Effect of Humic Acid, Biofertilizers and Mineral Phosphate on Soil Microbial Activity and Productivity of Pea Plants under Toshka Conditions

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ABSTRACT

Two field experiments were conducted during the winter season of 2015/2016 & 2016/2017, at Toshka Research Station - Desert Research Center. The aim of the study was to investigate the effect of humic acid (HA) at rates of 0, 4 and 8 kg/fed. combined with phosphate dissolving bacteria (PDB) and mineral phosphate fertilizer at rates of 100, 90, 80 and 70% P2O5 of the recommended dose in commercial production on pea plants. Treatment with humic acid at 8 kg/fed. combined with inoculation of PDB and 100% of mineral phosphate fertilizer significantly increased the total microbial count, Bacillus megaterium count, CO2 evolution, organic carbon and phosphatase and dehydrogenase enzymes activities. The bio-fertilizer treatments (PDB) showed a clear superiority when added in combination with the phosphate fertilizer and humic acid compared to the results of using a mixture of humic acid and superphosphate only. Adding of humic acid and superphosphate with the presence of phosphate dissolving bacteria improved most of the vegetative growth characteristics of plants. Yield components had the highest positive response to humic acid combined with mineral fertilizer percentage with phosphate-dissolving bacteria. The highest concentration of N, P, and K were with the use of humic acid at (8 kg), phosphate-dissolving bacteria and 100% phosphate fertilization P2O5.

The study revealed that using 8 kg HA/fed in combination with PDB and high level of P2O5 as a fertilizer application to improve soil properties, vegetative growth, mineral content and yield of pea plants in new soils was recommended.

Key words: Microbial activity, Pea, Growth, yield components, Humic acid, Bio-fertilizers, Super phosphate (P2O5), Toshka.

INTRODUCTION

The over increased world population required both horizontal and vertical agriculture extension to meet the increased food demands. Vasil (1998) and Leisinger (1999) reported that increasing food productivity by about 50% in the next twenty years is needed to meet the population pressure. Horizontal and vertical agriculture extension in desert areas faced with the problem of low soil fertility. Vikram and Hamzehzarghani (2008) stated that phosphorus is the second major macronutrients for plants because it has an important role in plant metabolism. Yagodin (1990) added that phosphorus has a great role in biosynthesis and translocation of carbohydrates, yield and fruits quality.

Most of soils contain large amounts of total phosphorus but only less than 10-15 % of that P content enter the plant – animal cycle and the rest amount remained inert-due to its fixation (Kucey et al., 1989). Such inert phosphorus could become soluble and available to plants by the soil microorganisms (Palss, 1998; Hilda and Fraga, 1999). With this respect, Rodriguez and Fraga (1999) stated that strains from Pseudomonas, Bacillus and Rhizobium genera were among the most powerful phosphate solubilizes which, in turn, resulted in increases of P uptake and crop yield.

Using PDB inoculation was recommended to overcome the ever increasing cost of phosphorus mineral fertilizer and soil health maintenance (Babulkar et al., 2000) and avoiding its harmful effect on environment (Bogatyre, 2000). Rhizobacteria was also used to increase bioavailability of P and K in soils which resulted in increasing their uptake and plant growth (Lin et al. 2002; Sahin et al. 2004; Girgis, 2006 and Eweda et al. 2007). Han and Lee (2005) added that Phosphate solubilizing bacteria has used to convert insoluble phosphate compounds into a available soluble form for plant uptake. As a result, El-Gizawy et al. (2009) found that adding 30 kg P2O5 mineral fertilizer in combination with PDB markedly increased growth of bean plants as well as its yield, protein content and mineral uptake. Abdel-Kader and Selah (2017) found that growth of Roselle plants and its yield was significantly increased due to co-inoculation of PDB (Bacillus megaterium var. phosphaticum) and KSB (Bacillus mucilaginosus) combined with rock phosphate and feldspar.

Humic acid (HA) application is a wide spread compound used in agriculture development. It improves physical, chemical, fertility and biological properties of soils (Keeling et al., 2003; Nardi et al., 2004; Mikkelsen, 2005; Sarir et al., 2005 and Mart, 2007). Such positive effects of humic acid on soil properties reflected on positive effects on plants (Ashraf et al., 2005 and Susilawati et al., 2009) through improving mineral availability (Mauromicale et al., 2011) and

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enhancing nutrients uptake (Mackowiak et al., 2001 and Mauromicale et al., 2011). Likewise, humic acid application increased yield of vegetables such as tomatoes, potatoes, onions, pepper, Peas and other leafy vegetables (Erik et al., 2000; Albayrak, 2005; Vetayasuporn, 2006; Mohamed et al., 2009 and Khan et al., 2013).

Sarwar et al. (2014) found that rhizobacteria (PGPR) inoculation combined with humic acid (HA) and P2O5 recorded the highest grain yield of mung bean and gave the highest concentration of P and N in mung bean shoot as well as improved P use efficiency (PUE) and enhanced P availability through chelating and reduce soil P fixation.

Keeping the declining soil fertility, ever increasing mineral fertilizer costs and continuous increasing demand for more food, the current study aimed to investigate the effect of humic acid, biofertilizers and phosphorus application as well as their interactions on microbial activity, mineral content and pea growth and yield grown at Toshka region.

MATERIALS AND METHODS

Two experiments were carried out in 2016 / 2017 and 2017 / 2018 at Toshka Experimental Station, South Egypt. The aim of the study was to investigate the effect of humic acid, biofertilizers and phosphorus application on microbial activity, mineral contents and growth and yield of pea plants.

The composite soil samples were collected before planting at depth of 0-30 cm; air dried and sieved (2 mm).

Some physical and chemical properties of the experimental farm soil and irrigation water were determined according to Klute (1986), Jackson (1973) and shown in Tables (A and B.).

Treatments:

1) Humic acid treatments:

Humic acid was applied as soil addition at rates of zero (control), 4 and 8 kg/fed. Twice after germination and at flowering. The source of humic acid is potassium humate, which contains 60% humic acids and 8% K2O.

2) Biofertilizer treatments:

Bacillus megaterium as bacterial suspensions (105 cfu/ml) with Carboxy methyl cellulose 0.5% as an adhesive agent was applied to grains at planting time and the inoculation was repeated after 30 days of germination. Control treatment without bacterial inoculation was also designed. Isolates has been produced in soil microbiology laboratory, Desert Research Center (DRC).

3) Phosphorus treatments:

Superphosphate (15.5%) was incorporated into the soil two weeks before planting at the following rates:

1) 100 % of the recommended dose (200 kg superphosphate / fed)
2) 90 % of the recommended dose (180 kg superphosphate / fed)
3) 80 % of the recommended dose (160 kg superphosphate / fed)
4) 70 % of the recommended dose (140 kg superphosphate / fed)

### Table A. Some physical and chemical properties of soil in studied area

| Particle size distribution | Organic matter | Chemical properties |
|---------------------------|----------------|---------------------|
| Sand (%)                  | Organic (%)    | pH E.C. dS.m⁻¹ | Soluble anions (mg/L.) | Soluble cations (mg/L.) |
| 50.88                     | 0.67           | 8.62              | 3.98                  | 7.61                  |
| 21.84                     |                | 11.71             | 20.48                 | 8.21                  |
| 27.28                     |                | 26.99             | 1.11                  |                       |
| SCL                       |                |                    |                       |                       |

SCL= Sandy clay loam.

### Table B. Analysis of the irrigation water:

| well No. | pH  | EC (µS/cm) | TDS mg/l | Soluble cations | Soluble anions |
|----------|-----|------------|----------|-----------------|----------------|
|          |     |            |          | Ca** Mg** Na+ K+ | CO3⁻ HCO₃⁻ SO₄⁻ Cl⁻ |
| 85       | 6.9 | 768        | 447.25   | 81.32 11.29 50.00 2.00 | 3.00 111.15 151.25 87.98 |
|          |     |            |          | 4.06  0.93 2.18 0.05 | 0.10 1.82 3.15 2.48 |
|          |     |            |          | 56.26 12.87 30.16 0.71 | 1.32 24.12 41.70 32.85 |

| Trace elements (mg/L) | Ag | Al | B  | Ba  | Cd | Co | Cr  | Cu  | Fe  | Mn  | Mo  | Ni  | Pb  | Si  | Sr  | V   | Zn  |
|-----------------------|----|----|----|-----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| n.d.                  | n.d.| n.d.| 0.05| n.d.|    |    |     |     |     |     |     |     |     |     |     |     |
| n.d.                  | n.d.| n.d.|     | n.d.| 0.15| 0.02| 0.25| 0.002| n.d.| 0.014| 0.003| 4   | 0.35| n.d.| 0.008|
Organic manure (EL-Nile Compost) was provided from ECARU (Egyptian Company for Agriculture Residues Utilization) Dokki, Giza, Egypt, and mixed into the soil surface two weeks before planting; its analysis was: pH 6.81, EC 2.91 dSm⁻¹, total N 1.21%, total P 0.25 %, total K 0.62% and C/N 17.31. In addition, *Rhizobium leguminosarum* was added two times (during planting and after germination), which were isolated by microbiology laboratory at the Desert Research Center (DRC). 200kg ammonia sulfate/fed. and 100 kg potassium sulphate/fed were divided into two doses and added after germination and flowering.

