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# EFFECT OF PHOSPHATE DISSOLVING BACTERIA (PHOSPHOREIN) ON GROWTH, YIELD AND CHEMICAL COMPOSITION OF MUNG BEAN UNDER DIFFERENT LEVELS OF MINERAL PHOSPHORUS FERTILIZATION

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## ABSTRACT

Two field experiments were conducted to study the effect of different rates of biofertilizer (Phosphorein) combined with different levels of phosphorus on mung bean plants.

Using phosphorein with the rates of 200, 300 and 400 (g) / feddan in combination with 15.50, 23.25 and 31.00 kg $P_2O_5$/fed. promated the vegetative growth and seed yield of mung bean plants.

The highest values of main stem length, number of branches, total leaf area, dry weight of shoot and seed yield plant, were obtained when the combination between 200 (g)/ feddan of phosphorein and 23.25 kg $P_2O_5$/ feddan was used.

The vigor of vegetative growth recorded due to phosphorein application at the rate of 200 g/fed. in combination with 23.25 kg $P_2O_5$ and accompanied with increasing in amounts of different tissues of stem and leaf specially the vascular tissues.

High values of N, P and K concentrations in both shoots and seeds as well as chlorophyll a and b in the leaves and protein % in the seeds were recorded by the plants treated by any of the three different rates of biofertilizer phosphorein either alone or when combined with any of the three different rates of phosphorus fertilization if compared with corresponding plants untreated with biofertilizer. However, a reverse trend was obtained in total carotenoids by the same treatments.

## INTRODUCTION

Fruitful efforts have been made by Egyptian investigators to benefit from mung bean (*Vigna radiata* (L.) Wilczek) as a pluse crop to be cultivated under local conditions. These efforts resulted in producing the local mung bean cv. Kawmy 1 being registered and certified in 1997 by Egyptian Ministry of Agriculture.

Highly nutritions seeds of mung bean are eaten split or whole, boiled or roasted. Green pods are eaten as vegetable. In China and the United States sprouted mungbean are a common vegetable in dishes. Ripe roasted seeds are made into flour in many tropical areas. Seeds are utilized in making soups, curries, bread, sweets, noodles, salads and many other culinary products. Protein in the seeds ranging between 24-28% (Poehlman, 1991). Mung bean is grown as manures, hay, cover crop and for forage. Husks are soaked and used for cattle feed.

It was found that biofertilization either with single or multi application, using several bacterial strains, such as *Bacillus megatherium*, *Azotobacter*, *Azospirillum* or *Pseudomonas* induced significant increases in plant growth and yield (Yousry *et al.*, 1978; Radwan, 1983; Saber and Gomaa, 1993; Awad, 1998 and Hewedy, 1999). Applying biofertilizers alone without simulative rates from mineral fertilizers (25%, 33% , 50% or 75% from the recommended chemical fertilizers) according to soil fertility, or organic manure was less effective than the recommended rates of NPK fertilizer (Gomaa, 1989; Shawky, 1990; Saber and Gomaa, 1993; Abdel-Ati *et al.*, 1996; Awad, 1998 and Hewedy, 1999).

The present investigation was carried out to study the effect of combination between different rates of biofertilizer (phosphorein) and three levels of phosphorus fertilization on growth characters and internal structure of mung bean. The effect on yield and some chemical constituents was also discussed.

## MATERIAL AND METHODS

Two field experiments were conducted at the Experimental Farm, Faculty of Agriculture, Cairo University, Giza, Egypt during the two successive seasons 1999 and 2000 to study the effect of different rates of biofertilizer (phosphorein) combined with different levels of phosphorus on mung bean. Seeds of mung bean (Vigna radiata var. Kawmy I) used in this study were obtained from the Food Legume Section, Field Crop Research Institute, Agricultural Research Center, Giza, Egypt. The sowing dates were 5th and 7th of May for the two seasons 1999 and 2000, respectively.

The layout of the field experiment was split plot design with three replications ($10m^2$, 4× 2.5 m.). Seeds were sown in ridges, each four meter long and 60 cm apart. Seeds were hand sown in the two sides of the ridges with 4 seeds / hill, 30 cm distance between hills. Three weeks after sowing the plants were thinned to two plants / hill.

Irrigation and agricultural practices were applied according to the recommendations of the Ministry of Agriculture (4 irrigation in the season to two weeks intervals).

Nitrogen and potassium fertilization were applied according to the recommendations of the Ministry of Agriculture, 50 kg/fed. ammonium sulphate (20.5 % N) during sowing and 50 kg/fed. potassium sulphate (48% $K_2O$) three weeks after sowing.

The experiment included 12 treatments, in each of the two seasons, three levels of phosphorus fertilizer were added to the soil before planting in the form of calcium super phosphate 15.5% $P_2O_5$ (15.50, 23.25 and 31.00 kg $P_2O_5$ / fed.) as main plots as the following :

1- Phosphorus was applied at 100 kg / fed. calcium super phosphate 15.50% (15.5 kg $P_2O_5$ / fed.).
2- Plants fertilized with 150 kg / fed. calcium super phosphate 15.50% (23.25 kg $P_2O_5$ / fed.).
3- Plants fertilized with 200 kg / fed. calcium super phosphate 15.50% (31.00 kg $P_2O_5$ / fed.).

For each mineral phosphorus fertilization level four rates of phosphorein biofertilizer soil addition were applied as sub-plot treatments as the following :

1- Control treatment without biofertilizer soil addition.
2- Biofertilizer phosphorein at the rate of 200 g/fed.
3- Biofertilizer phosphorein at the rate of 300 g/fed.
4- Biofertilizer phosphorein at the rate of 400 g/fed.

Phosphorein (phosphate dissolving bacteria *Bacillus megatheruium* var. phosphaticum) was obtained from the Agricultural Balance Institute, Agricultural Research Center, Giza, Egypt (G. O. A. E. F.). Phosphorein mixed with seeds at sowing in hills.

At the age of 75 days, 9 plants were taken at random from each treatment and the following morphological and growth characters were recorded:

1- Main stem length (cm)
2- Number of branches / plant.
3- Total leaf area / plant ($cm^2$)
4- Dry weight of shoot/plant.

At harvesting (90 days after sowing) the following yield components were recorded:

1- Number of pods / plant.
2- Number of seeds / plant
3- Weight of 1000 seeds (g).
4- Seed yield (g/plant).

**Anatomical studies:**

For anatomical study, samples of main stem and leaf, taken at the age of 45 days, were killed and fixed in F. A. A. (10 ml. Formalin, 5 ml. Glacial acetic acid, 85 ml. Ethyl alcohol 70%).

Fixed materials were dehydrated by normal butyl alcohol method and embedded in paraffin wax, melting point 54.58 °C.

Sections 15-20 μ thick were cut. Crystal violet erythrosine combination methods was used for staining (Jackson, 1926). Stained sections were mounted in canada balsam (Willey, 1971).

