and Mekki (2016).

Phosphorus use efficiency (PUE)

Data in Table 11 illustrated the chemical phosphorus use efficiency expressed as the amounts of seed yield (kg) produced by one kg of applied chemical phosphorus.

Table 11. Effect of mineral and bio-phosphorus fertilizers and compost on phosphorus use efficiency (PUE, kg seeds/ kg P).

Treatment		2020 /21	2021/ 22
Mineral P(A)	Organic and biofertilizer (B)		
50% RR P	Zero	34.76	37.62
	compost	85.71	87.14
	Biofertilizer	71.91	75.24
	Compost+ biofertilizer	130.48	135.71
	mean	80.71	83.92
100% RR P	Zero	64.05	66.67
	compost	63.57	67.62
	Biofertilizer	65.24	65.48
	Compost+ biofertilizer	65.95	68.10
	mean	64.47	66.97
	L. S. D at 0.05		
	A	5.11	6.03
	B	4.03	4.79
	A×B	6.17	7.02

The results, clearly showing that combined 50% RRP with both organic and bio-fertilizer recorded the highest in both growing seasons (130.48 and 135.71 kg seeds/ kg P applied in both growing seasons, respectively), meanwhile every kg P yielded 98.72 kg seeds under application of 100% RRP. On the other hand, the lowest / MPFUE were recorded when fertilized faba bean plants without organic or bio-fertilizer application. These results are in line with those obtained by Mekki (2016). Many workers stated that various crops utilize only 15-20% of applied phosphorus and the remaining converted to unavailable form in the soil (El-Ramady et al, 2019). Therefor using organic manure and biofertilizer are proving to converting insoluble P to soluble form, hence improving its uptake and crop yield (El-Naqma et al, 2024).

CONCLUSION

In the light of the obtained results of this research it could be recommended that under the alluvial clay soil on Beni-Suif area in Egypt, supplying faba bean plants with 50% RRP (about 21 kg P ha^{-1}) in combined with 5 t ha^{-1} compost and inoculating its seeds with phosphin bio-fertilizer led to highest values of growth parameters, yield and yield component as well as nutrients status in both seeds and straw and to save about 50% from mineral P fertilizer. Also, using organic and/or bio-fertilizers increased mineral phosphorus fertilizer use efficiency (PUE) and enhanced soil health with increasing organic carbon content , microbial population and activity and finally maintained nutrients and water availability for plants.

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تحسين صحة التربة وكفاءة استخدام الأسمدة الفوسفاتية المعدنية لنباتات الفول البلدي بأستخدام الأسمدة العضوية والحيوية

غادة فتح الله حافظ الشريف[1] ، أحمد محمود منصور[1] و رضا علي ابراهيم[2]

[1] معهد بحوث الأراضي والمياه والبيئة - مركز البحوث الزراعية بالجيزة- مصر

[2] معهد بحوث المحاصيل الحقلية- قسم بحوث المحاصيل البقولية - مركز البحوث الزراعية بالجيزة- مصر

الملخص

يعد استخدام ممارسات الإدارة التي تعمل على تحسين صحة التربة وزيادة الإنتاجية والربحية أمرًا مهمًا لذا فقد أجريت تجربة حقلية بالمزرعة البحثية بمحطة البحوث الزراعية بسدس- مركز البحوث الزراعية - محافظة بني سويف- مصر خلال عامي 2021/2020 و 2022/2021 لدراسة كيفية تعزيز صحة التربة وتحسين كفاءة استخدام السماد الفوسفوري (صفر، 50، 100% من المعدل الموصي به) بأستخدام الأسمدة العضوية (5 طن/هكتار كمبوست) وتلقيح البذور بالفوسفورين وتأثيرها علي صفات النمو (طول النبات، عدد الأوراق للنبات) والمحصول ومكوناته وتركيز العناصر بالنبات). ويمكن تلخيص أهم النتائج فيما يلي:-- أدي زيادة معدل التسميد الفوسفاتي حتي 100% من الموصي به (42 كجم فو/هكتار) الي زيادة معنوية في صفات النمو والمحصول ومكوناته وكذلك تركيز وامتصاص عناصر النيتروجين والفوسفور والبوتاسيوم في البذور والقش.- أدي إضافة السماد العضوي أو الحيوي سواء منفردا أو مختلطة معا الي تحسين كل الصفات السابقة.إضافة السماد العضوي الكومبوست مع التلقيح بالفوسفورين مع اضافة 50% من المعدل الموصي به من سماد الفوسفور المعدني ادى الي ان قيم الصفات السابقة مساويه احصائيا للقيم المتحصل عليها عند إضافة 100% من سماد الفوسفور المعدني، مما يعني إمكانية تقليل 50% من سماد الفوسفور المعدني باستخدام السماد العضوي والفوسفور الحيوي مما يقلل من تكلفة الانتاج مع تقليل التلوث البيئي من استخدام الأسمدة المعدنية.ومن النتائج المتحصل عليها يمكن التوصية باستخدام 5طن /هكتار كمبوست مع التلقيح البكتيرى بالفوسفيرين لتقاوى الفول حتي يمكن توفير 50% من سماد الفوسفور المعدنى مع عدم نقص في المحصول وتحسين صحة التربة من خلال زيادة محتوى الكربون العضوي والمجموعات الميكروبية المفيدة وتوافر العناصر الغذائية.