Soil samples were collected from the soil at depth of 0-30 cm at 90 days from pea sowing to estimate density of total microbial and PDB which were quantified on yeast extract agar medium (Allen, 1959) and modified by Bunt and Rovira medium (Abd El-Hafez, 1966) using the dilution frequency method. CO₂ evolution (µg/g dry soil/ hr.), dehydrogenase activity (µg TPF g⁻¹ dry soil 24h.) and phosphatase enzyme (PNP g/soil/h) in the rhizosphere were determined according to Pramer and Schmidt (1994), Thalmann (1967) and Tabatabai and Brimmer, (1969), respectively. Organic carbon content was determined by Walkley and Black’s wet oxidation method (1934) and CO₂ evolution (µg/g dry soil/ hr.) in the rhizosphere were determined according to Pramer and Schmidt (1994). Total nitrogen percentage was determined by using the modified microkjeldahl method as described by Peach and Tracey (1956). Available phosphorous was extracted using 0.5 M NaHCO₃ at pH 8.5 according to Olsen *et al.* (1982) and measured colorimetrically using the chlorostannus phosphomolybdic-sulfuric acid method as described by Jackson (1973). Electrical conductivity (EC) and soil pH was determined in a 1: 2.5 soil to water extract using conductivity meter and Beckman pH meter, respectively according to Jackson (1973) and McLean (1982).

Plant height (cm), number of branches /plant, fresh and dry weights (gm) /plant of shoots and number of leaves /plant were recorded before harvest (after 95 days from sowing). Whereas, total chlorophyll (SPAD unit) was determined according to A.O.A.C. (1990). Nitrogen content of pea seeds (%) were determined using Micro-Kjeldahl method according to Peach and Tracey (1956). Phosphorus content of pea seeds (%) were estimated using Spectrocolormeter and potassium content of pea seeds by using Flame photometer (Jackson, 1973).

At the harvest, plants of one row from each experimental plot were harvested to estimate yield parameters such as number of dry pods /plant, length of pods (cm), diameter of pods (mm), average seed number /dry pod, average weight of seeds (g) /pod and weight of seed yield.

**Experimental design and statistical analysis:**

Split plot design was used with three replicates. Main plots were assigned for humic acid and sub plots were used for bio-fertilization; where phosphorus treatments were distributed in the sub sub plots. Obtained data were subjected to statistical analysis according to (Snedecor and Cochran, 1989).

**RESULTS AND DISCUSSION**

Microbial activity and Soil estimates:

Data concerned with the effect of humic acid, biofertilizers and phosphorus application on microbial activity expressed as total microbial counts, PDB density, CO₂ evolution, organic carbon, dehydrogenase activity (DHA) and phosphatase enzyme. Obtained data were presented in Tables (1, 2 and 3). As for soil estimates, Obtained data concerned with total nitrogen, available phosphorous, C/N ratio and C/P ratio in the soil cultivated with pea plants at Toshka region were presented in Tables (4- 5). Results indicated significant positive effect for either humic acid, biofertilizers and phosphorus application on the investigated characters, the highest values were obtained with 8 kg humic acid, PDB inoculation or 100% of phosphorus recommended dose (200 kg superphosphate / fed.). These results are in accordance with those reported by Pandya and Saraf (2010), Amal M. Omer (2010) who mentioned that biofertilizers application can increase the availability of nutrients by their biological activity, which in turn, improve soil fertility by increasing the number of such microorganisms and accelerate certain microbial processes. In addition, Yosefi *et al.* (2011) reported that biofertilizers improved soil fertility. It solubilized insoluble soil phosphates and increased plant growth substances in the soil.

With this respect, it is of interest to mention that multiple regression of *Bacillus megaterium* count (count×10⁴ CFU) on total microbial count and total microbial count without *Bacillus megaterium* was presented in equation (1 and 2). Regression coefficients indicated that *Bacillus megaterium* count was increased in the first season an average of 0.00062 unit for each unit of total microbial count but only 0.00010 for each unit of total microbial count without *Bacillus megaterium*. The corresponding values in the second season were 0.01102 and 0.0002. This indicated that total microbial was more effective than total microbial count without *Bacillus megaterium*; in the same time indicated that total microbial count other than *Bacillus megaterium* increased *Bacillus megaterium* count which could lead to conclude that there were mutual cooperation effect for some other bacteria on *Bacillus megaterium*. Such conclusion was true in both investigated seasons.
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\[ Y^\wedge = 17.4 + 0.00062X_1 + 0.00010X_2 \]  
Equation (1) for the first season

\[ Y^\wedge = 45.9 + 0.01102X_1 + 0.00023X_2 \]  
Equation (1) for the second season

Where \( Y \) stand for the dependent variable \( Bacillus megaterium \) count (count×10\(^4\) CFU), the independent variables \( X_1 \) stand for total microbial count (count×10\(^4\) CFU) and \( X_2 \) stand for total microbial count without \( Bacillus megaterium \) (count×10\(^4\)CFU).

It is, also, of great interest to know the relation between \( Bacillus megaterium \) density (count×10\(^4\) CFU) and the available phosphorus in the soil (%). Linear correlation indicated that there was highly significant positive correlation between the available phosphorus in the soil and \( Bacillus megaterium \) density. Correlation coefficients (r) were 0.945 and 0.946 in the first and second seasons, respectively. Linear regression of the available phosphorus in the soil on the independent variable showed that regression coefficients were 7.31 and 9.9 in the first and second seasons, respectively. This means that soil available phosphorus would increase by 7.31 and 9.9 % in the first and second seasons, respectively, for each unit increase of \( Bacillus megaterium \).

As for the interactions, the highest values were obtained generally with application of either 8 kg humic acid / fed combined with PDB inoculation or 8 kg humic acid / fed combined with 100 % of phosphorus recommended dose. The beneficial effect of humic acid on microbial activity may be due to its activation through its positive effects on soil and plant characteristics (Zhang and Ervin, 2004), its various functional groups which, in turn, stimulate enzyme activity, membrane permeability, photosynthesis and respiration (Muscolo \textit{et al}., 2007 and Nardi \textit{et al}., 2002), its useful effects in minimizing the amount of mineral fertilization (Eman Abdel-Monem \textit{et al}., 2008). In addition, biofertilizer inoculation plays an important role in exchanges of CO\(_2\) between land biosphere and atmosphere through soil microbial activity and CO\(_2\) production (Luo and Zhou, 2006) as well as biofertilizer inoculation led to higher dehydrogenase activity than those in un-inoculated treatments (Amal \textit{et al}., 2014). In this respect, Al-Haddad et al. (2014) showed that the highest significant increase in percentages of enzyme activity (dehydrogenase) was recorded in the Eucalyptus camaldulensis inoculated with a mixed microbial treatment of (\textit{Azotobacter chroococcum}, \textit{Bacillus circulans} and \textit{Arbuscular mycorrhizal} fungi AMF) rather than those of individual and dual treatments in the two investigated seasons.