Data of growth characters and yield components were statistically analyzed by using Complete Randomized Blocks Design (C. R. B. D.) for factor A (phosphorus) as a main plot treatments and factor B (phosphorein) as a sub-plot treatments, and the means were compared using the least significant difference test (L. S. D.) values at 5% and 1% levels (Snedecor and Cochran, 1980).

**Chemical analysis:**

Plant pigments (chlorophyll a, chlorophyll b and carotenoids) in fresh leaves were extracted with dimethyl formamid (DMF) solvent and determined according to method described by Nornai (1982).

Determination of total nitrogen, phosphorus and potassium were carried out on the ground dry material of shoot and seeds. For the determination of total nitrogen, the modified Micro Kjeldahl apparatus was used as described by Pregl (1945). For total phosphorus and potassium determination, the wet digestion of 0.2 g plant material with sulphuric and perchloric acids as recommended by Piper (1947) was used. Phosphorus was estimated colorimetrically using the chlorostnnous reduced molybdophosphoric by Jackson (1967). Potassium was determined by using flamephotometer.

## RESULTS AND DISCUSSION

**1- Effect on external features of plant shoot:**

Data of main stem length, number of branches, total leaf area per plant and dry weight of plant shoot in the two growing seasons 1999 and

2000 as affected with phosphorein under different levels of mineral phosphorus fertilization are presented in Tables 1 and 2.

It is obvious from the tables that, irrespective of the effect of different phosphorus levels, phosphorein at any of the three used rates increased the average of each of the above mentioned characters comparing with the corresponding controls. These increments were statistically significant in the two seasons, with some exceptions.

As to the effect of combination between different rates of phosphorein and the three levels of phsphorus fertilization, it is clear that using phosphorein with the rates of 200, 300 or 400 (g) / feddan in combination with 15.50, 23.25 or 31.00 kg $P_2O_5$ / fed. promoted the growth of mung bean stem. The combination between 23.25 kg $P_2$ $O_5$/ fed. and 200 or 300 g / fed. of phosphorein was more effective in this respect. The positive effect of phosphorein on stem elongation might be due to increase in number and / or length of internodes. These results are in agreement with the findings of Kostov *et al.* (1991) on tomato, Yadav *et al.*, (1992) on mung bean, Abdel-Ati *et al.* (1996) on potato and Awad (1998) on tomato plants.

Application of biofertilizer (phosphorein) not only promoted main stem extension but also increased its branching as well as the total leaf area / plant. The highest number of branches were recorded with the combination between the rate of 200 g/feddan phosphorein and 23.25 kg $P_2O_5$ / feddan. However, in both seasons using phosphorein at any concentration significantly increased the average total leaf area per plant when compared with control. In this connection Abdel-Ati *et al.* (1996) noticed that values of plant height and number of branches of potato plant inoculated with phosphate dissolving bacteria in the presence of the recommended dose of the chemical fertilizers were significantly higher than those of untreated ones.

Under the phosphorus level of 23.25 or 31.00 kg $P_2O_5$ / feddan, the highest value of shoot dry weight was obtained by using 200 g/feddan of phosphorein. The two higher rates of phosphorein produced values of shoot dry weight lower than those recorded for 200 g/feddan of phosphorein.

Under the phosphorus level of 15.50 kg $P_2O_5$ / feddan, the highest value of shoot dry weight was recorded with phosphorein rate of 400 g/feddan. It could be said therefore, that under this level of phosphorus dry weight of plant shoot responded positively by raising the rate of phosphorein up to 400 g/feddan. It is worthy to notice that the values of plant shoot dry weight of combination between 300 or 400 g / feddan of phosphorein and 15.50 kg $P_2O_5$ / feddan were higher than those of 23.25 and 31.00 kg $P_2O_5$ / feddan without phosphorein.

Table (1): Some growth characters of mungbean plants at 75 days after sowing as affected by phosphorein under different levels of phosphorus fertilization during season 1999.

| Characters | Main stem length (cm) / plant | | | | Number of branches / plant | | | | Total leaf area $(cm)^2$ / shoot plant | | | | Dry weight of shoot (g) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $P_2O_5$ kg/fed. Phosphorein g/fed. | 15.50 | 23.25 | 31.00 | Average (B) | 15.50 | 23.25 | 31.00 | Average (B) | 15.50 | 23.25 | 31.00 | Average (B) | 15.50 | 23.25 | 31.00 | Average (B) |
| Control | 74.2 | 85.2 | 68.8 | 76.1 | 3.7 | 4.8 | 3.5 | 4.0 | 1525 | 1906 | 1176 | 1536 | 24.7 | 33.3 | 22.4 | 26.8 |
| 200 | 75.2 | 102.0 | 71.2 | 82.8 | 4.1 | 5.9 | 4.0 | 4.7 | 2262 | 4895 | 2433 | 3197 | 28.0 | 38.9 | 23.2 | 30.0 |
| 300 | 79.8 | 87.9 | 70.2 | 79.3 | 5.1 | 5.8 | 3.7 | 4.9 | 3715 | 4401 | 2141 | 3419 | 31.9 | 33.4 | 22.0 | 29.1 |
| 400 | 80.2 | 85.2 | 70.8 | 78.7 | 5.3 | 4.5 | 3.6 | 4.5 | 3387 | 3691 | 2225 | 3101 | 32.3 | 29.1 | 19.2 | 26.8 |
| Average (A) | 77.4 | 90.1 | 70.3 | | 4.6 | 5.3 | 3.7 | | 2722 | 3723 | 1994 | | 29.2 | 33.7 | 21.7 | |
| L. S. D. | 5 % | | 1% | | 5 % | | 1 % | | 5 % | | 1 % | | 5 % | | 1 % | |
| A | 1.57 | | 2.60 | | 0.51 | | N.S | | 168.1 | | 278.7 | | 2.46 | | 4.08 | |
| B | 1.89 | | 2.58 | | 0.32 | | 0.43 | | 245.4 | | 336.3 | | 1.37 | | 1.88 | |
| A * B | 3.27 | | 4.47 | | 0.55 | | 0.75 | | 425.1 | | 582.4 | | 2.38 | | 3.26 | |

Table (2): Some growth characters of mungbean, plants at 75 days after sowing as affected by phosphorein under different levels of phosphorus fertilization during season 2000.

