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EFFECT OF BIOFERTILIZER WITH PHOSPHATE DISSOLVING BACTERIA UNDER DIFFERENT LEVELS OF PHOSPHORUS FERTILIZATION ON MUNGBEAN PLANT

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ABSTRACT: **The present investigation was carried out at Giza Experimental Station, ARC, during the two growing seasons of 2000 and 2001 to study the influence of biofertilization with phosphate dissolving bacteria (PDB) under different levels of phosphorus fertilization (0.0, 7.75, 15.50 and 23.25 kg P_2O_5/feddan) on vegetative characters, growth analysis, photosynthetic pigments, yield components and seed quality of mungbean cv. VC-1000.**

The obtained results indicated that the application of phosphorus fertilization induced significant increases in most of the studied characters; i.e., plant height, number of branches/plant, number of leaves/plant, shoot dry weight/plant, leaf area index (LAI), leaf chlorophylls, number of pods/plant, number of seeds/plant, yield of seeds/plant, yield of seeds/plot (1/400 feddan), yield of straw/plot and seed protein yield/feddan as well as percentages of total carbohydrates, total lipids and phosphorus in seeds of mungbean cv. VC-1000. It is clear that the rate of promotion increased significantly as the rate of phosphorus fertilizer increased up to 23.25 kg P_2O_5/feddan. Likewise, plants obtained from biofertilized seeds with PDB showed significant increases in this respect.

Worthy to note that the maximum increase in seed yield per plot (1/400 feddan) as well as in seed protein yield per feddan were recorded at the combined treatment of 23.25 kg P_2O_5/feddan in the presence of PDB.

Key words: Mungbean, Phosphorus fertilization, Biofertilizers, Yield.

INTRODUCTION

Pulses are important world food crops because they provide an inexpensive source of vegetable dietary protein. In Egypt, most of pulse crops are grown in winter season such as broadbean (*Vicia faba* L.), lentil (*Lens esculenta* L.), chickpea (*Cicer arietinum* L.), Egyptian lupine (*Lupinus termis* Forsk.) and pea (*Pisum sativum* L.). Local production of pulses is not sufficient to meet the increasing demand for human utilization.

Therefore, introducing high yielding pulse crops with short growing season is considered as an effective tool for narrowing the food gap in Egypt. Mungbean [*Vigna radiata* (L.) Wilczek] is a new introduced summer pulse crop in Egypt with short growing season grown principally for its protein rich edible seeds (Ashour *et al.*, 1992). It needs a lot of work to enhance its productivity through choosing the optimal agricultural practices.

Phosphorus is one of the major essential elements for plant growth and production. Phosphate fertilization is essential for production of legumes, as mungbean. It seems that this crop is responsive to phosphate fertilization {Srivastava and Varma (1982), Kalita (1989), Pandrangi *et al.* (1990), Patel and Patel (1991), Singh *et al.* (1994), El-Naggar (1998), and Hessien (2000)}.

Phosphate ions in the soil are relatively immobile and most of the phosphate fertilizer applied is rendered unavailable for crop uptake. Plant roots must expend considerable energy for adequate phosphate absorption in soil with low phosphate. Therefore, further annual applications are often done to maintain adequate labile phosphate. Because phosphate concentration of many soils has increased markedly over time. Soils commonly have large reserve of fixed phosphate that could support long-term crop requirements if it could be economically exploited (Abd El-Lateef *et al.*, 1998).

Under Egyptian conditions a great attention is being devoted to reduce the higher rates of mineral fertilizers by using biofertilized farming system.

Many investigators demonstrated that biofertilization with phosphate dissolving microorganisms might be comparable to a treatment with a chemical phosphate fertilizer.

In this connection, Saber (1996) reported that the increase in dry weight of inoculated plants ranged from 5.1 to 18.0% for grain crops, sugar beet and soybean. Generally, the use of biofertilizers improved soil fertility and enriched its biological activity under biofertilized farming system.

Likewise, Abd El-Lateef *et al.* (1998) mentioned that the biofertilization increased seed yield by 20.4% over the control treatment for soybean. However, seed oil content showed a reversible trend compare to seed yield. The highest seed protein content was found by using 100 kg/fed. superphosphate for soybean plants.

Therefore, this research was designed to disclose the influence of biofertilization with phosphate dissolving bacteria under different levels of phosphate fertilization on vegetative characters, growth analysis, photosynthetic pigments, yield components and seed quality of mungbean cv. VC-1000 throughout the two consecutive seasons of 2000 and 2001.

MATERIALS AND METHODS

Field experiments were conducted at Giza Experimental Station, Agricultural Research Center (ARC), during the two successive seasons 2000 and 2001 in order to investigate the influence of biofertilizer with phosphate dissolving bacteria (PDB)* under different levels of phosphorus fertilization on growth, yield and phytochemical analysis of mungbean cv. VC-1000.

Seeds of mungbean cv. VC-1000 were treated by the adhesive material Arabic gum to make their surface sticky before inoculation with specific rhizobia. All used seeds were inoculated with *Bradyrhizobium japonicum* and then divided equally to two groups. Seeds of the first group were subjected to inoculation with biofertilizer of phosphorus dissolving bacteria. Whereas, the other group were not subjected to inoculation with phosphorus dissolving bacteria.

* Commercial product released by Ministry of Agriculture, Giza.

Phosphorus fertilizer was applied at sowing in the form of calcium superphosphate (15.5% P_2O_5). Four levels of phosphorus fertilizer; namely, 0.0, 7.75, 15.50 and 23.25 kg P_2O_5/feddan were used in this investigation.