![First season](image1.png)

![Second season](image2.png)

**Fig. 1. Regression of available P (Y, %) on Bacillus megaterium (X, count×10\(^4\) CFU)**

\[ Y^\wedge = 0.000542+ 7.31E-05 X, r = 0.945 \text{ in the 1st season.} \]

\[ Y^\wedge = 0.000693 + 9.9 X, r = 0.946 \text{ in the 2nd season.} \]
Table 1. Influence of humic acid, biofertilizers and phosphorus applications on total microbial counts (Counts x 10^6 CFU g dry soil) and *Bacillus megaterium* count (count×10^4 CFU) during 2016/2017 seasons

| Bacterial Inoculation | Phosphorus % | Total microbial count (count×10^6CFU) | *Bacillus megaterium* count (count×10^4CFU) |
|-----------------------|--------------|----------------------------------------|---------------------------------------------|
|                       |              | **Without** 4 Kg /fed. | **8 Kg /fed.** | Mean | **Without** 4 Kg /fed. | **8 Kg /fed.** | Mean |
| Without               |              |                          |                       |       |                          |                       |       |
| 100                   |              | 31.33                    | 35.33                  | 39.33 | 35.33                    | 37.33                  | 41.00 |
| 90                    |              | 28.67                    | 32.67                  | 35.67 | 32.67                    | 35.00                  | 38.33 |
| 80                    |              | 27.00                    | 31.33                  | 34.67 | 31.00                    | 33.33                  | 36.67 |
| 70                    |              | 21.00                    | 30.67                  | 33.00 | 28.22                    | 31.33                  | 34.00 |
| Mean                  |              | 27.00                    | 32.50                  | 35.67 | 31.72                    | 34.25                  | 37.50 |
| PDB                   |              |                          |                       |       |                          |                       |       |
| 100                   |              | 38.33                    | 47.00                  | 84.00 | 56.44                    | 42.67                  | 51.33 |
| 90                    |              | 32.67                    | 42.67                  | 78.33 | 51.22                    | 38.33                  | 47.67 |
| 80                    |              | 29.67                    | 38.00                  | 68.67 | 45.44                    | 36.67                  | 43.33 |
| 70                    |              | 25.33                    | 33.00                  | 62.67 | 40.33                    | 34.00                  | 37.00 |
| Mean                  |              | 31.50                    | 40.17                  | 73.42 | 48.36                    | 37.92                  | 44.83 |
| **P × HU**            |              |                          |                       |       |                          |                       |       |
| 100                   |              | 34.83                    | 41.17                  | 61.67 | 45.89                    | 40.00                  | 46.17 |
| 90                    |              | 30.67                    | 37.67                  | 57.00 | 41.78                    | 36.67                  | 43.00 |
| 80                    |              | 28.33                    | 34.67                  | 51.67 | 38.22                    | 35.00                  | 40.00 |
| 70                    |              | 23.17                    | 31.83                  | 47.83 | 34.28                    | 32.67                  | 35.50 |
| Mean                  |              | 30.25                    | 36.33                  | 54.54 | 36.08                    | 41.17                  | 62.08 |

LSD 5%

| Treatment                  | LSD 5% |
|----------------------------|--------|
| Humic acid                 | 3.037  |
| Biofertilizer              | 3.595  |
| Phosphorus                 | 1.164  |
| Humic*Bio                  | 6.226  |
| Humic*Phosphorus           | 2.016  |
| Bio*Phosphorus             | 1.366  |
| Humic*Bio*Phosphorus       | 2.366  |

* Initial total bacterial count was 50 × 10^3 (CFU/g dry soil).
* Initial total *Bacillus* count was 45×10^2 (CFU/g dry soil).
* P × HU = Interaction of Phosphorus treatment with humic acid treatments.
Table 2. Influence of Humic acid, biofertilizers and Phosphorus applications on CO₂ evolution (mg CO₂/100 g dry soil/24 hr.) and Organic carbon % during 2016/2017 seasons

| Bacterial Inoculations | Phosphorus % | CO₂ evolution (mg CO₂/100 g dry soil/24 hr.) | Organic carbon % |
|------------------------|--------------|----------------------------------------------|------------------|
|                        |              | First Season                                  | Second Season     |
|                        |              | Humic Acid                                    | Humic Acid        |
|                        |              | Mean Without 4 Kg /fed. 8 Kg /fed. Mean       | Mean Without 4 Kg /fed. 8 Kg /fed. Mean |
|                        |              | Without                                       | Without           |
|                        |              | Without                                       |                   |
|                        |              | Mean                                          |                   |
|                        |              | PDB                                           |                   |
|                        |              | Mean                                          |                   |
|                        |              | P × HU                                         |                   |
|                        |              | Mean                                          |                   |
|                        |              | LSD 5%                                         |                   |
|                        |              | Humic acid                                    | 0.981            |
|                        |              | Biofertilizer                                 | 0.561            |
|                        |              | Phosphorus                                    | 0.414            |
|                        |              | Humic*Bio                                     | 0.972            |
|                        |              | Humic*Phosphorus                              | 0.717            |
|                        |              | Bio*Phosphorus                                | 0.746            |
|                        |              | Humic*Bio*Phosphorus                          | 0.773            |
|                        |              |                                                |                  |
|                        |              | *- Initial total bacterial count was 5 × 10³ (CFU/g dry soil). |
|                        |              | *- Initial total Bacillus count was 45 × 10² (CFU/g dry soil). |
|                        |              | *- P × HU= Interaction of Phosphorus treatment with humic acid treatments. |
Table 3. Influence of Humic acid, biofertilizers and Phosphorus applications on phosphatase enzyme (PNP g/soil/h) and dehydrogenase activity (DHA) (µg TPF g⁻¹ dry soil 24hr.) during 2016/2017 seasons

| Bacterial Inoculation | Phosphorus % | phosphatase enzyme (PNP g/soil/h) | (DHA) (µg TPF g⁻¹ dry soil 24hr.) |
|-----------------------|--------------|-----------------------------------|------------------------------------|
|                       |              | Humic Acid                        |                                    |
|                       |              | First Season                      | Second Season                      |
|                       |              | Without 4 Kg /fed.               | Without 8 Kg /fed.                 |
|                       |              | Mean                               | Mean                               |
|                       |              | First Season                      | Second Season                      |
|                       |              | Without 4 Kg /fed.               | Without 8 Kg /fed.                 |
|                       |              | Mean                               | Mean                               |
| Without               | 100          | 1.050                             | 1.467                             |
|                      | 90           | 0.933                             | 1.240                             |
|                      | 80           | 0.813                             | 1.037                             |
|                      | 70           | 0.700                             | 0.943                             |
| Mean                  |              | 0.874                             | 1.172                             |
| PDB                  | 100          | 1.933                             | 2.600                             |
|                      | 90           | 1.500                             | 2.203                             |
|                      | 80           | 1.270                             | 2.077                             |
|                      | 70           | 1.043                             | 1.950                             |
| Mean                  |              | 1.437                             | 2.208                             |
| P × HU                | 100          | 1.492                             | 2.033                             |
|                      | 90           | 1.217                             | 1.722                             |
|                      | 80           | 1.042                             | 1.557                             |
|                      | 70           | 0.872                             | 1.447                             |
| Mean                  |              | 1.155                             | 1.690                             |

LSD 5%

- Humic acid: 0.087
- Biofertilizer: 0.054
- Phosphorus: 0.074
- Humic*Bio: 0.094
- Humic*Phosphorus: NS
- Bio*Phosphorus: 0.087
- Humic*Bio*Phosphorus: 0.150

* Initial phosphatase enzyme 0.65 (PNP g/soil/h)
* Initial Dehydrogenase activity 2.01 (µg TPF g⁻¹ dry soil 24hr.)
* - para-nitrophenol (PNP)
* P × HU= Interaction of Phosphorus treatment with humic acid treatments.
Table 4. Influence of Humic acid, biofertilizers and Phosphorus applications on total nitrogen in soil % and C/N ratio during 2016/2017 seasons