| Characters | Main stem length (cm)/plant | | | | Number of branches / plant | | | | Total leaf area $(cm)^2$ / shoot plant | | | | Dry weight of shoot (g) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $P_2O_5$ kg/fed. Phosphorein g / fed. | 15.50 | 23.25 | 31.00 | Average (B) | 15.50 | 23.25 | 31.00 | Average (B) | 15.50 | 23.25 | 31.00 | Average (B) | 15.50 | 23.25 | 31.00 | Average (B) |
| Control | 77.6 | 105.4 | 77.5 | 86.8 | 4.0 | 5.6 | 4.1 | 4.6 | 4669 | 4544 | 3069 | 4094 | 41.6 | 49.1 | 38.6 | 43.1 |
| 200 | 102.7 | 123.6 | 88.1 | 104.8 | 3.8 | 5.7 | 4.9 | 4.8 | 4348 | 6952 | 3125 | 4808 | 43.1 | 90.8 | 55.3 | 63.1 |
| 300 | 123.5 | 125.8 | 97.7 | 115.7 | 4.4 | 5.6 | 4.2 | 4.7 | 3645 | 6359 | 3485 | 4496 | 58.6 | 59.7 | 31.6 | 50.0 |
| 400 | 125.8 | 100.5 | 87.3 | 104.5 | 5.6 | 4.9 | 4.1 | 4.9 | 6518 | 3875 | 2518 | 4304 | 77.0 | 47.8 | 29.9 | 51.6 |
| Average (A) | 107.4 | 113.8 | 87.7 | | 4.5 | 5.5 | 4.3 | | 4795 | 5433 | 3049 | | 55.1 | 61.9 | 38.9 | |
| L. S. D. | 5 % | | 1 % | | 5 % | | 1% | | 5% | | 1% | | 5% | | 1% | |
| A | 2.58 | | 4.28 | | 0.32 | | 0.69 | | 205.2 | | 457.5 | | 3.29 | | 5.45 | |
| B | 2.89 | | 3.96 | | 0.31 | | N.S | | 276.4 | | 378.6 | | 1.56 | | 2.13 | |
| A * B | 5.00 | | 6.86 | | 0.55 | | 0.75 | | 478.7 | | 655.8 | | 2.69 | | 3.69 | |

The increase in shoot dry weight could be attributed to the increase in stem growth, number of branches, number of leaves, fresh weight of shoot and total leaf area / plant. The enhancement of plant shoot dry weight due to inoculation with phosphorein was found by many workers. Saber (1994) reported that dry matter increased by 259% in wheat, 112% in corn, 234 in barley, 112% in squash and 119% in tomatoes over the control due to the effect of biofertilization. Abdel – Ati *et al.* (1996) on potato and Awad (1998) on tomato noticed similar results.

**2- Effect of phosphorein on internal structure of plant shoot:**

Transactions of different levels of mung bean main stem, and leaf at the median portion of main stem were examined at the age of 45 days to study the effect of phosphorein on their structure under phosphorus level which induced higher vegetative growth (23.25 kg $P_2O_5$ / feddan) when combined with phosphorein.

**a- Structure of main stem:**

Transactions of the upper internode, directly below the shoot apex, revealed that phosphorein affected the different primary tissues of the stem (Fig. 1). The diameter of whole cross section increased from 3454 μ for control up to 3846 by treatment with 200 g/feddan of phosphorein. On the other hand, it decreased to 3100 μ by the rate of 400 g/feddan phosphorein. Thickness of cortex unchanged at the rate of 200 g/feddan but decreased with the rate 400 g/feddan of phosphorein in comparison with control. Number of vascular bundles, number of vessels per bundle and size of small bundles increased at the rate of 200 g/feddan phosphorein, then decreased by raising phosphorein up to 400 g/feddan when compared with control. The mean area of large vascular bundle in the transverse section increased by treatment with phosphorein at the rate of 200 or 400 g/feddan. The increment was more pronounced at the rate of 200 g/feddan phosphorein. No differences in diameter of pith were recorded between phosphorein treatments and control except a slight decrease at the rate of 400 g/feddan phosphorein (Table 3).

Transverse sections of median and basal interondes showed that inoculation with phosphorein increased the diameter of main stem (Table 4 and Figs. 2 and 3). The mean diameter of median internode increased by about 27% and 25% while that of the basal internode increased by about 22% and 25% with 200 and 400 g/feddan of phosphorein, respectively.

Diameter of xylem cylinder and thickness of xylem were increased indicating that the amount of xylem tissue was increased due to treatment with phosphorein. Thickness of vascular cylinder was increased as a result of the enhancement of xylem and phloem formation. The increment of vascular tissues could be attributed to the promotion of cambial activity, which produced higher amount of secondary conducting tissues due to phosphorein application. Fig. (4) show the increase in width of cambial region of main stem due to the higher activity of vascular cambium in phosphorein treated plants.

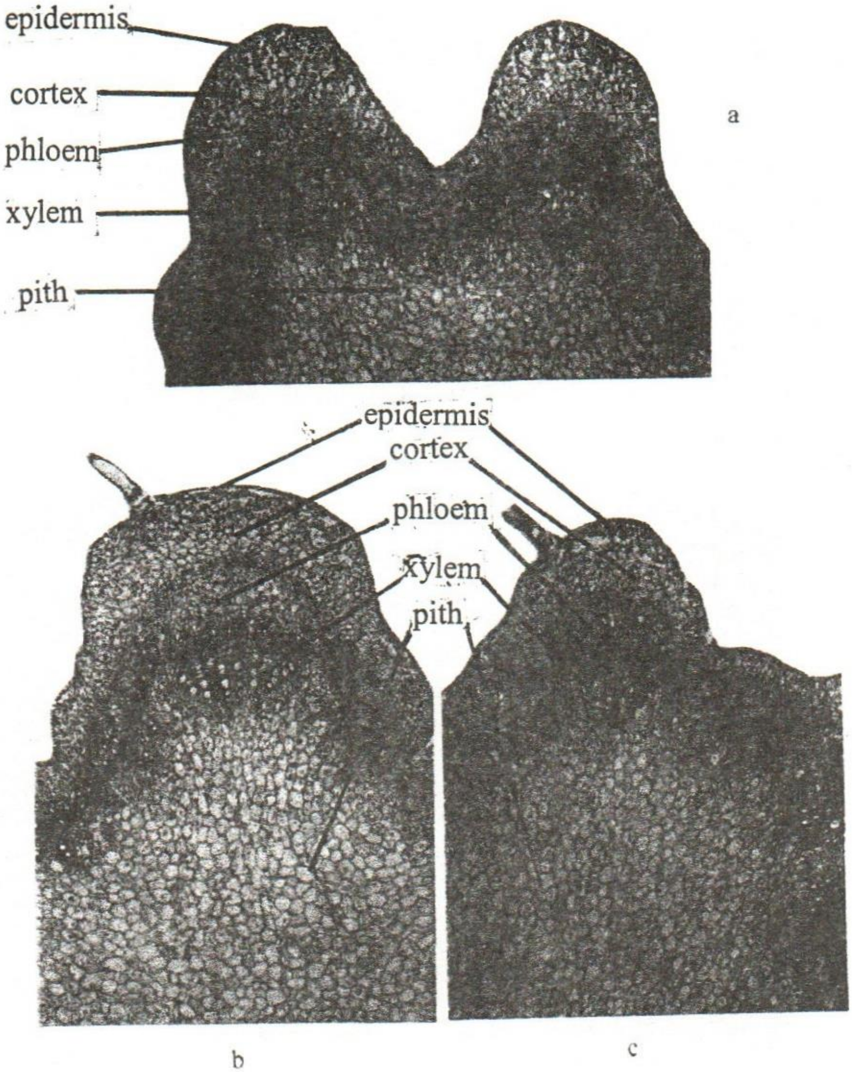



Fig. 1 : Transverse sections of main stem upper internode as affected by phosphorein under phosphorus level of 23.25 kg $P_2O_5$ /feddan. (x 40)
a: Control. b: 200 g/fed. of Phosphorein c: 400 g/fed. of Phosphorein