Procedure of the experiment :

The experiment was made in a split plot design with four replicates. The replicate contains four main plots, each assigned for one level of phosphorus fertilization. Each main plot was divided into two subplots, one sown with seeds inoculated with PDB and the other subplot was sown with seeds not inoculated with PDB. Thus, the four levels of phosphorus fertilizer beside the two levels of PDB biofertilizer required that the experimental land of each replicate be divided into eight subplots, each contained one treatment. The experimental area of subplot was 10.5 m^2; i.e., 1/400 feddan, consisted of five ridges, three meters in length and 70 cms in width.

Treated and non-treated seeds with PDB were, immediately, sown in hills on both sides of the ridge at 20 cm apart. Seeds were sown on 9th May 2000 in the first season, and replicated on 17th May 2001 in the second one. Cultural practices were completed according to the usual methods being adopted for mungbean crop.

Chemical analysis for the soil of the experimental sites in each growing season was done before sowing according to Jackson (1958). Data of soil chemical analysis are presented in Table (1).

Table (1): Soil chemical analysis of the experimental sites in the two growing season.

Seasons	pH	Organic matter %	Available N (ppm)	Available P (ppm)	Available K (ppm)
2000	7.6	1.64	49	8.5	486
2001	7.4	1.58	52	8.9	481

Recording of data :

A- Vegetative characters :

A random sample of five plants was chosen for investigation in each subplot; i.e., a total of 20 plants was fixed for each treatment. The following measurements were recorded at the age of 80 days: plant height (cm), number of branches per plant, number of leaves per plant and dry weight of the shoot (g) per plant. For dry matter determination, plant shoot was dried at 70°C in an electric oven for 48 hours and weighted accurately.

B- Growth analysis :

Three growth stages were assigned for this purpose; ages, 45, 60 and 75 days from sowing date. In each growth stage, a random sample of five plants was taken from each subplot; i.e., a total of 20 plants was fixed for each treatment. Data were recorded on individual plants. Total leaf area (cm^2)/ plant was measured by means of LI - 3000 A portable area meter, LI-3050 A Transparent belt conveyer - of LI- Cor, Inc., Lincoln, Nebraska, U.S.A. Shoot dry weight (g)/plant was determined using an electric oven at 70°C till constant weight. The following formulae (Hunt, 1982) were used for analyzing mungbean growth under different levels of phosphorus fertilizer in the absence or presence of PDB.

1- Leaf area index (L.A.I.):

$$\text{Leaf area index} = \frac{\text{Leaf area in cm}^2\text{/ plant}}{\text{Ground area occupied by the plant in cm}^2}$$

2- Net assimilation rate (N.A.R.):

$$\text{Net assimilation rate} = \frac{(\text{Loge } A_2\text{-Loge } A_1)\ (W_2\text{-}W_1)}{(T_2\text{-}T_1)\ (A_2\text{-}A_1)}\ \text{ing./dcm}^2\text{/week}$$

Where :

A_2-A_1 = difference in leaf area between two successive samples in dcm^2.

W_2-W_1 = difference in dry matter accumulation between two successive samples in g.

T_2-T_1= number of weeks between two successive samples.

3- Crop growth rate (C.G.R.):

Crop growth rate = N.A.R. X L.A.I.

It is worthy to note that : N.A.R. and C.G.R. were estimated for the two periods 45 - 60 and 60 - 75 days from sowing.

C- Yield characters :

Data on yield characters were recorded on individual plants at harvest time; i.e., 90 days from sowing date. A random sample of ten plants was assigned for investigation in each subplot (totaling 40 plants for each treatment). The following yield and yield components per individual plant were estimated number of pods per plant, number of seeds per plant, weight of 100 seeds (g) per plant (specific weight of seeds) and seed yield (g) per plant. Moreover, the yield of seeds (kg)/plot (1/400 feddan) and the yield of straw (kg)/plot were also estimated.

D- Chemical analysis :

Photosynthetic pigments concentration (mg/ g F.W. of leaves) were determined at 45 days from sowing. Absorbency reading for chlorophyll a (chl.a), chlorophyll b (chl.b), total chlorophyll (chl.a+b) and carotenoides (c) were measured by Spectrophotometer at wavelength 663 and 645 nm for chlorophylls, and at wavelength 452 nm for carotenoides (A.O.A.C., 1990).

Mature dried seeds of the first season (2000) were subjected to chemical analysis for crude protein % (Pregl, 1945 and A.O.A.C., 1990), total carbohydrates as glucose % (Dubois *et al.*, 1956), total lipids (fats) % (A.O.A.C., 1990), phosphorus % (determined colourmetrically according to Moore and Chapman, 1986), potassium and sodium in ppm (were determined using Flame-photometric method as described in A.O.A.C., 1990).

E- Statistical analysis :

The obtained data were subjected to appropriate statistical analysis according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

1. Vegetative characters :

Data on vegetative characters of mungbean cv. VC-1000 as affected by biofertilizer with phosphate dissolving bacteria (PDB) under different levels of phosphorus fertilization in two seasons are presented in Table (2). Investigated characters included : plant height (cm), number of branches per plant, number of leaves per plant and dry weight of the shoot (g) per plant.

Results in Table (2) clearly show that the application of phosphorus fertilization induced significant increase in all vegetative characters of mungbean cv. VC-1000 under investigation in both studied seasons. Worthy to note that the rate of promotion increased significantly as the rate of phosphorus fertilizer increased up to 23.25 kg P_2O_5/feddan. Claims to the promotion effect of phosphorus fertilizer on vegetative growth of mungbean plant were reported by various workers. Kalita (1989), Kothari and Saraf (1990), Pal and Jana (1991) and Gunawardena *et al.* (1992) recorded significant increase in shoot dry weight of

Table (2): Vegetative characters of mungbean cv. VC-1000 as affected by biofertilizer and phosphorus applications in two successive seasons (2000 and 2001).