| Bacterial Inoculations | Phosphorus % | Total nitrogen in soil % | C/N ratio |
|------------------------|--------------|--------------------------|-----------|
|                        |              | First Season              | Second Season |
|                        |              | Humic Acid                | Humic Acid |
|                        |              | Without 4 Kg /fed.       | 8 Kg /fed. | Mean | Without 4 Kg /fed. | 8 Kg /fed. | Mean | Without 4 Kg /fed. | 8 Kg /fed. | Mean | Without 4 Kg /fed. | 8 Kg /fed. | Mean |
| Without                | 100          | 0.20                     | 0.31       | 0.36 | 0.29                     | 0.27       | 0.39 | 0.43                     | 0.36 | 6.70 | 5.29                     | 5.46 | 5.82 | 5.49                     | 4.48 | 5.00 | 4.99 |
|                        | 90           | 0.17                     | 0.27       | 0.34 | 0.26                     | 0.23       | 0.35 | 0.40                     | 0.33 | 6.75 | 5.27                     | 4.96 | 5.66 | 5.76                     | 4.37 | 4.83 | 4.99 |
|                        | 80           | 0.13                     | 0.22       | 0.28 | 0.21                     | 0.19       | 0.30 | 0.36                     | 0.29 | 8.08 | 5.48                     | 5.01 | 6.19 | 6.08                     | 4.35 | 4.72 | 5.05 |
|                        | 70           | 0.11                     | 0.15       | 0.24 | 0.17                     | 0.16       | 0.28 | 0.33                     | 0.26 | 8.03 | 7.03                     | 5.01 | 6.69 | 6.37                     | 4.15 | 4.41 | 4.98 |
| Mean                   |              | 0.15                     | 0.24       | 0.31 | 0.23                     | 0.21       | 0.33 | 0.38                     | 0.31 | 7.22 | 5.59                     | 5.13 | 5.98 | 5.85                     | 4.35 | 4.76 | 4.99 |
| PDB                    |              |                          |            |      |                          |            |      |                          |      |      |                          |      |      |                          |      |      |      |
|                        | 100          | 0.29                     | 0.40       | 0.67 | 0.45                     | 0.34       | 0.47 | 0.78                     | 0.53 | 4.99 | 4.84                     | 3.57 | 4.47 | 4.95                     | 4.43 | 3.28 | 4.22 |
|                        | 90           | 0.25                     | 0.34       | 0.60 | 0.40                     | 0.31       | 0.41 | 0.71                     | 0.48 | 5.00 | 4.88                     | 3.57 | 4.48 | 4.89                     | 4.63 | 3.38 | 4.30 |
|                        | 80           | 0.20                     | 0.28       | 0.55 | 0.34                     | 0.27       | 0.38 | 0.66                     | 0.43 | 5.25 | 4.90                     | 3.66 | 4.60 | 4.68                     | 4.39 | 3.25 | 4.11 |
|                        | 70           | 0.17                     | 0.25       | 0.54 | 0.32                     | 0.23       | 0.33 | 0.58                     | 0.38 | 5.49 | 4.69                     | 3.26 | 4.48 | 4.71                     | 4.15 | 3.22 | 4.03 |
| Mean                   |              | 0.23                     | 0.32       | 0.59 | 0.38                     | 0.29       | 0.40 | 0.68                     | 0.46 | 5.15 | 4.83                     | 3.52 | 4.50 | 4.82                     | 4.41 | 3.28 | 4.17 |
| P × HU                 |              |                          |            |      |                          |            |      |                          |      |      |                          |      |      |                          |      |      |      |
|                        | 100          | 0.24                     | 0.36       | 0.52 | 0.37                     | 0.31       | 0.43 | 0.61                     | 0.45 | 5.71 | 5.03                     | 4.22 | 4.99 | 5.19                     | 4.45 | 3.88 | 4.51 |
|                        | 90           | 0.21                     | 0.30       | 0.47 | 0.33                     | 0.27       | 0.38 | 0.55                     | 0.40 | 5.70 | 5.06                     | 4.07 | 4.94 | 5.25                     | 4.51 | 3.90 | 4.55 |
|                        | 80           | 0.17                     | 0.25       | 0.42 | 0.28                     | 0.23       | 0.34 | 0.51                     | 0.36 | 6.36 | 5.15                     | 4.12 | 5.21 | 5.27                     | 4.36 | 3.77 | 4.47 |
|                        | 70           | 0.14                     | 0.20       | 0.39 | 0.24                     | 0.19       | 0.31 | 0.46                     | 0.32 | 6.52 | 5.57                     | 3.80 | 5.30 | 5.40                     | 4.15 | 3.65 | 4.40 |
| Mean                   |              | 0.19                     | 0.28       | 0.45 | 0.25                     | 0.36       | 0.53 | 6.00                     | 5.15 | 4.06 | 5.27                     | 4.38 | 3.81 |

LSD 5%

|                        |             |                       |             |
|                        |             | Humic acid             | Biofertilizer |
|                        |             | 0.017                  | 0.013        |
|                        |             | 0.015                  | 0.008        |
|                        |             | 0.013                  | 0.009        |
|                        |             | 0.023                  | 0.014        |
|                        |             | 0.023                  | 0.016        |
|                        |             | 0.015                  | 0.011        |
|                        |             | Humic*Bio*Phosphorus   |               |
|                        |             | NS                     | 0.019        |

* - Initial total nitrogen in soil 0.09%

* - Initial C/N ratio in soil 9.33 %

* - P × HU= Interaction of Phosphorus treatment with humic acid treatments.

* - C/N ratio = Organic Carbon % / Total nitrogen %
Table 5. Influence of Humic acid, biofertilizers and Phosphorus applications on available phosphorus % and C/P ratio during 2016/2017 seasons

| Bacterial Inoculations | Phosphorus % | Available phosphorus % | C/P ratio in soil |
|------------------------|--------------|------------------------|------------------|
|                        |              | First Season           | Second Season     | First season     | Humic Acid | Second Season | Humic Acid |
|                        |              | 4 Kg /fed. | 8 Kg /fed. | Mean | Without | 4 Kg /fed. | 8 Kg /fed. | Mean | Without | 4 Kg /fed. | 8 Kg /fed. | Mean | Without | 4 Kg /fed. | 8 Kg /fed. | Mean |
| Without                | 100          | 0.0021       | 0.0029      | 0.0035 | 0.0028 | 0.0026 | 0.0033 | 0.0041 | 0.0033 | 638.1 | 565.5 | 557.1 | 586.9 | 576.9 | 525.2 | 520.2 | 540.8 |
|                        | 90           | 0.0017       | 0.0025      | 0.0031 | 0.0025 | 0.0021 | 0.0029 | 0.0037 | 0.0029 | 674.7 | 569.2 | 539.7 | 594.5 | 622.4 | 532.1 | 518.1 | 557.5 |
|                        | 80           | 0.0015       | 0.0020      | 0.0026 | 0.0020 | 0.0018 | 0.0026 | 0.0032 | 0.0025 | 700.0 | 611.5 | 545.0 | 618.8 | 651.7 | 506.5 | 531.3 | 563.2 |
|                        | 70           | 0.0011       | 0.0017      | 0.0020 | 0.0016 | 0.0014 | 0.0022 | 0.0028 | 0.0021 | 802.7 | 607.6 | 608.5 | 673.0 | 714.3 | 522.7 | 523.9 | 587.0 |
| Mean                   |              | 0.0016       | 0.0023      | 0.0028 | 0.0022 | 0.0020 | 0.0028 | 0.0035 | 0.0027 | 690.6 | 578.3 | 558.6 | 609.2 | 622.5 | 512.9 | 515.4 | 550.3 |
| PDB                    | 100          | 0.0029       | 0.0035      | 0.0044 | 0.0036 | 0.0037 | 0.0048 | 0.0057 | 0.0047 | 494.1 | 557.1 | 545.5 | 532.2 | 454.9 | 430.6 | 450.4 | 445.3 |
|                        | 90           | 0.0026       | 0.0031      | 0.0039 | 0.0032 | 0.0034 | 0.0045 | 0.0053 | 0.0044 | 480.8 | 530.0 | 551.3 | 520.7 | 441.2 | 422.2 | 452.8 | 438.7 |
|                        | 80           | 0.0021       | 0.0026      | 0.0032 | 0.0026 | 0.0030 | 0.0040 | 0.0047 | 0.0039 | 500.0 | 528.1 | 625.0 | 551.0 | 416.7 | 416.8 | 453.8 | 429.1 |
|                        | 70           | 0.0017       | 0.0020      | 0.0027 | 0.0021 | 0.0027 | 0.0036 | 0.0041 | 0.0035 | 539.4 | 586.5 | 648.1 | 591.4 | 401.0 | 384.2 | 455.4 | 413.5 |
| Mean                   |              | 0.0023       | 0.0028      | 0.0036 | 0.0029 | 0.0032 | 0.0042 | 0.0050 | 0.0041 | 505.7 | 548.2 | 576.4 | 543.4 | 403.9 | 417.6 | 448.4 | 432.3 |
| P × HU                 | 100          | 0.0025       | 0.0032      | 0.0040 | 0.0032 | 0.0031 | 0.0041 | 0.0049 | 0.0040 | 554.8 | 560.9 | 543.8 | 553.2 | 513.5 | 463.4 | 479.6 | 485.5 |
|                        | 90           | 0.0022       | 0.0028      | 0.0035 | 0.0028 | 0.0028 | 0.0037 | 0.0045 | 0.0037 | 544.5 | 547.5 | 546.3 | 546.1 | 501.1 | 465.4 | 479.6 | 482.0 |
|                        | 80           | 0.0018       | 0.0023      | 0.0029 | 0.0023 | 0.0024 | 0.0033 | 0.0040 | 0.0032 | 583.3 | 564.3 | 589.0 | 578.9 | 505.0 | 452.1 | 479.3 | 478.8 |
|                        | 70           | 0.0014       | 0.0019      | 0.0024 | 0.0019 | 0.0020 | 0.0029 | 0.0035 | 0.0028 | 642.9 | 580.5 | 617.9 | 613.8 | 521.0 | 436.9 | 476.3 | 478.1 |
| Mean                   |              | 0.0020       | 0.0025      | 0.0032 | 0.0031 | 0.0041 | 0.0049 | 567.0 | 573.2 | 568.8 | 423.2 | 389.0 | 412.9 |

