Synergistic Effect of Bio-and Meneral Phosphorous Fertilizers to Improve Seed Yield and Quality of Broad Bean (*VICIA FABA*, L.)

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ABSTRACT

Two field experiments were conducted during the winter seasons of 2003/2004 and 2004/2005 at Sabahia Horticulture Research Station, Alexandria, Egypt. This investigation aimed to study the combined effect of microbin or phosphorin as bio-fertilizers and different rates of mineral phosphorus on seed yield and its components of broad bean to find out the best combination, to minimize the heathers of using chemicals on the environment. Generally, increasing P fertilizer level increased all the studied characters except that of the number of seeds/pod. Moreover, using either microbin or phosphorin gave similar effects on most of the studied characters. Such effect was higher significantly than that of untreated plots. The interaction between either bio-fertilizers and mineral P fertilizer levels was significant in most traits. It was found that the effects of applying P fertilizer at 30 Kg P_2O_5/fed. was similar to the effect of the applications of P at 20 or 30 Kg P_2O_5/fed. combined with either microbin or phosphorin, and gave the highest mean values of the studied traits. These results suggested that 10 Kg P_2O_5/fed. (33.3% of the recommended dose) could be saved by using mineral P at 20 Kg P_2O_5/fed. when broad bean seeds are inoculated with either microbin or phosphorin without any reduction in yield or quality of seeds.

INTRODUCTION

Broad bean (*Vicia faba*, L.) is the most important leguminous seed crop in Egypt which it is inexpensive source of protein with high calories and nutritive value (Radwan and Wafaa, 2005). The total production in Egypt is still below the demand. To meet the national requirement of this crop, both the area devoted could be increased and the high yielding cultivars can be planted. Since the cultivated area in Egypt is limited, and to achieve abundant yield, the use of high yielding cultivars and good agricultural practices are recommended.

Plant nutrients are essential for plant life and yield, therefore, mineral fertilization is a common agricultural practice to improve productivity. Phosphorus fertilizer is essential for leguminous crop. Recently, bio-fertilization became important bractes to increase the availability of phosphorus in the soil. Phosphate dissolving bacteria is a biological fertilizer, which dissolve P and enhance its absorption by plant. The ability of rhizosphere bacteria to solubilize phosphorus is important in Egypt, where soil available phosphorus is low. Microbin and phosphorine, produced by Ministry of Agriculture, are bio-fertilizers containing phosphate-

dissolving bacteria. Certain phosphate-dissolving bacteria supply the grown plants with available forms of phosphorus through the production of organic, inorganic acids and Co_2. It increases the soil acidity consequently convert insoluble forms of phosphorus into soluble ones (Alexander, 1977). Several workers reported that the application of phosphate solubilizing bacteria increases the phosphorous level in the soil (Badr El-Din *et al.*, 1986; El-Sayed 1999, Koreish *et al.*, 2001 and Radwan and Wafaa, 2005).

The present investigation was initiated to study the effect of microbin and phosphorin as phosphorous bio-fertilizers when accompanied with different rates of mineral phosphorus on seed production of broad bean plants and its components to find out the best rate of mineral P fertilizer with bio-fertilizers to minimize the heathers created when mineral P is used.

MATERIALS AND METHODS

Two field experiments were conducted during winter seasons of 2003/2004 and 2004/2005 at Sabahia Horticulture Research Station, Alexandria, Egypt. The physical and chemical properties of the used soil are presented in Table 1.

Table 1: Some physical and chemical analyses of the experimental soil.

soil properties	2003/2004	2004/2005
soil texture	coarse clay with shales	coarse clay with shales
pH	8.32	8.37
E.C. (dS/m)	1.70	1.85
Available N (mg/l)	25.6	33.8
Available P (mg/l)	19.6	19.9
Available K (mg/l)	830	960
Organic matter (%)	0.55	0.62

Plant material for this investigation was a selected line, Equadols cv. (Sabaaty), originated from selection and improving of broad bean which was obtained from the local marke of Alexandria (Ragheb, 1994).