Treatments		Plant height			No. of branches/ plant			No. of leaves/ plant			Dry weight of shoot (g)/plant		
		Seasons		combin. two seasons	Seasons		combin. two seasons	Seasons		combin. two seasons	Seasons		combin. two seasons
(P_2O_5 kg/fed.)	Biofertilizers	2000	2001		2000	2001		2000	2001		2000	2001	
0	-	61.5	67.8	64.7	2.0	2.3	2.15	17.5	19.1	18.3	51.7	57.9	54.8
	+	66.0	73.1	69.6	2.2	2.4	2.30	18.4	19.7	19.1	55.2	60.6	57.9
Mean		63.8	70.5	67.2	2.1	2.35	2.23	17.95	19.40	18.7	53.5	59.3	56.4
7.75	-	72.4	80.2	76.3	2.5	3.0	2.75	20.2	22.1	21.2	63.9	72.5	68.2
	+	78.2	86.5	82.4	2.9	3.4	3.15	22.7	24.4	23.6	72.3	78.9	75.6
Mean		75.3	83.4	79.4	2.7	3.2	2.95	21.45	23.25	22.4	68.1	75.7	71.9
15.50	-	77.6	87.2	82.4	2.8	3.4	3.10	22.7	24.0	23.4	71.8	76.6	74.2
	+	84.8	95.4	90.1	3.2	3.8	3.50	24.8	26.4	25.6	78.1	85.3	81.7
Mean		81.2	91.3	86.3	3.0	3.6	3.30	23.75	25.20	24.5	75.0	81.0	78.0
23.25	-	82.5	94.7	88.6	3.3	3.7	3.50	25.4	27.3	26.4	80.6	85.6	83.1
	+	89.3	101.2	95.3	3.6	4.0	3.80	28.3	29.8	29.1	88.2	94.2	91.2
Mean		85.9	98.0	92.0	3.5	3.85	3.65	26.85	28.55	27.75	84.4	89.9	87.2
Seed inoc.	-	73.5	82.5	78.0	2.65	3.1	2.88	21.45	23.13	22.33	67.0	73.2	70.1
	+	79.6	89.1	84.4	2.98	3.4	3.19	23.55	25.08	24.35	73.5	79.8	76.6
L.S.D. (0.05) for :													
Phosphorus appl.	(A)	4.36	5.17	4.42	0.19	0.25	0.23	1.49	1.74	1.57	4.11	4.47	4.28
Seed inoc.	(B)	3.18	4.22	3.26	0.13	0.18	0.16	0.89	1.16	0.98	2.46	2.78	2.69
Interaction	(A x B)	5.42	6.95	5.83	0.24	0.35	0.29	1.86	2.14	1.99	4.93	5.48	5.16

mungbean plant as a result of phosphorus fertilization. Likewise, Patel and Patel (1991), Meena *et al.* (1993) and Sharma and Singh (1997) found that application of phosphorus fertilizer increased plant height and number of branches per mungbean plant. Also, Hessien (2000) stated that phosphorus fertilization increased significantly vegetative growth characters of mungbean plant; i.e., plant height, number of branches/plant, number of leaves/plant and shoot dry weight of the plant. In all studied characters, he found that the rate of promotion increased with increasing rates of phosphorus fertilizer up to 30 kg P_2O_5/feddan. In this respect, Saxena and Verma (1995) reported that phosphorus fertilizer application induced significant increase in plant height and number of leaves/plant of frenchbean. Likewise, Abo El-Nour *et al.* (1996) and El-Kalla *et al.* (1997) using faba bean plants as well as Abd El-Lateef *et al.* (1998) using soybean plants recorded significant increase in plant height and number of branches due to application of phosphorus fertilization. All, being in accordance with the present findings.

Likewise, plants obtained from biofertilized seeds with phosphate dissolving bacteria (PDB) showed significant increase in plant height, number of branches per plant, number of leaves per plant and dry weight of the shoot per plant at 80 days from sowing date in both studied seasons of 2000 and 2001. This may be attributed to the fact that phosphate solubilizing bacteria play a fundamental role in correcting the solubility problem in soil by converting the fixed form to soluble form ready for plant nutrition, El-Kalla *et al.* (1997). Similar results were previously reported by Abo El-Nour *et al.* (1996) and El-Kalla *et al.* (1997) on faba bean plants, as well as by Abd El-Lateef *et al.* (1998) on soybean plants.

The interaction between phosphorus fertilization levels and biofertilizer with phosphate dissolving bacteria revealed significant effect in both studied seasons for all investigated characters of vegetative growth of mungbean cv. VC-1000. From the combined analysis of the two seasons, it was found that the highest values of vegetative characters (95.3 cm for plant height, 3.8 for number of branches per plant, 29.1 for number of leaves per plant and 91.2 g for dry weight of the shoot per plant) were recorded at the combined treatment of 23.25 kg P_2O_5/feddan in the presence of biofertilization with PDB. These results are in harmony with those obtained by Abo El-Nour *et al.* (1996) and El-Kalla *et al.* (1997) on faba bean and by Abd El-Lateef *et al.* (1998) on soybean plants.