LSD 5%

| Humic acid | 0.00015 | 0.00016 | NS | NS |
| Biofertilizer | 0.00005 | 0.00007 | 77.4 | 58.5 |
| Phosphorus | 0.00006 | 0.00008 | 40.9 | NS |
| Humic*Bio | 0.00009 | 0.00011 | 134.0 | NS |
| Humic*Phosphorus | 0.00011 | 0.00013 | NS | 30.6 |
| Bio*Phosphorus | 0.00007 | NS | NS | 20.7 |
| Humic*Bio*Phosphorus | NS | NS | NS | 35.9 |

* - Initial available phosphorus in soil 0.0001%  
* - Initial C/P ratio in soil 8400 %  
* - P × HU = Interaction of Phosphorus treatment with humic acid treatments.  
* - C/P ratio = Organic Carbon % / Available phosphorus %
**Pant growth:**

Data concerned with the effect of humic acid, biofertilizers and phosphate application on plant measurements expressed as plant height (cm), number of branches, fresh weight, dry weight, number of leaves, chlorophyll, number of dry pods, length of pods, diameter of pods, average seed number, average weight of seeds and weight of seed yield of both investigated seasons were presented in Tables (6 - 8). Obtained results indicated significant positive effect for either humic acid, biofertilizers and phosphorus application on the investigated characters; the highest values were obtained with 8 kg humic acid, PDB inoculation and 100% of phosphorus recommended dose (200 kg superphosphate / fed).

Multiple regression was, also, carried out between plant dry weight, the most expressive growth parameter, on total microbial count and total microbial count without Bacillus megaterium and presented in equations (3 and 4). Regression coefficients indicated that plant dry weight (gm/plant) was increased in the first season an average of 0.00533 (gm/plant) for each unit of total microbial count, but only by 0.00012 for each unit of total microbial count without Bacillus megaterium. The corresponding values in the second were 0.00927 and 0.000113. This means that total microbial was more effective than total microbial count without Bacillus megaterium; in the same time indicated that total microbial count without Bacillus megaterium increased plant dry weight which could lead to conclude that microbial inoculation is very important in new reclaimed lands. Such conclusion was true in both investigated seasons.

\[ Y^* = 82.7 + 0.00533*X_1 + 0.00012*X_2 \] Equation (3) for the first season

\[ Y^* = 120 + 0.00927*X_1 + 0.000113*X_2 \] Equation (4) for the second season

Where \( Y \) stand for the dependent variable plant dry weigh (gm / plant), the independent variables \( X_1 \) stand for total microbial count (count×10⁴ CFU) and \( X_2 \) stand for total microbial count without Bacillus megaterium (count×10⁴ CFU).

Data showed that humic acid (8 kg/fed.), PDB inoculation and phosphate application (concentrin 100%) gave the highest values of the investigated plant growth measurements in the first and second seasons.

Ramana, V. et al. (2010) studied the effect of bio-fertilizers VAM (Vescicular Arbuscular Mycorrhizae) and PSB (Phosphorus Solubulizing Bacteria) along with their graded dose of fertilizers on growth of French bean. Their results revealed that the application of 75 per cent recommended Dose of Fertilizer + VAM + PSB significantly increased the plant height (cm), number of branches per plant, leaf area (cm²) and dry weight (g) of plant. In addition, Yosefi et al. (2011) reported that biofertilizers improved soil fertility by fixing atmospheric nitrogen both in association with plant roots as well as solubilized insoluble soil phosphates and increased plant growth substances in the soil. Furthermore, Hala Kandil (2014) reported that pea growth as well as of other legumes was affected by both phosphorous and humic acid application. In this respect, Agamy et al. (2012) showed that the application of Bio and/or FM in combination with NPK on wheat (Triticum aestivum L.) significantly increased all growth characters i.e., plant height, number of spikes/plant, leaf area and fresh and dry weights of both shoot and spikes / plant. Shehata et al. (2006) added that there was some microorganism which stimulates the Azotobacter population in soil thereby increasing the nitrogen fixation by Azotobacter. They showed that the maximum increments of vine length and leaf number as well as fresh and dry weight of shoots were recorded by the inoculation of squash seeds with Azotobacter. Sarhan et al. (2011) added that Biogein and Netropein produced the intermediate values.
Table 6. Influence of Humic acid, biofertilizers and phosphorus applications on plant height (cm) and number of branches/plant of pea during 2016/2017 seasons

| Bacterial Inoculations | Phosphorus % | Plant height (cm) of pea | Number of branches/plant of pea |
|------------------------|--------------|--------------------------|---------------------------------|
|                        |              | First Season             | Second Season                   | First season | Second Season |
|                        |              | With 4 Kg /fed. | With 8 Kg /fed. | Mean | With 4 Kg /fed. | With 8 Kg /fed. | Mean | With 4 Kg /fed. | With 8 Kg /fed. | Mean |
| Without                |              | 42.7 | 55.7 | 60.9 | 60.9 | 46.3 | 67.1 | 70.9 | 70.9 | 8.7 | 15.3 | 13.4 | 13.4 | 12.3 | 26.3 | 24.4 | 24.4 |
|                        |              | 41.3 | 54.3 | 59.8 | 59.8 | 44.9 | 65.3 | 67.8 | 67.8 | 8.3 | 15.0 | 12.8 | 12.8 | 10.7 | 23.7 | 21.9 | 21.9 |
|                        |              | 40.3 | 52.7 | 58.2 | 58.2 | 43.1 | 62.2 | 65.0 | 65.0 | 8.0 | 14.3 | 12.3 | 12.3 | 9.3 | 20.7 | 19.6 | 19.6 |
|                        |              | 38.7 | 50.7 | 56.6 | 56.6 | 42.2 | 58.6 | 62.5 | 62.5 | 7.3 | 12.7 | 11.2 | 11.2 | 8.0 | 18.7 | 17.0 | 17.0 |
| Mean                   |              | 40.8 | 53.3 | 82.5 | 82.5 | 55.6 | 102.2 | 96.7 | 96.7 | 13.3 | 20.7 | 20.7 | 20.7 | 18.3 | 32.3 | 29.4 | 29.4 |
| PDB                    |              | 47.7 | 93.3 | 87.2 | 87.2 | 55.6 | 102.2 | 96.7 | 96.7 | 13.3 | 20.7 | 20.7 | 20.7 | 18.3 | 32.3 | 29.4 | 29.4 |
|                        |              | 47.3 | 89.3 | 82.0 | 82.0 | 52.3 | 96.7 | 91.7 | 91.7 | 11.7 | 19.3 | 18.7 | 18.7 | 15.3 | 28.7 | 26.0 | 26.0 |
|                        |              | 45.7 | 87.3 | 77.7 | 77.7 | 49.7 | 92.1 | 86.3 | 86.3 | 10.3 | 17.7 | 16.3 | 16.3 | 13.7 | 24.7 | 23.0 | 23.0 |
|                        |              | 43.3 | 72.7 | 67.7 | 67.7 | 47.7 | 86.9 | 80.5 | 80.5 | 9.0 | 16.0 | 14.8 | 14.8 | 12.3 | 22.3 | 21.0 | 21.0 |
| Mean                   |              | 46.0 | 85.7 | 114.3 | 78.6 | 51.3 | 94.5 | 120.6 | 120.6 | 11.1 | 18.4 | 23.3 | 23.3 | 17.6 | 27.0 | 32.7 | 24.9 |
| P x HU                 |              | 45.2 | 74.5 | 74.1 | 74.1 | 51.0 | 84.7 | 83.8 | 83.8 | 11.0 | 18.0 | 17.1 | 17.1 | 15.3 | 29.3 | 26.9 | 26.9 |
|                        |              | 44.3 | 71.8 | 70.9 | 70.9 | 48.6 | 81.0 | 79.7 | 79.7 | 10.0 | 17.2 | 15.7 | 15.7 | 13.0 | 26.2 | 23.9 | 23.9 |
|                        |              | 43.0 | 70.0 | 67.9 | 67.9 | 46.4 | 71.1 | 75.7 | 75.7 | 9.2 | 16.0 | 14.3 | 14.3 | 11.5 | 22.7 | 21.3 | 21.3 |
|                        |              | 41.0 | 61.7 | 62.1 | 62.1 | 44.9 | 72.7 | 71.5 | 71.5 | 8.2 | 14.3 | 13.0 | 13.0 | 10.2 | 20.5 | 19.0 | 19.0 |
| Mean                   |              | 43.4 | 69.5 | 93.4 | 47.7 | 78.9 | 106.4 | 9.6 | 16.4 | 19.1 | 12.5 | 24.7 | 31.2 |