The experiments were laid out in a split plot design with four replicats. The main plots consisted of three treatments; two types of bio-fertilizers i.e., microbin and phosphorin, and control (without bio-fertilization). The sub-plots were devoted to involve three levels of mineral P fertilizer as follows: 1) 10 kg P_2O_5/fed (33.3% of the recommended dose), 2) 20 kg P_2O_5/fed (66.6% of the recommended dose), and 3) 30 kg P_2O_5/fed (100% of the recommended dose). Phosphorus was added as super phosphate (15.5% P_2O_5) during seedbed preparation. Potassium at a rate of 50 Kg K/fed.

(added as potassium sulphate, 48% K_2O) and nitrogen at a rate of 40 Kg N/fed.

(added as ammonium sulphate, 20.6 % N) both fertilizers were divided into two equal doses, the first dose was applied just before seeding irrigation and the second one was added at the beginning of flowering stage. The phosphorin is a phosphate-solubilizing bacterial *Bacillus megaterium* and microbin contains a mixture of phosphorous dissolving bacteria and N_2-fixing bacteria, e.g., *Azotobacter spp*, Azosprillum *spp*, *Bacillus megaterium*, and *Bacillus polymyxa*. Such products are produced by the General Organization for Agricultural Equalization Fund, Ministry of Agriculture, Egypt. The inoculation was performed by coating broad bean seeds at the rate of 0.90 kg/fed of bio-fertilizers using a sticking substance (Arabic gum solution 5%) just before sowing.

Seeds of each treatment were planted in 5 rows, 4.5 m long, 0.6 m wide making an area of 13.5 m^2, hills were 30 cm apart, 2 seeds per hill. Sowing date was on November 15th and 13th for the two seasons, respectively. Three weeks later, seedlings were thinned on one in each hill. Other agricultural practices were carried out as recommended for the conventional broad bean planting.

Recorded measurements:

1. Vegetative growth characters:

The following growth attributes were measured, 95 days after sowing, using ten random plants from each treatment; plant height (cm), number of branches / plant, number of leaves/plant, foliage fresh weight / plant (g) and foliage dry weight / plant (g).

2. Seed yield and its components:

At harvest, on mid May, samples of ten random plants were used, from each plot to record the following data: number of pods/plant, number of seeds/pod, and total seed yield g/plant and ton/fed. Average seed yield/fed was calculated based on the plot area.

3. Seed quality:

Three random samples, 100 seeds each, were used from each treatment for calculating the following records; weight of 100 seeds (in gram), germination (as %) and germination rate. Germination rate was calculated according to Thompson (1979) as following;

$$\text{Germination rate} = \Sigma \frac{\text{No. of normal seedlings at first count}}{\text{No. of days until first count}} + \ldots + \frac{\text{No. of normal seedlings at last count}}{\text{No. of days until last count}}$$

Statistical procedures:

All the collected data were tabulated and statistically analyzed using the analyses of variance method as reported by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

1- Effects of bio fertilizers and mineral phosphorus fertilizer levels on growth attributes of broad bean plants.

All growth attributes of broad bean plants in Table 2 were improved significantly as P fertilizer rate increased in both seasons. Similarly, the inoculated broad bean seeds with either bio-fertilizers microbin or phosphorin gave higher plants and higher fresh and dry weight of foliage than that uninoculated seeds in both seasons. Application of P fertilizer at 20 or 30 Kg P_2O_5/fed. with microbin or phosphorin had apparently the same effect and gave the highest mean values of fresh and dry weight of foliage /plants in both seasons. These results indicated that inoculated broad bean seeds with either bio-fertilizer, microbin or Phosphorin, and fertilized with 20 Kg P_2O_5/fed. is recommended to obtain the highest values of both characters. These effects may be due to the ability of the microorganisms to produce growth regulator substances i.e., indole acetic acid (IAA), gibbrelic acid (GAs), and cytokinones (CKs) (Megahed and Mohamed, 2001). These growth substances may play an important role in plant growth through promoting photosynthesis, translocation and accumulation of dry matter within different plant organ. It may also be related to the role of the more available P, produced by P releasing bacteria, in plant growth (Ragab, 1998; Said, 1998). These results are in agreement with those obtained by Radwan (1997), Rehab (1999), Radwan and Wafaa (2005) on faba bean and Sharma and Namdeo (1999) on soybean.