2- Growth analysis :

A- Leaf area index (L.A.I.) :

The study was extended for analyzing mungbean growth by determination leaf area index (L.A.I.) and net assimilation rate (N.A.R.) from which crop growth rate (C.G.R.) was evaluated. The data of mungbean growth i.e., (L.A.I.), (N.A.R.) and (C.G.R.) is illustrated in Table (3). Leaf area index increased by advancing age up to 75 days from sowing. This is mainly due to the production of new leaves as well as leaves expansion through the growth of mungbean plants. The application of phosphorus fertilization or biofertilizer (PDB) increased significantly (L.A.I.). These results are similar in the studied ages or in combined analysis of two seasons. It can be noticed in three ages under study that, L.A.I. was increased significantly with raising phosphorus fertilizer up to 23.25 kg P_2O_5/fed. or inoculated seeds with (PDB). This results can be explained on the basis that phosphorus play an important role in plant metabolism, i.e., energy transfer reactions and nucleotide transfer reactions which reflect on leaf growth. In this respect, Balachandran and Sasidhar (1991) concluded that increasing phosphorus rates increased L.A.I. of greengram (*Vigna radiata*) cultivars. Also, El-Naggar (1998) reported that L.A. and L.A.I. increased when mungbean plants treated with 48 kg P_2O_5/fed. The interaction between phosphorus fertilizer and biofertilizer (PDB) recorded a significant effect on L.A.I. in three stages, i.e. 45, 60 and 75 days from sowing. The maximum value in three ages were obtained when mungbean plants received 23.25 kg P_2O_5/fed. and inoculated seeds with (PDB).

Table (3): Effect of biofertilizer and phosphorus fertilizer on L.A.I., N.A.R. and C.G.R. on different ages of mungbean growth at 2000 and 2001 seasons.

Treatments		Leaf area index (L.A.I.)								
		45 days			60 days			75 days		
		Seasons		combin. two	Seasons		combin. two	Seasons		combin. two
(P_2O_5 kg/fed.)	Biofertilizers	2000	2001	seasons	2000	2001	seasons	2000	2001	seasons
0	-	1.85	2.04	1.95	2.80	3.10	2.95	5.67	6.28	5.97
	+	2.21	2.48	2.35	3.62	4.06	3.84	6.04	6.78	6.41
Mean		2.03	2.26	2.15	3.21	3.58	3.40	5.86	6.53	6.19
7.75	-	2.48	2.88	2.68	3.93	4.57	4.25	6.57	7.63	7.10
	+	2.84	3.40	3.12	5.22	6.17	5.70	7.64	9.04	8.34
Mean		2.66	3.14	2.90	4.58	5.37	4.98	7.11	8.34	7.72
15.50	-	3.00	3.36	3.18	5.64	6.33	5.99	7.99	8.97	8.48
	+	3.50	3.89	3.69	6.44	7.17	6.81	8.72	9.69	9.21
Mean		3.25	3.63	3.44	6.04	6.75	6.40	8.36	9.33	8.85
23.25	-	3.42	4.07	3.75	6.43	7.73	7.08	8.29	9.97	9.13
	+	4.24	4.81	4.53	7.37	8.39	7.88	9.19	10.46	9.83
Mean		3.83	4.44	4.14	6.90	8.06	7.48	8.74	10.22	9.48
Seed inoc.	-	2.69	3.09	2.89	4.70	5.43	5.07	7.13	8.21	7.67
	+	3.20	3.65	3.42	5.66	6.45	6.06	7.90	8.99	8.45
L.S.D. (0.05) for :										
Phosphorus appl.	(A)	0.04	0.11	0.014	0.05	0.19	0.064	0.23	0.17	0.10
Seed inoc.	(B)	0.03	0.08	0.036	0.04	0.14	0.055	0.16	0.12	0.08
Interaction	(A x B)	0.06	N.S	0.037	0.07	0.27	0.099	0.32	0.24	0.18

Cont.

Table (3): Cont.

Treatments		Net assimilation rate (N.A.R.) g /dcm^2/ week						Crop growth rate (C.G.R.)					
		(45 - 60) days			(60 - 75) days			(45 - 60) days			(60 - 75) days		
		Seasons		combin. two seasons	Seasons		combin. two seasons	Seasons		combin. two seasons	Seasons		combin. two seasons
(P_2O_5 kg/fed.)	Biofertilizers	2000	2001		2000	2001		2000	2001		2000	2001	
0	-	0.734	0.688	0.711	0.964	0.957	0.961	2.06	2.13	2.10	5.47	6.01	5.74
	+	0.735	0.718	0.727	0.914	0.893	0.904	2.66	2.92	2.79	5.52	6.06	5.79
Mean		0.735	0.703	0.719	0.939	0.930	0.930	2.36	2.53	2.45	5.50	6.04	5.77
7.75	-	0.670	0.661	0.666	1.047	1.023	1.035	2.63	3.02	2.83	6.88	7.81	7.35
	+	0.660	0.608	0.634	0.936	0.864	0.900	3.45	3.75	3.60	7.15	7.81	7.48
Mean		0.665	0.635	0.650	0.992	0.944	0.968	3.04	3.39	3.22	7.02	7.81	7.42
15.50	-	0.649	0.616	0.633	0.886	0.783	0.835	3.66	3.90	3.78	7.08	7.02	7.05
	+	0.607	0.563	0.585	0.863	0.810	0.837	3.91	4.04	3.98	7.53	7.85	7.69
Mean		0.628	0.590	0.609	0.875	0.797	0.836	3.79	3.97	3.88	7.31	7.43	7.37
23.25	-	0.590	0.517	0.554	0.831	0.791	0.811	3.79	4.00	3.90	6.89	7.89	7.39
	+	0.514	0.483	0.499	0.804	0.811	0.808	3.79	4.05	3.92	7.39	8.48	7.94
Mean		0.552	0.500	0.527	0.818	0.801	0.810	3.79	4.03	3.91	7.14	8.19	7.67
Seed inoc.	-	0.661	0.621	0.641	0.932	0.889	0.914	3.04	3.26	3.15	6.58	7.18	6.88
	+	0.629	0.593	0.611	0.879	0.845	0.862	3.45	3.69	3.57	6.90	7.55	7.23
L.S.D. (0.05) for :													
Phosphorus appl.	(A)	0.021	0.085	0.031	0.035	0.093	0.037	0.06	0.280	0.094	0.25	0.371	0.193
Seed inoc.	(B)	0.015	N.S	N.S	0.025	N.S	N.S	0.04	0.196	0.072	0.18	0.262	0.119
Interaction	(A x B)	0.029	N.S	N.S	0.050	N.S	N.S	0.09	0.392	0.135	N.S	N.S	N.S