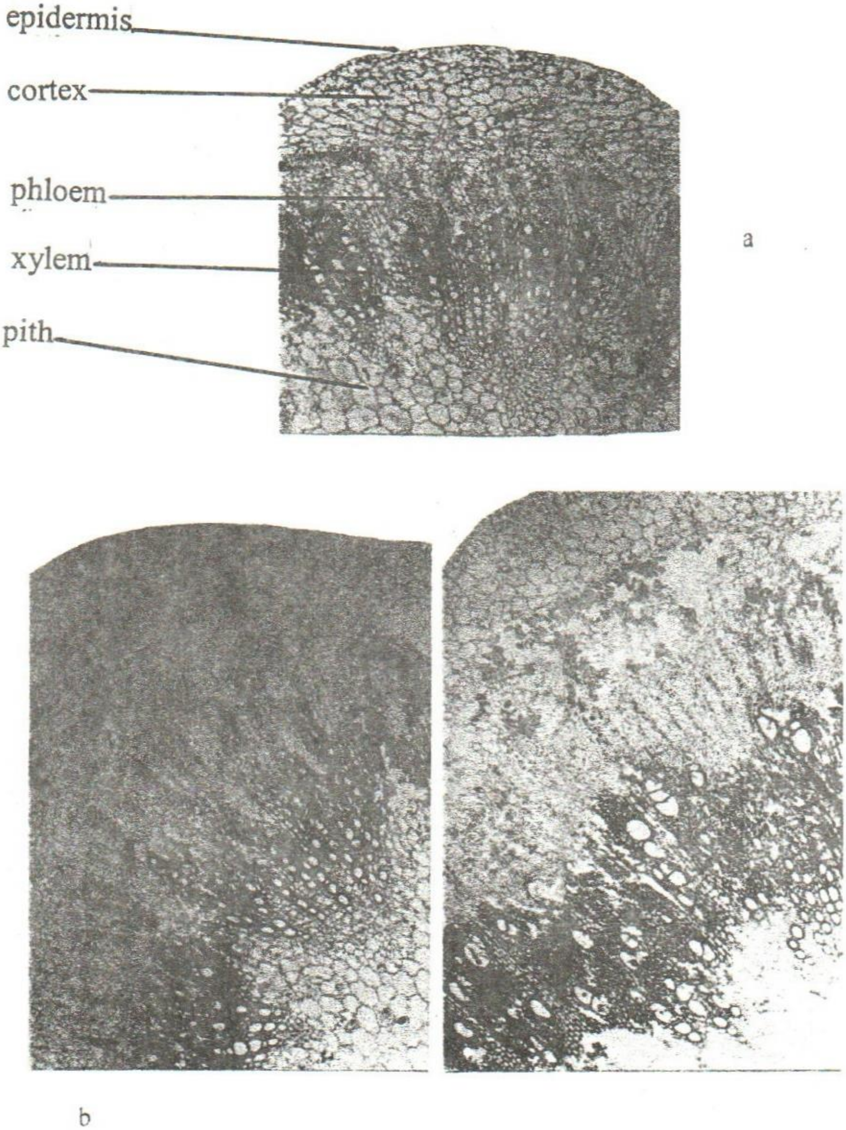



**Fig. 2 : Transverse sections of main stem medain internode as affected by phosphorein under phosphorus level of 23.25 kg $P_2O_5$ /feddan. (x 40)**
a: Control. b: 200 g/fed. of Phosphorein c: 400 g/fed. of Phosphorein

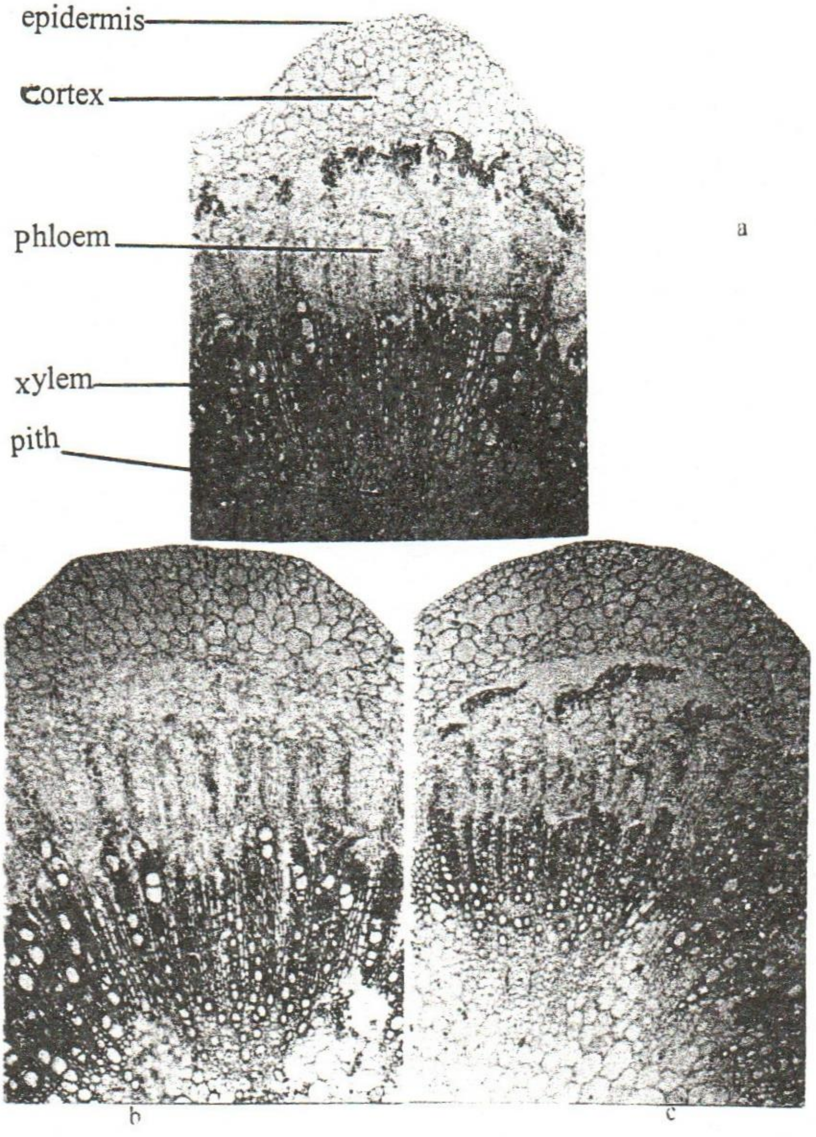
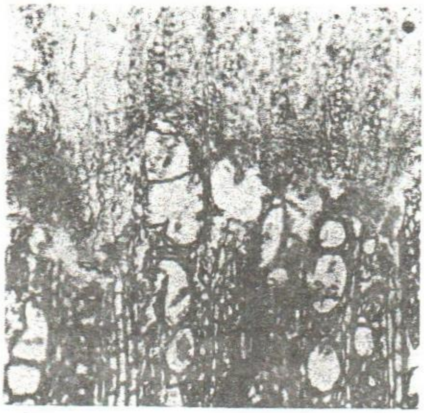
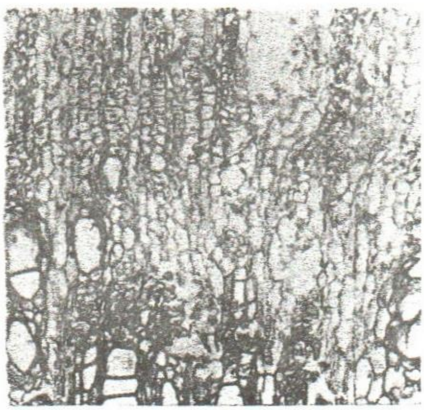