2. Effects of bio fertilizers and mineral phosphorus fertilizer levels on broad bean seed yield and its components

Application of P fertilizer at 30 Kg P_2O_5/fed. had the highest significant mean values for all the studied traits in Table 3 in both seasons except that of number of seeds/pods. This trait is related to genetic characteristics of cultivar, so, it is not affected too much with any fertilization treatment. In addition, the inoculated broad bean seeds with either bio-fertilizers microbin or phosphorin had about the same effect and produced higher number of pods/plant and seed yield than that of uninoculated seeds in both seasons. Application of P fertilizer at 30 Kg P_2O_5/fed. only gave the same effect of the application of P fertilizer at 20 or 30 Kg P_2O_5/fed. with either microbin or Phosphorin. This treatment gave the highest mean values of number of pods/plant and seed yield. These results suggested that 10 Kg P_2O_5/fed could be save by using P fertilizer at 20 Kg P_2O_5/feddan when inoculated broad bean seeds with either bio-fertilizers microbin or phosphorin to obtain the highest number of pods/plant and seed yield. Similar results were reported by Singer et al., (2000) on snab bean and Yakout and Greish (2001) on faba bean.

Table 2: Effects of bio-fertilizers and mineral phosphorus fertilizer levels on vegetative growth characters of broad bean during 2003/2004 and 2004/2005 winter seasons.

Character	Plant height (cm)				No. of branches / plant				No. of leaves/Plant				Foliage fresh weight / plant (g)				Foliage dry weight / plant (g)			
Treatment	P level (Kg P_2O_5/fed)			Mean	P level (Kg P_2O_5/fed)			Mean	P level (Kg P_2O_5/fed)			Mean	P level (Kg P_2O_5/fed)			Mean	P level (Kg P_2O_5/fed)			Mean
	10	20	30		10	20	30		10	20	30		10	20	30		10	20	30	
2003/2004 season																				
Bio-fertilizer																				
Microbin	131.7a*	139.6a	144.5a	138.4A	7.9a	8.0a	8.8a	8.2A	63.8a	68.2a	71.1a	67.7A	1582.1b	1885.4a	2055.1a	1921.9A	131.1b	182.9a	201.2a	171.7A
Phosphorin	131.1a	137.8a	143.3a	137.6A	7.3a	9.2a	9.2a	8.6A	61.1a	61.0a	68.6a	66.7A	1547.7b	1869.1a	2048.8a	1640.9A	129.0b	140.2b	187.1a	152.4A
Without	120.7a	131.1a	139.0a	130.3B	6.7a	8.4a	8.8a	7.9A	60.8a	66.5a	69.7a	65.6A	1206.7c	1495.8b	1802.0a	1501.5B	98.1bc	146.2b	181.8a	140.0B
Mean	127.8C	136.2B	142.3A		7.3B	8.5A	8.9A		61.9C	67.7B	70.4A		1445.5C	1750.1B	1968.7A		119.4C	184.8B	190.0A	
2004/2005 season																				
Bio-fertilizer																				
Microbin	137.9a	144.3a	150.0a	144.1A	10.1a	10.6a	11.3a	10.7A	70.2a	75.0a	78.2a	74.4A	1572.7ab	1871.7a	2040.1a	1907.8A	137.3b	181.5a	188.7a	169.2A
Phosphorin	137.9a	148.2a	151.3a	144.9A	9.4a	11.8a	11.8a	11.0A	67.1a	75.4a	77.4a	73.3A	1555.4ab	1834.2a	2033.9a	1828.2A	124.6bc	178.3a	184.9a	162.6A
Without	126.4a	137.3a	145.6a	136.4B	8.6a	10.8a	11.3a	10.0A	66.9a	73.1a	76.6a	72.2A	1197.9c	1484.8b	1791.1a	1491.3B	111.7c	146.8b	180.4a	146.3B
Mean	133.9C	142.6B	149.0A		9.4B	11.0A	11.4A		68.0C	74.5B	77.4A		1442.0C	1730.2B	1955.0A		124.5C	168.9B	184.7A	