B- Net assimilation rate (N.A.R.):

Results concerning N.A.R. of mungbean plant under the various treatments are presented in Table (3). The data clearly indicate that N.A.R. was higher in the second period (60-75 days after sowing) compared with the first one (45-60 D.A.S.). These results could be ascribed to the rate of dry matter accumulation or photosynthesiate compounds in the second period which was more in proportion to the rate of leaf expansion (increase in leaf area), because mungbean plants in the first period (45-60 D.A.S.) directed its effort for flowering formation. Such results may demonstrated that the second period seemed to be the most important growth period for mungbean growth cycle.

The application of phosphorus fertilizer decreased significantly N.A.R. with raising phosphorus rate up to 23.25 kg P_2O_5/fed. in the first and second periods under study, i.e., 45-60 D.A.S. and 60-75 D.A.S.; respectively. Such decreased may be due to the role of phosphorus which increased L.A. of mungbean plants in the first and second periods in proportion to the rate of dry matter accumulation.

It is worthy to mention that inoculated mungbean seeds with (PDB) or the interaction effect between phosphorus fertilizer and biofertilizer (PDB) recorded insignificant effect on N.A.R. of mungbean plants.

C- Crop growth rate (C.G.R.) :

Table (3) show (C.G.R.) values of mungbean plant in the first and second periods. The values of (C.G.R.) were higher in the second period (60-75 D.A.S.) compared with the first one (45-60 D.A.S.). Such trend may due to the increase of L.A.I. by advancing age of mungbean as well as the increase of N.A.R. from the first period up to the second period.

Treated mungbean plants with phosphorus fertilizer increased significantly the values of C.G.R. These results may be owing to the increase of L.A.I. with raising phosphorus levels up to 23.25 kg P_2O_5/fed. In this connection, El-Naggar (1998) reported that on mungbean plant the values of C.G.R. were increased with raising phosphorus fertilizer from 24 kg P_2O_5/fed. up to 48 kg P_2O_5/fed. Also, inoculated mungbean seeds with (PDB) increased significantly

(C.G.R.) of mungbean plant in the first and second periods. Such findings may ascribed to the increase of L.A.I. with using (PDB).

It is worthy to mention that the interaction effect between phosphorus fertilizer and biofertilizer (PDB) recorded a significant effect on (C.G.R.) in the first period (45-60 D.A.S.), whereas insignificant effect was recorded in the second period (60-75 D.A.S.).

3- Photosynthetic pigments :

Data presented in Table (4) show the effect of phosphorus fertilizer and biofertilizer; i.e., phosphorus dissolving bacteria (PDB) on photosynthetic pigments in mungbean leaves (at 45 days old). The obtained data revealed that concentration of chl.a, chl.b and chl.(a+b) were increased significantly with increasing the rate of phosphorus fertilizer from 7.75 to 23.25 kg P_2O_5/fed. The maximum increase was detected at 23.25 kg/fed, being 76.50, 116.02 and 84.65% over the control for chl.a, chl.b and chl.(a+b), respectively. Such increase recorded a linear relationship. These findings may prove the role of phosphorus in stimulated chlorophyll synthesis through encourage pyridoxal phosphate enzymes formation which play an important role in α-amino levulinic acid synthetase as a primary compound in chlorophyll synthesis. In this respect, Maiti *et al.* (1988) reported that leaf chlorophyll concentration of mungbean plants was pronounced at higher level of phosphorus fertilizer; i.e., 100 kg P_2O_5/ha.

Data also indicated that biofertilizers caused significant increase in chl.a, chl.b and chl.(a+b) of mungbean leaves by 10.31, 16.58 and 11.72% more than the control, respectively.

Concerning the interaction effect between inorganic phosphorus fertilizer and biofertilizer (PDB) on chlorophyll pigments of mungbean leaves, obtained results showed insignificant effect. It is worthy to mention that the maximum values of chl.a, chl.b and chl.(a+b) were gained when plants received 23.25 kg P_2O_5/fed under treatment with phosphate dissolving bacteria (PDB).

Table (4): Effect of biofertilizer on photosynthetic pigments (mg/g F.Wt.) of leaves of mungbean plants cv. VC-1000 (45 days old) grown under different levels of phosphorus fertilizer in the first growing season of 2000.