Fig. 3 : Transverse sections of main stem basal internode as affected by phosphorein under phosphorus level of 23.25 kg $P_2O_5$ /feddan. (x 40)
a. Control. b. 200 g/fed. of Phosphorein. c: 400 g/fed. of Phosphorein.



a



b

Fig. 4 : **Transverse sections of main stem basal internode as affected by phosphorein under level of phosphorus 23.25 kg $P_2O_5$ /feddan. (x100)**
Notice the increase in cambial zone of phosphorein inoculated stems.
a: Control. b: 200 g/fed. of Phosphorein.

**Table (3): Some anatomical parameters of the upper intrnode of mung bean main stem (45 days-old) treated with phosophorein under level of 23.25 kg $P_2O_5$ / feddan of phosphorus fertilization.**

| Treatments / Parameters (in micron) | Control | Phosphorein (g/fed.) | |
|---|---|---|---|
| | | 200 | 400 |
| Diameter of whole section | 3454.0 | 3846.5 | 3100.8 |
| Thickness of cortex | 353.3 | 353.3 | 235.5 |
| Number of vascular bundles | 18 | 22 | 17 |
| Length & Width of: | | | |
| - Large bundle: | | | |
| Length | 565.2 | 628.0 | 459.5 |
| Width | 392.5 | 549.5 | 471.0 |
| - Small bundle: | | | |
| Length | 314.0 | 345.4 | 392.5 |
| Width | 314.0 | 314.0 | 235.5 |
| Number of vessels / bundle: | | | |
| Large bundle | 20 | 26 | 16 |
| Small bundle | 7 | 8 | 7 |
| Diameter of pith | 2198.0 | 2198.0 | 1962.5 |

**Table (4) : Average of different anatomical parameters of the median and basal internodes of mung bean main stem (45 days-old) treated with phosphorein under level of 23.25 kg $P_2O_5$/ fed phosphorus fertilization.**

| Internode | Median internode | | | Basal internode | | |
|---|---|---|---|---|---|---|
| Treatments / Parameters (in micron) | Control | Phosphorein (g/fed.) | | Control | Phosphrein (g/fed.) | |
| | | 200 | 400 | | 200 | 400 |
| Diameter of whole section | 7065.0 | 8988.3 | 8847.0 | 7771.5 | 9537.8 | 9773.3 |
| Diameter of xylem cylinder | 5769.8 | 7025.8 | 5926.8 | 6319.3 | 6751.0 | 7614.5 |
| Thickness of cortex | 510.3 | 667.3 | 745.8 | 745.8 | 785.0 | 785.0 |
| Thickness of vascular cylinder | 957.8 | 1491.6 | 1373.8 | 1059.8 | 2669.0 | 1884.0 |
| Thickness of xylem | 667.3 | 1059.8 | 981.3 | 785.0 | 1962.5 | 1413.0 |
| Thickness of phloem | 290.5 | 431.8 | 392.5 | 274.8 | 706.5 | 471.0 |
| Diameter of pith | 4239.0 | 4867.0 | 5573.5 | 4867.0 | 4749.3 | 5220.3 |

Thickness of cortex and diameter of pith was increased in the median internode by application of 200 or 400 g/feddan phosphorein comparing with control. However cortex and pith were wider in stems of plants treated with 400 g/feddan phosphorein than those inoculated with 200 g/feddan. In basal internode, thickness of cortex was increased with the two rates 200 and 400 g/feddan of phosphorein, while diameter of pith decreased with the rate of 200 g/feddan phosphorein and increased by raising phosphorein rate up to 400 g/feddan.

**b- leaf structure:**

Transverse section of leaf blade at the median region of main stem were examined at the age of 45 days.

It is clear from Table (5) and Fig. (5) that phosphorein at the rate of 200 or 400 g/feddan increased the sizes of midrib and midvein. The larger size of midvein could be reasoned by the higher thickness of xylem tissue due to phosphorein inoculation. However the thickness of midvein phloem was decreased in blades of phosphorein treated plants, in comparison with those untreated.

Thickness of blade was enhanced with the application of 200 or 400 g/feddan phosphorein comparing with control. The increase in blade thickness could be attributed to the increase in thickness of both palisade and spongy tissues due to phosphorein application.