LSD 5%

- Humic acid: 3.8
- Biofertilizer: 2.4
- Phosphorus: 3.4
- Humic*Bio: 4.1
- Humic*Phosphorus: 5.9
- Bio*Phosphorus: 4.0
- Humic*Bio*Phosphorus: 6.9

*P × HU= Interaction of Phosphorus treatment with humic acid treatments.
### Table 7. Influence of humic acid, biofertilizers and phosphorus applications on fresh weight (g)/plant and dry weight (g)/plant during 2016/2017 seasons

| Bacterial Inoculations | Phosphorus (% | **Without** | **4 Kg /fed.** | **8 Kg /fed.** | **Mean** | **Without** | **4 Kg /fed.** | **8 Kg /fed.** | **Mean** | **Without** | **4 Kg /fed.** | **8 Kg /fed.** | **Mean** |
|-----------------------|---------------|-------------|----------------|----------------|---------|-------------|----------------|----------------|---------|-------------|----------------|----------------|---------|
| **Without**           | 100           | 245.3       | 1899.7         | 1849.7         | 1849.7  | 346.7       | 2330.0         | 2143.3         | 2143.3  | 72.2        | 132.4         | 227.8         | 144.1   |
|                       | 90            | 215.7       | 1775.7         | 1401.7         | 1401.7  | 311.7       | 2238.3         | 1991.7         | 1991.7  | 54.5        | 123.0         | 215.2         | 130.9   |
|                       | 80            | 210.3       | 1460.3         | 1225.0         | 1225.0  | 290.0       | 2040.0         | 1749.4         | 1749.4  | 36.9        | 108.2         | 171.7         | 105.6   |
|                       | 70            | 144.7       | 410.7          | 763.7          | 763.7   | 246.7       | 1511.7         | 1464.4         | 1464.4  | 22.1        | 87.0          | 137.5         | 82.2    |
|                       | **Mean**      | 204.0       | 1386.6         | 2339.4         | 1310.0  | 298.8       | 2030.0         | 3182.9         | 1837.2  | 46.4        | 112.6         | 188.0         | 115.7   |
| **PDB**               | 100           | 365.3       | 3200.3         | 2856.7         | 2856.7  | 565.7       | 4041.7         | 3568.0         | 3568.0  | 102.4       | 192.1         | 365.2         | 219.9   |
|                       | 90            | 330.7       | 3000.7         | 2612.3         | 2612.3  | 528.3       | 3537.0         | 3160.1         | 3160.1  | 93.1        | 169.1         | 329.3         | 197.2   |
|                       | 80            | 275.3       | 2175.7         | 2018.2         | 2018.2  | 510.7       | 3170.7         | 2899.6         | 2899.6  | 75.2        | 147.5         | 282.5         | 168.4   |
|                       | 70            | 254.7       | 2154.7         | 1971.3         | 1971.3  | 460.0       | 2883.3         | 2590.6         | 2590.6  | 61.6        | 113.8         | 223.3         | 132.9   |
|                       | **Mean**      | 306.5       | 2632.8         | 4154.6         | 2364.6  | 516.2       | 3408.2         | 5239.3         | 3054.6  | 83.1        | 155.6         | 300.1         | 179.6   |
| **P × HU**            | 100           | 305.3       | 2550.0         | 2353.2         | 2353.2  | 456.2       | 3185.8         | 2855.7         | 2855.7  | 87.3        | 162.2         | 296.5         | 182.0   |
|                       | 90            | 273.2       | 2388.2         | 2007.0         | 2007.0  | 420.0       | 2887.7         | 2575.9         | 2575.9  | 73.8        | 146.1         | 272.3         | 164.0   |
|                       | 80            | 242.8       | 1818.0         | 1621.6         | 1621.6  | 400.3       | 2605.3         | 2324.5         | 2324.5  | 56.0        | 127.8         | 227.1         | 137.0   |
|                       | 70            | 199.7       | 1282.7         | 1367.5         | 1367.5  | 353.3       | 2197.5         | 2027.5         | 2027.5  | 41.8        | 100.4         | 180.4         | 107.6   |
|                       | **Mean**      | 255.3       | 2009.7         | 3247.0         | 407.5   | 2719.1      | 4211.1         | 1476.0         | 1476.0  | 64.7        | 134.1         | 244.1         | 182.4   |

**LSD 5%**

- **Humic acid**: 9.8
- **Biofertilizer**: 6.0
- **Phosphorus**: 9.2
- **Humic*Bio**: 10.4
- **Humic*Phosphorus**: 16.0
- **Bio*Phosphorus**: 10.8
- **Humic*Bio*Phosphorus**: 18.7

*P × HU = Interaction of Phosphorus treatment with humic acid treatments.
Table 8. Influence of humic acid, biofertilizers and phosphorus applications on number of leaves /plant and chlorophyll (SPAD unit) during 2016/ 2017 seasons

| Bacterial Inoculations | Phosphorus % | Number of leaves /plant | Chlorophyll (SPAD unit) |
|------------------------|--------------|-------------------------|-------------------------|
|                        |              | First Season             | Second Season           |
|                        |              | Humic Acid               |                         |
|                        |              | Without 4 Kg /fed. | 8 Kg /fed. | Mean | Without 4 Kg /fed. | 8 Kg /fed. | Mean | Without 4 Kg /fed. | 8 Kg /fed. | Mean |
| Without                |              |                          |                         |
| 100                    |              | 14.3                     | 28.0            | 26.6    | 26.1    | 33.0 | 33.2 | 19.3 | 23.0 | 39.0 | 27.1 | 22.3 | 26.5 | 43.1 | 30.6 |
| 90                     |              | 12.7                     | 24.3            | 22.8    | 22.8    | 28.7 | 29.4 | 29.4 | 17.7 | 18.3 | 35.6 | 23.9 | 19.6 | 23.7 | 40.1 | 27.8 |
| 80                     |              | 11.3                     | 22.3            | 20.1    | 20.1    | 24.7 | 26.4 | 26.4 | 14.9 | 14.4 | 29.3 | 19.5 | 16.8 | 19.0 | 35.4 | 23.7 |
| 70                     |              | 9.7                      | 18.0            | 17.7    | 17.7    | 21.7 | 23.2 | 23.2 | 12.9 | 10.9 | 23.0 | 15.6 | 14.6 | 14.7 | 28.0 | 19.1 |
| Mean                   |              | 12.0                     | 23.2            | 30.2    | 21.8    | 17.7 | 27.0 | 39.6 | 28.1 | 16.2 | 16.7 | 31.7 | 21.5 | 18.3 | 21.0 | 36.7 | 25.3 |
| PDB                    |              |                          |                         |
| 100                    |              | 20.7                     | 35.3            | 40.6    | 40.6    | 46.7 | 47.8 | 47.8 | 26.2 | 44.4 | 59.1 | 43.2 | 28.5 | 47.7 | 70.6 | 48.9 |
| 90                     |              | 18.3                     | 31.7            | 35.1    | 35.1    | 43.0 | 42.7 | 42.7 | 22.8 | 39.7 | 54.6 | 39.0 | 25.1 | 43.2 | 62.2 | 43.5 |
| 80                     |              | 15.7                     | 27.3            | 31.6    | 31.6    | 38.7 | 38.1 | 38.1 | 18.6 | 35.2 | 47.2 | 33.7 | 21.5 | 39.0 | 57.0 | 39.2 |
| 70                     |              | 11.7                     | 24.7            | 25.6    | 25.6    | 34.7 | 34.6 | 34.6 | 14.8 | 27.9 | 43.1 | 28.6 | 17.9 | 34.5 | 52.6 | 35.0 |
| Mean                   |              | 16.6                     | 29.8            | 53.3    | 33.2    | 20.9 | 40.8 | 60.7 | 40.8 | 20.6 | 36.8 | 51.0 | 36.1 | 23.2 | 41.1 | 60.6 | 41.6 |
| P x HU                 |              |                          |                         |
| 100                    |              | 17.5                     | 31.7            | 33.6    | 33.6    | 39.8 | 40.5 | 40.5 | 22.8 | 33.7 | 49.0 | 35.2 | 25.4 | 37.1 | 56.8 | 39.8 |
| 90                     |              | 15.5                     | 28.0            | 28.9    | 28.9    | 35.8 | 36.1 | 36.1 | 20.2 | 29.0 | 45.1 | 31.5 | 22.3 | 33.5 | 51.2 | 35.7 |
| 80                     |              | 13.5                     | 24.8            | 25.8    | 25.8    | 31.7 | 32.3 | 32.3 | 16.7 | 24.8 | 38.3 | 26.6 | 19.2 | 29.0 | 46.2 | 31.5 |
| 70                     |              | 10.7                     | 21.3            | 21.6    | 21.6    | 28.2 | 28.9 | 28.9 | 13.8 | 19.4 | 33.0 | 22.1 | 16.2 | 24.6 | 40.3 | 27.0 |
| Mean                   |              | 14.3                     | 26.5            | 41.7    | 19.3    | 33.9 | 50.1 | 18.4 | 26.7 | 41.4 | 20.8 | 31.0 | 48.6 | 1.3  | 0.6  | 0.8  |