*Values with alphabetical letter, within a comparable group of means, do not differ significantly from one another using LSD Test at 0.05 level of probability.

Table 3: Effects of bio-fertilizers and mineral phosphorus fertilizer levels on seed yield and its components of broad bean during 2003/2004 and 2004/2005 winter seasons.

Character	No. of pods / plant				No. of seeds / pod				Seed yield (g/plant)				Seed yield (ton/fed)			
Treatment	P level (Kg P_2O_5/fed)			Mean	P level (Kg P_2O_5/fed)			Mean	P level (Kg P_2O_5/fed)			Mean	P level (Kg P_2O_5/fed)			Mean
	10	20	30		10	20	30		10	20	30		10	20	30	
2003/2004 season																
Bio-fertilizer																
Microbin	15.5b*	18.6a	19.1a	17.7A	4.6a	5.0a	5.2a	4.9A	141.2b	194.6a	210.3a	179.8A	1.430b	1.656a	1.711a	1.599A
Phosphorin	16.3b	18.8a	19.6a	18.2A	4.4a	4.9a	5.1a	4.8A	136.9b	193.7a	210.8a	178.0A	1.417b	1.673a	1.652a	1.581A
Without	14.4c	15.9b	18.2a	16.1B	4.3a	4.6a	4.8a	4.6A	118.9c	145.9b	183.4a	148.1B	1.161c	1.418b	1.765a	1.485B
Mean	15.4C	17.8B	19.0A		4.4A	4.8A	5.0A		131.7C	176.3B	200.4A		1.373C	1.619B	1.673A	
2004/2005 season																
Bio-fertilizer																
Microbin	15.9b	20.7a	21.8a	19.5A	5.9a	6.4a	6.6a	6.3A	155.6b	220.4a	239.4a	203.2A	1.454b	1.679a	1.749a	1.627A
Phosphorin	16.3b	21.5a	22.3a	20.0A	5.6a	6.3a	6.5a	6.1A	150.1b	221.4a	239.5a	200.3A	1.456b	1.665a	1.711a	1.611A
Without	14.5c	16.9b	20.9a	17.4B	5.6a	6.0a	6.2a	5.9A	131.7c	163.2b	210.5a	166.2B	1.299c	1.543b	1.660a	1.501B
Mean	15.6C	19.7B	21.7A		5.7A	6.2A	6.4A		145.5C	199.6B	228.7A		1.403C	1.629B	1.707A	

* Values with alphabetical letter, within a comparable group of means, do not differ significantly from one another using LSD Test at 0.05 level of probability

3. Effects of bio fertilizers and mineral phosphorus fertilizer levels on broad bean seed quality.

Fertilization treatments with phosphorus caused significant differences for all seed quality characteristics in both seasons (Table 4). The highest level of P fertilizer produced the highest mean values for all studied traits. Moreover, using either microbin or phosphorin bio-fertilizer gave the same increasing effect on these traits, it was higher and significantly differ from that of uninculcated seeds. These findings resulted from the favorable effect of bio-fertilizers on growth attributes (Table 2) and seed yield and its components (Table 3). These effects may be attributed to; 1) the role of bio-fertilizer in increasing uptake of N, P, K and Mg as reported by Ragab (1998) in olive, 2) the role of bio-fertilizer in increasing the plant growth substances like IAA, GAs, and CKs which promote plant growth, cell division, encourage the photosynthesis and assimilates accumulation (Said, 1998), 3) the effect of bio-fertilizer in releasing phosphorus which plays an important role in plant development.