**Table (5): Some anatomical parameters of the leaflet blade of mung bean (45 days –old) treated with phosophorein under level of 23.25 kg $P_2O_5$ / feddan of phosphorus fertilization.**

| Treatments / Parameters (in micron) | Control | Phosphorein (g/fed.) | |
|---|---|---|---|
| | | 200 | 400 |
| Thickness of midrib | 1208.9 | 1208.9 | 1570.0 |
| Width of midrib | 863.5 | 1099.0 | 989.1 |
| Dimention of midvein: | | | |
| Length | 361.1 | 392.5 | 345.4 |
| Width | 502.4 | 549.5 | 596.6 |
| Xylem thickness | 204.1 | 282.6 | 266.9 |
| Phloem thickness | 157.0 | 109.9 | 78.5 |
| Number of vessels / bundle: | | | |
| Large bundle | 60 | 65 | 58 |
| Small bundle | 13 | 5 | 14 |
| Thickness of blade | 235.5 | 251.2 | 266.9 |
| Thickness of palisade tissue | 157.0 | 157.0 | 188.4 |
| Thickness of spongy tissue | 78.5 | 94.2 | 78.5 |

It could be concluded therefore that when mung bean plants fertilized with 23.25 kg $P_2O_5$/feddan and inoculated with phosphate dissolving bacteria (phosphorein) especially at the rate of 200 g/feddan produced thicker and taller stems than those received mineral phosphorus alone. Photosynthetic area was also increased in phosphorein treated plants due to enhancement of leaf area / plant as well as leaf thickness. Promotion of main stem thickness was mainly due to the enhancement of vascular tissue formation in phosphorein treated plants. The increase in the amount of conducting tissues might be responsible for vigorous vegetative growth and increased yield of phosphorein inoculated plants.

**3- Effect on seed yield/plant:**

Data in Tables (6 and 7) reveal that the different rates of phosphorein specially 200 g / feddan significantly increased the average yield of seeds / plant. However, the increased yield induced by the two rates 300 and 400 g/feddan of phosphorein was statistically insignificant in the first season. In the two seasons the combination between 200 g/ feddan of phosphorein and 23.25 kg $P_2O_5$ / feddan produced the highest seed yield / plant.

Table (6): Yield and yield components of mung bean plant as affected by Phosphorein under different levels of phosphorus fertilization during season 1999.

| Yield Components | Number of pods / plant | | | | Number of seeds / plant | | | | Weight of 1000 seed (g) | | | | Seeds yield (g/plant) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $P_2O_5$ kg/fed. Phosphorein (g/fed.) | 15.50 | 23.25 | 31.00 | Average (B) | 15.50 | 23.25 | 31.00 | Average (B) | 15.50 | 23.25 | 31.00 | Average (B) | 15.50 | 23.25 | 31.00 | Average (B) |
| Control | 44.3 | 52.3 | 45.0 | 47.2 | 130.9 | 272.1 | 138.5 | 180.5 | 44.3 | 44.8 | 36.1 | 41.7 | 5.8 | 12.2 | 5.0 | 7.7 |
| 200 | 47.0 | 45.3 | 47.7 | 46.7 | 226.2 | 290.2 | 158.5 | 225.0 | 46.9 | 48.2 | 42.3 | 45.8 | 10.6 | 14.0 | 6.7 | 10.4 |
| 300 | 37.7 | 34.0 | 35.7 | 35.8 | 206.5 | 225.2 | 194.1 | 208.6 | 39.2 | 46.6 | 36.6 | 40.8 | 8.1 | 10.5 | 7.1 | 8.6 |
| 400 | 40.7 | 50.3 | 40.0 | 43.7 | 201.5 | 245.0 | 145.9 | 197.5 | 39.7 | 46.9 | 39.8 | 42.1 | 8.0 | 11.5 | 5.8 | 8.4 |
| Average (A) | 42.4 | 45.5 | 42.0 | | 191.3 | 258.1 | 159.3 | | 42.5 | 46.6 | 38.7 | | 8.1 | 12.1 | 6.2 | |
| L. S. D. | 5% | | 1% | | 5% | | 1% | | 5% | | 1% | | 5% | | 1% | |
| A | NS | | NS | | 17.3 | | 28.6 | | 12.0 | | 19.9 | | 1.1 | | 1.9 | |
| B | 7.1 | | 10.9 | | 12.2 | | 16.9 | | 5.6 | | 7.6 | | 0.6 | | 0.8 | |
| A * B | 13.7 | | NS | | 21.1 | | 28.9 | | 9.6 | | 13.2 | | 1.0 | | 1.4 | |

Table (7): Yield and yield components of mung bean plant as affected by Phosphorein under different levels of phosphorus fertilization during season 2000.

| Yield Components | Number of pods / plant | | | | Number of seeds / plant | | | | Weight of 1000 seed (g) | | | | Seeds yield (g/plant) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $P_2O_5$ kg/fed. Phosphorein (g/fed.) | 15.50 | 23.25 | 31.00 | Average (B) | 15.50 | 23.25 | 31.00 | Average (B) | 15.50 | 23.25 | 31.00 | Average (B) | 15.50 | 23.25 | 31.00 | Average (B) |
| Control | 42.0 | 43.7 | 37.7 | 41.1 | 197.4 | 240.2 | 150.2 | 195.9 | 29.9 | 38.3 | 40.6 | 36.3 | 5.9 | 9.2 | 6.1 | 7.1 |
| 200 | 49.0 | 56.0 | 48.3 | 51.1 | 380.4 | 455.8 | 306.2 | 380.8 | 36.0 | 40.4 | 38.9 | 38.4 | 13.7 | 18.4 | 11.9 | 14.7 |
| 300 | 43.3 | 40.0 | 40.0 | 41.1 | 189.8 | 327.7 | 143.4 | 220.3 | 38.5 | 41.2 | 36.3 | 38.7 | 7.3 | 13.5 | 5.2 | 8.7 |
| 400 | 34.3 | 41.7 | 37.0 | 37.7 | 217.0 | 290.5 | 176.7 | 228.1 | 36.4 | 42.7 | 34.0 | 37.7 | 7.9 | 12.4 | 6.0 | 8.8 |
| Average (A) | 42.2 | 45.4 | 40.8 | | 246.2 | 328.6 | 194.1 | | 35.2 | 40.7 | 37.5 | | 8.7 | 13.4 | 7.3 | |
| L. S. D. | 5% | | 1% | | 5% | | 1% | | 5% | | 1% | | 5% | | 1% | |
| A | 4.8 | | NS | | 6.2 | | 10.2 | | 1.5 | | 2.6 | | 0.4 | | 0.6 | |
| B | 6.9 | | 9.5 | | 13.2 | | 18.1 | | 2.6 | | 3.6 | | 0.4 | | 0.6 | |
| A * B | 12.2 | | 16.4 | | 22.9 | | 31.3 | | 4.6 | | 6.3 | | 0.8 | | 1.0 | |