LSD 5%

|                        |              | Humic acid               | Biofertilizer | Phosphorus | Humic*Bio | Humic*Phosphorus | Bio*Phosphorus | Humic*Bio*Phosphorus |
|------------------------|--------------|-------------------------|---------------|------------|------------|-------------------|-----------------|----------------------|
|                        |              | 3.3                     | 2.2           | 1.3        | 3.7        | 2.3               | 1.6             | 2.7                  |
|                        |              | 3.8                     | 3.2           | 2.1        | 5.6        | NS                | NS              | NS                   |
|                        |              | 2.6                     | 2.1           | 1.7        | 3.7        | NS                | NS              | NS                   |
|                        |              | 1.3                     | 0.6           | 0.8        | 1.0        | 1.3               | 0.9             | 1.6                  |

* P × HU = Interaction of Phosphorus treatment with humic acid treatments.
Yield and its components:

Data concerned with the effect of humic acid, biofertilizers and phosphate application on yield measurements expressed as number of dry pods, length of pods, diameter of pods, average seed number, average weight of seeds and weight of seed yield were presented in Tables (9 - 11). Obtained results indicated significant positive effect of all of humic acid, biofertilizers and phosphorus application on the investigated characters; the highest values were obtained with 8 kg humic acid, PDB inoculation or 100% of phosphorus recommended dose (200 kg superphosphate / fed). Data showed that humic acid (8 kg/fed.), PDB inoculation and phosphate application (100 % of recommended dose) gave the highest values. Numbers of dry pods were 14.427 and 16.158, lengths of pods were 9.967 and 10.950 (cm), diameters of pea pods were 0.915 and 0.978 (mm), average seeds number per pod were 3.488 and 3.850 (g) and weight of seeds yield / m² was 1356.7 and 1356.7 (g) in the first and second seasons respectively.

As for the relationship of seed yield and bacterial counts, multiple regression of seed yield (gm / m²) on total microbial count and total microbial count without Bacillus megaterium was estimated and presented in equations (5 and 6). Regression coefficients indicated that seed yield was increased in the first season an average of 0.31157 gm/m² for each unit of total microbial count but only by 0.00028 gm / m³ for each unit of total microbial count without Bacillus megaterium. The corresponding values in the second season were 0.393 and 0.00028. This means that total microbial was more effective than total microbial count without Bacillus megaterium; in the same time indicated that total microbial count without Bacillus megaterium increased seed yield which could lead to conclude, again, that microbial inoculation is very important in new reclaimed lands for increasing seed yield. Such conclusion was true in both investigated seasons.

\[ Y^\wedge = 1012 + 0.31157X_1 + 0.00028X_2 \quad \text{Equation (5)} \]

for the first season.

\[ Y^\wedge = 1442 + 0.393X_1 + 0.00028X_2 \quad \text{Equation (6)} \]

for the second season.

Where Y stand for the dependent variable seed yield (gm / m²), the independent variables X₁ stand for total microbial count (count×10⁴ CFU) and X₂ stand for total microbial count without Bacillus megaterium (count×10⁴ CFU).

It is, also, of great interest to know the relation between Bacillus density (count×10⁴) and seed yield of pea plants. Linear correlation indicated that there was highly significant positive correlation between seed yield (gm/m²) and Bacillus megaterium density (count×10⁴ CFU). Correlation coefficients (r) were 0.9 and 0.84) in the first and second seasons, respectively. Linear regression of seed yield on the independent variable showed that regression coefficients were 37.66 and 39.43 in the first and second seasons, respectively. This means that seed yield would increase by 37.66 and 39.43 (gm/ m²) in the first and second seasons, respectively, for each unit increase of Bacillus megaterium.

![Fig. 2. Regression of seed yield (Y, gm /m²) on Bacillus megaterium (X, count×10⁴ CFU)](image)

\[ Y^\wedge = 455.10 + 37.66 X, \ r = 0.9 \quad \text{in the 1_st season} \]

\[ Y^\wedge = -600.091 + 39.43384 X, \ r = 0.84 \quad \text{in the 2_st season} \]
On the other hand, uninoculated treatment gave the lowest values of the qualities listed earlier as following: Number of dry pods / plant were 7.768 and 8.392, lengths of pods were 6.817 and 8.021 (cm), diameters of pea pods were 0.645 and 0.698 (mm), average seeds number / pod were 6.800 and 7.929, average seeds weight / pod were 1.748 and 1.904 (g) and weights of seeds yield /m² were 730.7 and 803.3(g) in the first and second season, respectively. That consistent with Afifi et al. (2010) results who found that humic acid improved nutrient status and yield components of faba bean plants. In addition, Ramana, V. et al. (2010) studied the effect of bio-fertilizers VAM (Vesicular Arbuscular Mycorrhizae) and PSB (Phosphorus Solubilizing Bactiria) along with their graded dose of fertilizers on yield attributes and yield of french bean. Their results revealed that the application of 75 per cent recommended Dose of Fertilizer + VAM + PSB significantly increased number of pods per plant, number of pods per cluster, number of seeds per pod, 100 seed weight (g), pod length, pod yield per plant (g) and pod yield per hectare. As for phosphorus effect on plant growth, Sharma (2002) reported that one of the advantages of plant feeding with phosphorus is to create deeper and more abundant roots. Omar et al. (1990) and Tesfaye et al. (2007) added that phosphorus is one of the most important elements significantly affecting plant growth and metabolism. The crop production on more than 30% of the world arable lands related to P availability. Tsvetkova and Georgiev, (2007) added that phosphorus may be a critical constraint of legumes under low nutrient environments because there is a substantial need for P in the N₂ fixation process.

Seed analysis:

Regarding chemical constituents of pea seeds, nitrogen, phosphorus and potassium were estimated and shown in Tables (12, 13). It was clearly that pea plant treatments with only chemical fertilizers gave lower values than plants treated with biofertilizers in all the measurements in both investigated seasons. That result was in harmony with those obtained by El-Sayed et al. (2018 and Pandya and Saraf (2010). Also, Suke et al. (2011) reported that treated maize (Zea mays L.) with recommended dose fertilizer + Azotobacter + PSB led to increase of nitrogen, phosphorus and potassium contents in leaves.