Treatments		Photosynthestic pigments (mg/ g fresh weight)			
(P_2O_5 kg/fed.)	Biofertilizers	chl. a	chl. b	chl. a+b	carotenoides
0	-	7.822	1.894	9.713	0.669
	+	8.754	2.426	11.179	0.728
Mean		8.288	2.160	10.446	0.699
7.75	-	10.146	3.010	13.151	0.825
	+	11.642	3.510	15.147	0.753
Mean		10.894	3.260	14.149	0.789
15.50	-	12.384	3.588	15.968	1.109
	+	13.063	4.038	17.096	0.899
Mean		12.724	3.813	16.532	1.004
23.25	-	13.901	4.343	18.238	1.172
	+	15.354	4.989	20.339	0.705
Mean		14.628	4.666	19.289	0.939
Seed inoc.	-	11.063	3.209	14.268	0.944
	+	12.203	3.741	15.940	0.771
L.S.D. (0.05) for :					
Phosphorus appl.	(A)	0.522	0.309	0.731	0.184
Seed inoc.	(B)	0.369	0.218	0.517	0.130
Interaction	(A x B)	N.S	N.S	N.S	0.260

Regarding the effect of inorganic phosphorus fertilizer on carotenoides concentration of mungbean leaves, Table (4) indicate that increasing phosphorus fertilizer from 7.75 kg P_2O_5/ fed. up to 15.5 kg P_2O_5/fed. increased significantly carotenoides concentration compared with control; then a slight decrease was observed in carotenoides concentration of mungbean leaves when plants treated with 23.25 kg P_2O_5/fed. Whereas, inoculated mungbean seeds with PDB decreased significantly carotenoides concentration of mungbean leaves. The interaction showed a fluctuation in this respect.

4- Yield characters :

Data on yield characters of mungbean cv. VC-1000 as affected by biofertilizer with phosphate dissolving bacteria (PDB) under different levels of phosphorus fertilization in two seasons are given in Table (5). Traits which were followed up include : number of pods per plant, number of seeds per plant, weight of 100 seeds (g), yield of seeds (g) per plant, yield of seeds (kg) per plot (1/400 feddan) and yield of straw (kg) per plot (1/400 feddan).

Data presented in Table (5) reveal that the application of phosphorus fertilizer increased significantly all yield characters of mungbean cv. VC-1000 under investigation in both studied seasons except that of weight of 100 seeds (specific seed weight) in the first season where the differences among phosphorus levels are not significant. It is clear that number of pods per plant, number of seeds per plant, yield of seeds per plant, yield of seeds per plot (1/400 feddan) and yield of straw per plot (1/400 feddan) increased steadily with increasing level of phosphorus fertilizer up to 23.25 kg P_2O_5/feddan in both studied seasons. These results are in agreement with those obtained by Kalita (1989), Thakuria and Saharia (1990), Pal and Jana (1991), Patel and Patel (1991), Sarkar and Banik (1991), Tank *et al.* (1992), Ardeshna *et al.* (1993), Meena *et al.* (1993), Nikunja and Kakati (1996), Saxena *et al.* (1996), Sharma and Singh (1997) and Hessien (2000).

Also, it was found that plants obtained from biofertilized seeds

Table (5): Yield and yield components of mungbean cv. VC-1000 as affected by biofertilizer and phosphorus applications in two successive seasons (2000 and 2001).

Treatments		Yield characters								
		No. of pods/plant			No. of seeds/plant			Weight of 100 seeds (g)		
		Seasons		combin. two seasons	Seasons		combin. two seasons	Seasons		combin. two seasons
(P_2O_5 kg/fed.)	Biofertilizers	2000	2001		2000	2001		2000	2001	
0	-	19.5	21.3	20.40	198.9	208.7	203.8	5.62	5.79	5.71
	+	23.5	24.0	23.75	236.1	248.5	242.3	5.59	5.78	5.69
Mean		21.5	22.7	22.08	217.5	228.6	223.1	5.61	5.79	5.70
7.75	-	27.3	29.7	28.50	270.3	291.1	280.7	5.73	5.86	5.80
	+	30.0	34.3	32.15	316.0	343.0	329.5	5.92	5.98	5.95
Mean		28.7	32.0	30.33	293.2	317.1	305.1	5.83	5.92	5.88
15.50	-	30.3	36.7	33.50	337.2	381.7	359.5	5.69	6.17	5.93
	+	34.5	40.0	37.25	382.8	429.4	406.1	6.12	6.21	6.17
Mean		32.4	38.4	35.38	360.0	405.6	382.8	5.91	6.19	6.05
23.25	-	35.0	41.0	38.00	378.0	418.2	398.1	5.87	6.28	6.08
	+	40.7	46.7	43.70	416.9	471.7	444.3	6.24	6.29	6.27
Mean		37.9	43.9	40.85	397.5	445.0	421.2	6.06	6.29	6.18
Seed inoc.	-	28.03	32.18	30.10	296.1	324.9	310.5	5.73	6.03	5.88
	+	32.18	36.25	34.21	338.0	373.2	355.6	5.97	6.07	6.02
L.S.D. (0.05) for :										
Phosphorus appl. (A)		2.07	3.97	3.27	21.9	27.8	23.4	N.S	0.40	N.S
Seed inoc. (B)		1.42	2.38	2.12	15.6	20.1	15.8	N.S	N.S	N.S
Interaction (A x B)		2.65	4.53	3.85	28.4	35.2	29.2	N.S	N.S	N.S

Cont.

Table (5): Cont.