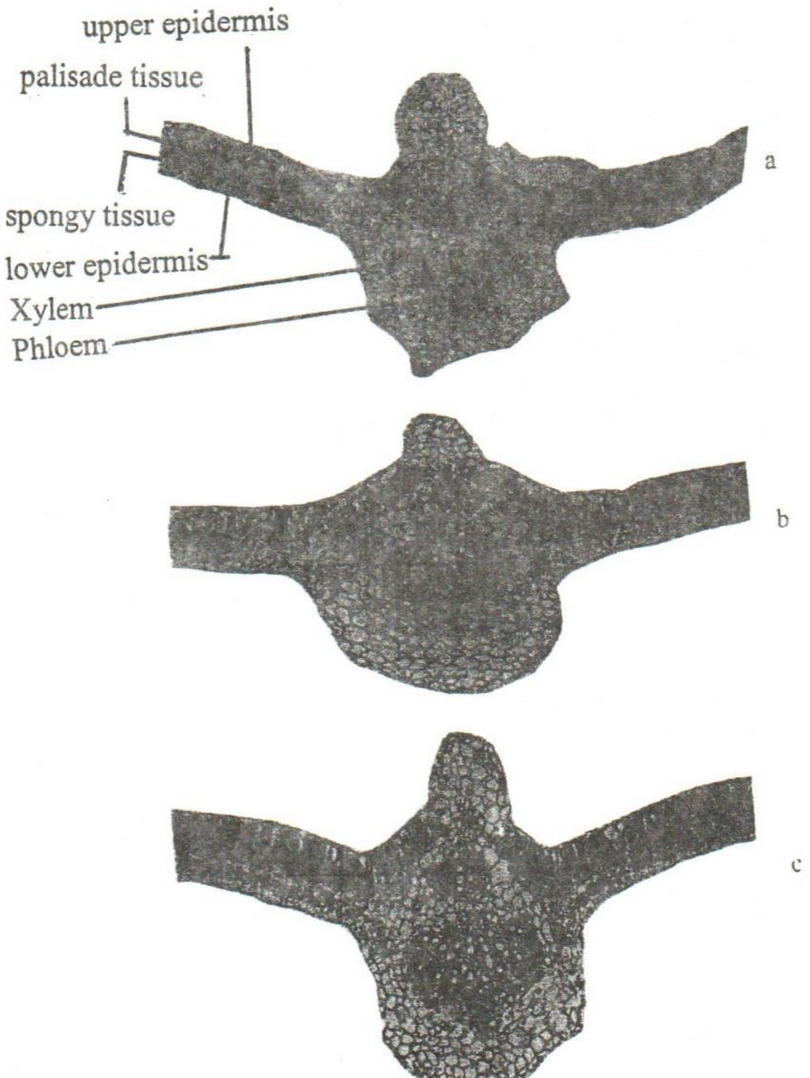



Fig. 5 : Transverse sections in leaflet blade of mung bean stem as affected by phosphorein under phosphorus level of 23.25 kg $P_2O_5$ /feddan. (x 40)
a: Control. b: 200 g/fed. of Phosphorein. c: 400 g/fed. of Phosphorein.

The increase in seed yield / plant due to the treatment with phosphorein could be reasoned by the higher number of pods and number of seeds / plant. Weight of 1000 seeds might be slightly shared in this respect.

The enhancement of seed yield and yield components could be attributed to the promotion effect of phosphorein on the vegetative growth of mung bean shoot. This might be due to the improvement in root development, increase in the rate of water and mineral uptake from the soil and to a lesser extent to biological nitrogen fixation by using biofertilizer (Sundara *et al.*, 1963, El-Dahtory *et al.*, 1989 and Volpin and Kapulnik, 1994).

Many workers recorded increase in yield of plants inoculated with biofertilizers, e.g. Radwan (1983) on cowpea, Kostov *et al.* (1991) on tomato, Abdel-Ati *et al.*, (1996) on potato, Bhar (1997) on chickpea, El-Kalla *et al.*, (1999) on faba bean and onion and El-Saadany and Abdeul-Rasoul (1999) on peanut.

**4- Chemical composition:**

Data in Tables (8 and 9) reveal that, in the three successive samples, high values of N, P and K concentration in both shoots and seeds as well as total chlorophylls (a and b) and carotenoids concentrations in leaves tended to recorded by mung bean plants supplied with the two high rates of phosphorus fertilization (23.25 and 31.00 kg $P_2O_5$ / feddan) either alone or when combined with any of the three different rates of biofertilizer phosphorein soil addition (200, 300 and 400 g/feddan) if compared with their controls received the lowest level of phosphorus fertilization (15.50 kg $P_2O_5$ / feddan), with some exceptions in N, K and total carotenoids concentrations. Similar results were obtained by Pandrangi *et al.* (1991), Rao *et al.* (1993) and Hoshiyar *et al.* (1994) on mung bean plants. In this respect, Leidi and Rodriguez (2000) mentioned that increasing P nutrition improved symbiotic $N_2$ fixation and nodule formation of bean plants.

Furthermore, high values of N, P and K concentrations in both shoots and seeds as well as total chlorophylls (a and b) in leaves and protein percentage in seeds were obtained by the plants inoculated by any of the three different rates of biofertilizer phosphorein combined with any of the three different rates of phosphorus soil addition when compared with their control plants received the same level of phosphorus fertilization but without any bioferetilizer phosphorein soil addition, with some exceptions.

However, a reverse trend was detected in total carotenoids by the same treatments. These results are in harmony with those obtained by El-Saadany and Abdul-Rasoul (1999) on peanut. In this respect, it can be suggested that the beneficial effect of biofertilizers on plant growth and yield might be due to the increase in availability of some nutrients in inoculated soil. Ibrahim and Abdel-Aziz (1977) explained the important role of biofertilizers in reducing soil pH and increasing N-P soil contents by secreting organic acids such as acetic, propionic, fumaric and succinic. Such acids lowered the pH and bring about the dissolution of bands forms of phosphate and render them available for growing plants. Saber *et al.*, (1981) observed an increase in K-uptake of inoculated pea plants with phosphate dissolving bacteria.

Table (8) : Nitrogen, phosphorus and potassium concentrations (mg/g d.w.) in the shoot and seeds of mung bean plant as affected by phosphorein under different / levels of phosphorus fertilization.

| Plant organ | | Shoot | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chemical | | Nitrogen (N) | | | | Phosphrous (P) | | | | Potassium (K) | | | |
| $P_2O_5$ (kg/fed.) / treatments | | 15.50 | 23.25 | 31.00 | Average (B) | 15.50 | 23.25 | 31.00 | Average (B) | 15.50 | 23.25 | 31.00 | Average (B) |
| Control | | 21.2 | 21.2 | 19.2 | 20.5 | 7.2 | 8.0 | 8.8 | 8.0 | 40.9 | 35.6 | 35.2 | 37.2 |
| Phos phrein (g/fed.) | 200 | 24.0 | 26.4 | 27.2 | 25.9 | 7.2 | 8.3 | 9.0 | 8.2 | 46.8 | 43.2 | 43.2 | 44.4 |
| | 300 | 24.4 | 28.0 | 22.40 | 24.9 | 8.0 | 8.6 | 9.2 | 8.6 | 40.4 | 40.8 | 38.8 | 40.0 |
| | 400 | 22.4 | 27.2 | 20.2 | 23.3 | 8.4 | 8.8 | 9.4 | 8.9 | 40.0 | 39.6 | 38.8 | 39.5 |
| Average (A) | | 23.0 | 25.7 | 22.3 | | 7.7 | 8.4 | 9.1 | | 42.0 | 39.8 | 39.0 | |
| Plant organ | | Seeds | | | | | | | | | | | |
| Control | | 35.4 | 42.3 | 34.0 | 37.2 | 7.4 | 8.4 | 9.4 | 8.4 | 25.2 | 26.4 | 26.8 | 26.1 |
| Phos phrein (g/fed.) | 200 | 46.0 | 52.4 | 40.0 | 46.1 | 9.4 | 10.2 | 10.5 | 10.0 | 27.2 | 28.8 | 30.0 | 28.7 |
| | 300 | 38.4 | 46.0 | 45.2 | 43.2 | 9.2 | 9.4 | 9.8 | 9.5 | 29.2 | 28.4 | 29.2 | 28.9 |
| | 400 | 34.8 | 50.4 | 45.2 | 43.5 | 8.6 | 9.2 | 9.8 | 9.2 | 30.0 | 27.2 | 31.6 | 29.6 |
| Average (A) | | 38.7 | 47.8 | 41.1 | | 8.7 | 9.3 | 9.9 | | 27.9 | 27.7 | 29.4 | |