Table 4: Effects of bio- fertilizers and mineral phosphorus fertilizer levels on quality of broad bean seeds during 2003/2004 and 2004/2005 winter seasons.

Character	Weight of 100 seeds (g)				Seed germination (%)				Germination rate			
Treatment	P level (Kg P_2O_5/fed)			Mean	P level (Kg P_2O_5/fed)			Mean	P level (Kg P_2O_5/fed)			Mean
	10	20	30		10	20	30		10	20	30	
						2003/2004 season						
Bio-fertilizer												
Microbin	178.6b#	184.0a	185.2a	182.6A	60.0c	100.0a	100.0a	86.0A	8.58c	14.28a	14.28a	12.38A
Phosphorin	173.1c	183.2a	184.7a	180.3A	65.0c	100.0a	100.0a	87.7A	9.29c	14.28a	14.28a	12.62A
Without	172.3c	177.2b	182.1a	177.2B	55.0cd	85.0b	100.0a	79.7B	7.86d	12.15b	14.28a	11.28B
Mean	174.7C	181.4B	184.0A		60.0C	95.0B	100.0A		8.58C	13.57B	14.28A	
						2004/2005 season						
Bio-fertilizer												
Microbin	181.9b	187.6a	188.7a	186.0A	70.0c	100.0a	100.0a	90.0A	9.91c	14.25a	14.33a	12.86A
Phosphorin	179.3c	185.9a	187.0a	184.0A	70.0c	100.0a	100.0a	90.0A	9.99c	14.30a	14.28a	12.86A
Without	178.4c	179.0b	185.6a	181.0B	60.0d	90.0b	100.0a	83.3B	8.58d	12.28b	14.26a	11.90B
Mean	179.8C	184.1B	187.1A		66.7C	96.6B	100.0A		9.53C	13.81B	14.28A	

#Values with alphabetical letter, within a comparable group of means, do not differ significantly from one another using LSD Test at 0.05 level of probability.

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الملخص العربى

التأثير المنشط للسماد الحيوى مع السماد الفوسفورى لتحسين محصول و جودة تقاوى الفول الرومى

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أجريت تجربتان حقليتان فى المزرعة البحثية لمحطة بحوث البساتين بالصبحية خلال موسمى الزراعة الشتويين ٢٠٠٣ / ٢٠٠٤ و ٢٠٠٤ / ٢٠٠٥؛ لدراسة تأثير الأسمدة الحيوية التجارية " الميكروبين " و "الفوسفورين" مع إضافة مستويات مختلفة من السماد الفوسفورى على محصول و جودة تقاوى الفول الرومى.

وكانت أهم النتائج المتحصل عليها كالآتى :

١. أدت زيادة مستوى السماد الفوسفورى إلى زيادة معنوية فى قيم كل الصفات المدروسة فيما عدا عدد البذور / القرن.
٢. تساوى تأثير كل من الميكروبين و الفوسفورين على معظم الصفات المدروسة ، وكان هذا التأثير أعلى معنويا عن معاملة الكنترول (بدون سماد حيوي).
٣. كان التداخل بين السماد الحيوى والفوسفورى معنويا فى معظم الصفات المدروسة، حيث وجد أن إضافة الفوسفور بمفرده بمعدل ٣٠ كجم/الفدان تساوى مع إضافة الفسفور بمعدل ٢٠ أو ٣٠ كجم/الفدان مع أى من السمادين الحيويين الميكروبين أو الفوسفورين.

تدل هذه النتائج على أنه باستخدام الأسمدة الحيوية (ميكروبين أو فسفورين) يمكن التوفير من السماد الفوسفورى بما يوازى ١٠ كجم/فدان (أي ثلث الكمية الموصى بها للفدان) ، دون الإضرار بمحصول تقاوى الفول الرومي أو جودته.