Treatments		Yield characters								
		Yield of seeds (g)/ plant			Yield of seeds (kg)/ plot (1/400 feddan)			Yield of straw (kg)/ plot (1/400 feddan)		
		Seasons		combin. two seasons	Seasons		combin. two seasons	Seasons		combin. two seasons
(P_2O_5 kg/fed.)	Biofertilizers	2000	2001		2000	2001		2000	2001	
0	-	11.18	12.08	11.63	1.621	1.773	1.697	7.548	8.453	8.001
	+	13.20	14.36	13.78	1.914	2.082	1.998	8.004	8.787	8.396
Mean		12.19	13.22	12.71	1.768	1.928	1.848	7.776	8.620	8.199
7.75	-	15.48	17.06	16.27	2.218	2.496	2.357	9.202	10.442	9.822
	+	18.71	20.51	19.61	2.730	2.972	2.851	10.411	11.519	10.965
Mean		17.10	18.79	17.94	2.474	2.734	2.604	9.807	10.981	10.394
15.50	-	19.19	23.55	21.37	2.808	3.438	3.123	10.426	11.107	10.767
	+	23.43	26.67	25.05	3.397	3.867	3.632	11.325	12.453	11.889
Mean		21.31	25.11	23.21	3.103	3.653	3.378	10.876	11.780	11.328
23.25	-	22.19	26.26	24.23	3.241	3.807	3.524	11.526	12.498	12.012
	+	26.02	29.67	27.85	3.825	4.302	4.064	12.877	13.565	13.221
Mean		24.11	27.97	26.04	3.533	4.055	3.794	12.202	13.032	12.617
Seed inoc.	-	17.01	19.74	18.38	2.472	2.879	2.675	9.676	10.625	10.151
	+	20.34	22.80	21.57	2.967	3.306	3.136	10.654	11.581	11.118
L.S.D. (0.05) for :										
Phosphorus appl.	(A)	1.78	2.58	2.24	0.259	0.337	0.329	0.604	0.659	0.625
Seed inoc.	(B)	1.23	2.12	1.82	0.195	0.284	0.272	0.377	0.406	0.393
Interaction	(A x B)	2.19	3.84	3.37	0.324	0.426	0.411	0.717	0.800	0.753

with phosphate dissolving bacteria (PDB) showed significant increase in all yield characters under investigation except that of 100-seed weight where the effect was not significant in both studied seasons. However, El-Kalla *et al.* (1997) on faba bean as well as Abd El-Lateef *et al.* (1998) on soybean recorded significant increase in 100-seed weight as a result of biofertilizer treatment with PDB, being in contrast with the present findings. From the combined analysis of the two seasons, the increase over the uninoculated control was 13.65% for number of pods/plant, 14.52% for number of seeds/plant, 17.36% for seed yield/plant, 17.23% for seed yield/plot (1/400 feddan) and 9.53% for straw yield/plot (1/400 feddan). In this respect, El-Kalla *et al.* (1997) found that the application of biophosphatic fertilizer (phosphorein) resulted in an increase in number of pods/ plant, number of seeds/pod, seed yield/plant and seed yield/feddan for faba bean plants, being in agreement with the present findings. Likewise, Abd El-Lateef *et al.* (1998) recorded significant increase in number of pods/plant and seed yield/plant of soybean due to application of PDB, being in accordance with the present findings.

The interaction between phosphorus fertilization levels and biofertilizer with phosphate dissolving bacteria revealed significant effect in both studied seasons for most of the investigated yield characters of mungbean cv. VC-1000. From the combined analysis of the two seasons, it is clear that the highest values of yield characters (43.7 for number of pods/plant, 444.3 for number of seeds/plant, 6.27 g for 100-seed weight, 27.85 g for yield of seeds/plant, 4.064 kg for yield of seeds/plot (1/400 feddan) and 13.221 kg for yield of straw/ plot) were detected at the combined treatment of 23.25 kg P_2O_5/feddan in the presence of biofertilization with PDB. These results are in conformity with those of Abo El-Nour *et al.* (1996) and El-Kalla *et al.* (1997) on faba bean and of El-Awag *et al.* (1993) and Abd El-Lateef *et al.* (1998) on soybean as well as of El-Sayed (1999) on lentil.

5- Chemical studies :

Data on chemical composition of mature dried seeds of mungbean cv. VC-1000 as affected by biofertilizer with phosphate dissolving bacteria under different levels of phosphorus fertilization in the first season of 2000 are shown in Table (6). Chemical analysis included percentages of crude protein, total lipids, total carbohydrates and phosphorus as well as potassium and sodium in ppm. Moreover, seed protein yield kg/feddan was calculated.

Results in Table (6) indicate that the application of phosphorus fertilizer increased significantly all investigated determinations except that of potassium and sodium concentrations in seeds of mungbean cv. VC-1000 where the differences among treatments proved insignificant. Likewise, seed protein yield was increased with increasing the rate of phosphorus fertilizer. The maximum increase in seed protein yield per feddan was detected at 23.25 kg P_2O_5/feddan, being 110.1% more than the control. It is worthy to note that the difference between 15.5 kg P_2O_5/feddan and 23.25 kg P_2O_5/feddan proved insignificant in this respect. Data also indicated that increasing phosphorus fertilizer from 7.75 to 15.5 P_2O_5/ feddan increased significantly the percentage of crude protein. Whereas, increasing phosphorus fertilizer from 15.5 to 23.25 kg P_2O_5/feddan decreased significantly crude protein percentage to the level that obtained by 7.75 kg P_2O_5/feddan.

Claims to the promoting effect of phosphorus fertilizer on protein content of seeds were also reported by Srivastava and Varma (1982) on greengram, Arya and Klara (1988) on *Vigna radiata*, Pandrangi *et al.* (1990) on *Phaseolus aureus*, Patel and Patel (1991) on *Vigna radiata*, Singh *et al.* (1994) on *Phaseolus radiatus* and El-Naggar (1998) on *Vigna radiata*. All, being in accordance with the present findings. Also, Pandrangi *et al.* (1990) as well as El-Naggar (1998) stated that phosphorus fertilizer increased the percentage of total carbohydrates in seeds of *Phaseolus aureus* and *Vigna radiata*, being in agreement with the present findings.

As to the effect of biofertilizer with phosphate dissolving bacteria (PDB), data revealed that such treatment increased significantly

Table (6): Some chemical composition of mature dried seeds of mungbean cv. VC-1000 as affected by seed inoculation with PDB, phosphorus fertilizer and interactions in the first season of 2000.