Khallaf *et al.* (1982) on faba bean, Radwan (1983) on tomato and Kabesh *et al.*, (1987) on soybean, reported that phosphate dissolving bacteria increased P-uptake. Saber and Kabesh (1990) found that application of phosphate dissolving bacteria resulted in a reduction of soil pH and increased the availability of some nutrients such as P, Fe, Zn, Mn and Ca which would be reflected on lentil plant uptake. In addition, Lin *et al.*, (1983), Sundaravelu and Muthukrishinan (1993) as well as Hanafy Ahmed *et al.*, (1997 and 2002) suggested that, addition of biofertilizers increase the ability to convert $N_2$ to $NH_4$ and thus make it available to plant. Moreover, the same authors mentioned that application of biofertilizers increased the water and mineral uptake by plants, which could be ascribed to increases in root surface area, root hairs and root elongation. Furthermore, Sattar and Gaur (1987)and Belimov *et al.* (1995) working on phosphate solubilizing bacteria reported that bacteria are able to produce gibberellin and cytokinin-like substances and also auxin from tryptophan. Such secreted growth promoting substances could improve the nutritional status of the plant.

In this connection, many reports stated that the biological role of biofertilizers in mineralization was due to producing gibberellins, auxins and cytokinin – like substances (Nieto and Frankenberger, 1989; Kluepfel and McInnis. 1991 and Turner and Bakman, 1991).

**Table (9): Chlorophyll (a, b and total) as well as total carotenoids concentrations as (mg/g fresh weight) of mung bean leaves as affected by phosphorein under different levels of phosphorus fertilization.**

| Plant pigments | | Chlorophyll a | | | | Chlorophyll b | | | |
|---|---|---|---|---|---|---|---|---|---|
| $P_2O_5$ Kg/fed Treatments | | 15.50 | 23.25 | 31.00 | Average (B) | 15.50 | 23.25 | 31.00 | Average (B) |
| Control | | 4.01 | 4.51 | 4.80 | 4.44 | 2.94 | 3.14 | 3.92 | 3.33 |
| Phosphorein (g/fed.) | 200 | 4.02 | 4.54 | 4.90 | 4.49 | 3.24 | 3.57 | 3.50 | 3.44 |
| | 300 | 3.97 | 3.54 | 3.94 | 3.82 | 3.62 | 2.61 | 2.86 | 3.03 |
| | 400 | 3.51 | 3.43 | 3.46 | 3.47 | 3.22 | 2.60 | 3.07 | 2.96 |
| | Average (A) | 3.88 | 4.01 | 4.28 | | 3.26 | 2.98 | 3.34 | |
| Plant pigments | | Total Chlorophyll | | | | Total carotenoids | | | |
| Control | | 6.95 | 7.65 | 8.72 | 7.77 | 0.15 | 0.82 | 0.58 | 0.52 |
| Phosphorein (g/fed.) | 200 | 7.26 | 8.03 | 8.40 | 7.90 | 0.22 | 0.23 | 0.18 | 0.21 |
| | 300 | 7.59 | 6.15 | 6.80 | 6.85 | 0.15 | 0.11 | 0.19 | 0.15 |
| | 400 | 6.73 | 6.03 | 6.53 | 6.43 | 0.10 | 0.15 | 0.16 | 0.14 |
| | Average (A) | 7.13 | 6.97 | 7.61 | | 0.16 | 0.33 | 0.28 | |

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## تأثير المخصب الحيوى الفوسفورين المذيب للفوسفور على النمو، المحصول والتركيب الكيماوى لنبات فول المانج النامى تحت مستويات مختلفة من التسميد الفوسفاتى

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أجريت تجربتين بالحقل لدراسة تأثير تركيزات مختلفة من المخصب الحيوى فوسفورين متحدا مع معدلات تسميد مختلفة من الفوسفور على نبات فول المانج.

وقد أدى استخدام الفوسفورين بالنسب ٢٠٠، ٣٠٠، ٤٠٠ جرام للفدان متحدا مع معدلات التسميد الفوسفورى ١٥,٥٠، ٢٣,٢٥، ٣١,٠٠ كجم $P_2O_5$ للفدان إلى تنشيط النمو الخضرى ومحصول البذور لنبات فول المانج. وكانت أعلى قيم لمتوسطات طول الساق الرئيسى وعدد الافرع والمساحة الكلية للأوراق والوزن الجاف للمجموع الخضرى ومحصول البذور للفدان عندما استخدم تركيز ٢٠٠ جرام للفدان من الفوسفورين متحدا مع معدل التسميد الفوسفورى ٢٣,٢٥ كجم $P_2O_5$ للفدان.

وقد لوحظ أن زيادة نمو المجموع الخضرى الناتجة من استخدام ٢٠٠ جرام فوسفورين للفدان مع ٢٣,٢٥ كجم $P_2O_5$ للفدان مصحوبة بزيادة فى كمية الانسجة المختلفة بالساق والورقة وخاصة الانسجة الوعائية.

وقد أوضحت النتائج زيادة تركيز النتروجين والفوسفور والبوتاسيوم فى كل من المجموع الخضرى والبذور بالإضافة لزيادة تركيز الكلوروفيلات (أ ، ب) فى الاوراق وكذلك النسبة المئوية للبروتينات فى البذور للنباتات المعاملة بأى من تركيزات المخصب الحيوى الفوسفورين سواء كان منفردا أو تحت أى مستوى من مستويات التسميد الفوسفاتى المستخدمة وذلك بالمقارنة بالنباتات الغير معاملة بالمخصب الحيوى تحت نفس المستوى من التسميد الفوسفاتى بالرغم من ذلك سجلت الكاروتينات إتجاه مخالف لنفس المعاملة.