Treatments (P_2O_5 kg/fed.)	Biofertilizers	Crude protein %	Total lipids %	Total carbohydrates %	Phosphorus %	Potassium ppm	Sodium ppm	seed protein yield kg/fed.
0	-	19.203	1.403	48.95	0.185	0.398	0.108	124.51
	+	19.204	1.727	50.20	0.217	0.410	0.117	147.03
Mean		19.204	1.565	49.575	0.201	0.404	0.113	135.77
7.75	-	19.782	1.877	50.61	0.259	0.412	0.093	175.51
	+	21.554	2.903	52.37	0.345	0.427	0.093	235.37
Mean		20.668	2.390	51.490	0.302	0.420	0.093	205.44
15.50	-	21.500	3.127	54.57	0.363	0.407	0.093	241.49
	+	22.782	3.460	55.66	0.419	0.424	0.112	309.56
Mean		22.141	3.294	55.115	0.391	0.416	0.103	275.53
23.25	-	19.975	3.307	56.19	0.432	0.410	0.077	258.96
	+	20.361	3.400	58.75	0.435	0.411	0.110	311.52
Mean		20.168	3.354	57.470	0.434	0.410	0.094	285.24
Seed inoc.	-	20.115	2.429	52.58	0.310	0.407	0.093	200.12
	+	20.975	2.873	54.25	0.354	0.418	0.108	250.87
L.S.D. (0.05) for:								
Phosphorus appl.	(A)	0.924	0.502	1.96	0.029	N.S	N.S	18.41
Seed inoc.	(B)	0.654	0.355	1.39	0.020	N.S	N.S	12.72
Interaction	(A x B)	N.S	N.S	N.S	0.041	N.S	N.S	22.64

seed percentages of crude protein, total lipids, total carbohydrates and phosphorus. Whereas, such treatment showed no statistical effect on concentrations of potassium and sodium. It is clear that biofertilizer with PDB increased significantly seed protein yield per feddan of mungbean cv. VC-1000. In this respect, El-Kalla *et al.* (1997) stated that phosphorein increased seed protein content in seeds of faba bean, being in agreement with the present findings.

The interaction between phosphorus fertilization levels and biofertilizer with phosphate dissolving bacteria revealed insignificant effect in all determinations except that of phosphorus and seed protein yield where the differences among treatments proved significant. The maximum increase in seed protein yield per feddan was recorded at the combined treatment of 23.25 kg P_2O_5/feddan in the presence of biofertilization with PDB, which in turn being indifferent with the combined treatment of 15.5 kg P_2O_5/feddan in the presence of PDB. The previous report of Abd El-Lateef *et al.* (1998) stated that crude protein and total lipids percentages in seeds of soybean plants treated with phosphorus fertilizer with the presence of PDB were increased, being in accordance with the present findings.

From the abovementioned results, it was found that the combined treatment of 23.25 kg P_2O_5/feddan in the presence of biofertilizer with phosphate dissolving bacteria gave maximum yield of seed as well as of protein seed of mungbean cv. VC-1000. Therefore, such treatment could be recommended in productivity of mungbean plant.

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تأثير التسميد الحيوى بالبكتيريا المذيبة للفوسفور تحت مستويات مختلفة من التسميد الفوسفاتى على نبات فول المانج

فاطمة عبدالمنصف عبده

قسم بحوث فسيولوجيا المحاصيل - معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية - الجيزة - مصر.

أجرى هذا البحث فى محطة بحوث التجارب الزراعية - مركز البحوث الزراعية بالجيزة خلال موسمى النمو ٢٠٠٠ و ٢٠٠١ لدراسة تأثير التسميد الحيوى بالبكتيريا المذيبة للفوسفات تحت مستويات مختلفة من التسميد الفوسفاتى (صفر ، ٧,٧٥ ، ١٥,٥ و ٢٣,٢٥ كجم فوسفور/للفدان على الصفات الخضرية ، تحليل النمو ، صبغات البناء الضوئى ، المحصول ومكوناته وكذلك محتوى البذور من البروتين والدهون والكربوهيدرات بالإضافة الى الفوسفور* والبوتاسيوم والصوديوم لصنف فول المانج VC-1000.

أوضحت النتائج المتحصل عليها أن إضافة التسميد الفوسفاتى يؤدى الى حدوث زيادة معنوية فى معظم الصفات المدروسة وهى ارتفاع النبات ، عدد الأفرع للنبات ، عدد أوراق النبات ، الوزن الجاف للمجموع الخضرى ، دليل مساحة الأوراق ، محتوى الأوراق من الكلوروفيلات ، عدد قرون النبات ، عدد بذور النبات ، محصول النبات من البذور ، محصول القطعة من البذور (١/٤٠٠ فدان) ، محصول القطعة من القش ومحصول الفدان من بروتين البذور بالإضافة الى النسبة المئوية فى البذور لكل من الكربوهيدرات الكلية والدهون والفوسفور. كما يتضح أن زيادة معدل التسميد الفوسفاتى يؤدى الى زيادة فى الصفات السابقة حتى معدل تسميد ٢٣,٢٥ كجم فوسفور للفدان. أيضاً النباتات الناتجة من البذور المعاملة بالتسميد الحيوى يزيد فيها قيم الصفات السابقة. ومما هو جدير بالذكر أن أقصى زيادة حدثت فى محصول القطعة (١/٤٠٠ فدان) من البذور وكذلك محصول الفدان من بروتين البذور تم تسجيلها عند معدل تسميد ٢٣,٢٥ كجم فوسفور للفدان مع إضافة التسميد الحيوى.