RECOMMENDATION

The study revealed that using 8kg HA/fed in combination with PDB and high level of P₂O₅ as a fertilizer application to improve soil properties, vegetative growth, mineral content and yield of pea plants in new soils was recommended.
### Table 9. Influence of humic acid, biofertilizers and phosphorus applications on number of dry pods/plant and length of pods (cm) of pea during 2016/2017 seasons

| Bacterial Inoculations | Phosphorus % | Number of dry pods/plant of pea | Length of pods (cm) of pea |
|------------------------|--------------|---------------------------------|---------------------------|
|                        |              | Without | 4 Kg /fed. | 8 Kg /fed. | Mean | Without | 4 Kg /fed. | 8 Kg /fed. | Mean | Without | 4 Kg /fed. | 8 Kg /fed. | Mean | Without | 4 Kg /fed. | 8 Kg /fed. | Mean |
| **Without**            |              |         |           |           |      |          |           |           |      |          |           |           |      |          |           |           |      |
| Humic Acid             | 100          | 5.7     | 7.0       | 9.4       | 7.4  | 6.6       | 7.5       | 10.1      | 8.1  | 3.9       | 5.4       | 8.7       | 6.0  | 5.1       | 6.3       | 9.5       | 6.9  |
|                        | 90           | 4.0     | 6.2       | 9.0       | 6.4  | 5.5       | 6.8       | 9.1       | 7.1  | 2.9       | 5.0       | 7.7       | 5.2  | 4.3       | 5.9       | 8.4       | 6.2  |
|                        | 80           | 3.2     | 5.3       | 6.9       | 5.1  | 4.9       | 5.9       | 7.8       | 6.2  | 2.8       | 4.4       | 5.7       | 4.3  | 3.3       | 5.0       | 7.8       | 5.4  |
|                        | 70           | 2.5     | 4.4       | 5.8       | 4.3  | 3.7       | 5.3       | 6.6       | 5.2  | 2.3       | 3.9       | 5.1       | 3.8  | 2.9       | 4.1       | 6.5       | 4.5  |
| **Mean**               |              | 3.9     | 5.7       | 7.8       | 5.8  | 5.2       | 6.4       | 8.4       | 6.6  | 3.0       | 4.7       | 6.8       | 4.8  | 3.9       | 5.3       | 8.0       | 5.7  |
| **PDB**                |              |         |           |           |      |          |           |           |      |          |           |           |      |          |           |           |      |
| Humic Acid             | 100          | 6.7     | 14.5      | 18.0      | 13.0 | 7.8       | 15.2      | 18.7      | 13.9 | 6.0       | 8.4       | 11.2      | 8.5  | 6.7       | 9.6       | 12.4      | 9.5  |
|                        | 90           | 6.1     | 12.5      | 15.8      | 11.5 | 7.2       | 13.5      | 17.2      | 12.6 | 5.1       | 7.5       | 10.5      | 7.7  | 6.1       | 9.0       | 11.4      | 8.8  |
|                        | 80           | 4.5     | 9.5       | 13.0      | 9.0  | 6.5       | 11.5      | 15.4      | 11.1 | 4.1       | 6.2       | 9.5       | 6.6  | 5.7       | 8.0       | 10.6      | 8.1  |
|                        | 70           | 3.1     | 7.7       | 11.0      | 7.3  | 5.8       | 10.5      | 13.5      | 9.9  | 3.7       | 4.2       | 8.7       | 5.5  | 4.6       | 6.4       | 9.4       | 6.8  |
| **Mean**               |              | 5.1     | 11.0      | 14.4      | 10.2 | 6.8       | 12.7      | 16.2      | 11.9 | 4.7       | 6.6       | 10.0      | 7.1  | 5.7       | 8.2       | 11.0      | 8.3  |
| **P × HU**             |              |         |           |           |      |          |           |           |      |          |           |           |      |          |           |           |      |
| Humic Acid             | 100          | 6.2     | 10.7      | 13.7      | 10.2 | 7.2       | 11.4      | 14.4      | 11.0 | 4.9       | 6.9       | 10.0      | 7.3  | 5.9       | 7.9       | 10.9      | 8.2  |
|                        | 90           | 5.1     | 9.3       | 12.4      | 8.9  | 6.3       | 10.1      | 13.1      | 9.9  | 4.0       | 6.2       | 9.1       | 6.4  | 5.2       | 7.4       | 9.9       | 7.5  |
|                        | 80           | 3.9     | 7.4       | 9.9       | 7.1  | 5.7       | 8.7       | 11.6      | 8.7  | 3.5       | 5.3       | 7.6       | 5.4  | 4.5       | 6.5       | 9.2       | 6.7  |
|                        | 70           | 2.8     | 6.0       | 8.4       | 5.8  | 4.8       | 7.9       | 10.0      | 7.5  | 3.0       | 4.1       | 6.9       | 4.6  | 3.7       | 5.2       | 8.0       | 5.6  |
| **Mean**               |              | 4.5     | 8.4       | 11.1      | 6.0  | 9.5       | 12.3      | 3.8       | 5.6  | 8.4       | 4.8       | 6.8       | 9.5  |

LSD 5%

- Humic acid: 2.9, Biofertilizer: 0.6, Phosphorus: 0.5, Humic*Bio: 1.1, Humic*Phosphorus: 0.9, Bio*Phosphorus: 0.6, Humic*Bio*Phosphorus: 1.0

* - P × HU= Interaction of Phosphorus treatment with humic acid treatments.
Table 10. Influence of humic acid, biofertilizers and phosphorus applications on diameter of pods (mm) of pea and average seed number /dry pod of pea during 2016/2017 seasons

| Bacterial Inoculations | Phosphorus % | Diameter of pea pods (mm) | Average seed number /dry pea pod |
|------------------------|--------------|---------------------------|---------------------------------|
|                        |              | First Season              | Second Season                   | First Season | Humic Acid | Second Season |
|                        |              | Humic Acid                |                                |              | Humic Acid |                                |
|                        |              | Without 4 Kg /fed. | Without 8 Kg /fed. | Mean | Without 4 Kg /fed. | Without 8 Kg /fed. | Mean | Without 4 Kg /fed. | Without 8 Kg /fed. | Mean | Without 4 Kg /fed. | Without 8 Kg /fed. | Mean |
| Without                |              | 0.37 | 0.57 | 0.71 | 0.55 | 0.52 | 0.63 | 0.78 | 0.64 | 4.05 | 5.61 | 7.85 | 5.84 | 4.78 | 6.52 | 9.07 | 6.79 |
|                        |              | 0.32 | 0.52 | 0.67 | 0.50 | 0.41 | 0.57 | 0.72 | 0.57 | 3.48 | 5.35 | 7.02 | 5.29 | 4.38 | 5.95 | 8.45 | 6.26 |
|                        |              | 0.28 | 0.46 | 0.63 | 0.46 | 0.35 | 0.49 | 0.68 | 0.51 | 3.68 | 4.90 | 6.52 | 5.03 | 3.85 | 5.25 | 7.52 | 5.54 |
|                        |              | 0.23 | 0.37 | 0.57 | 0.39 | 0.26 | 0.42 | 0.61 | 0.43 | 3.27 | 4.52 | 5.82 | 4.54 | 3.52 | 4.77 | 6.68 | 4.99 |
| Mean                   |              | 0.30 | 0.48 | 0.65 | 0.48 | 0.38 | 0.53 | 0.70 | 0.54 | 3.62 | 5.09 | 6.80 | 5.17 | 4.13 | 5.62 | 7.93 | 5.89 |
| PDB                    |              | 0.48 | 0.87 | 1.02 | 0.79 | 0.61 | 0.96 | 1.16 | 0.91 | 4.71 | 7.25 | 9.18 | 7.05 | 5.98 | 8.65 | 9.88 | 8.17 |
|                        |              | 0.44 | 0.82 | 0.94 | 0.73 | 0.52 | 0.88 | 0.99 | 0.80 | 4.63 | 6.62 | 8.92 | 6.72 | 5.35 | 7.67 | 9.43 | 7.48 |
|                        |              | 0.37 | 0.75 | 0.88 | 0.67 | 0.46 | 0.84 | 0.91 | 0.74 | 4.31 | 6.28 | 8.08 | 6.23 | 4.78 | 6.95 | 8.70 | 6.81 |
|                        |              | 0.34 | 0.67 | 0.83 | 0.61 | 0.38 | 0.75 | 0.86 | 0.66 | 3.78 | 5.90 | 7.18 | 5.62 | 3.88 | 6.02 | 7.85 | 5.92 |
| Mean                   |              | 0.41 | 0.78 | 0.92 | 0.70 | 0.49 | 0.86 | 0.98 | 0.78 | 4.36 | 6.51 | 8.34 | 6.40 | 5.00 | 7.32 | 8.97 | 7.10 |
| P × HU                 |              | 0.42 | 0.72 | 0.86 | 0.67 | 0.56 | 0.80 | 0.97 | 0.78 | 4.38 | 6.43 | 8.52 | 6.44 | 5.38 | 7.58 | 9.48 | 7.48 |
|                        |              | 0.38 | 0.67 | 0.81 | 0.62 | 0.47 | 0.72 | 0.85 | 0.68 | 4.06 | 5.99 | 7.97 | 6.00 | 4.87 | 6.81 | 8.94 | 6.87 |
|                        |              | 0.32 | 0.61 | 0.75 | 0.56 | 0.41 | 0.67 | 0.80 | 0.62 | 4.00 | 5.59 | 7.30 | 5.63 | 4.32 | 6.10 | 8.11 | 6.18 |
|                        |              | 0.28 | 0.52 | 0.70 | 0.50 | 0.32 | 0.59 | 0.74 | 0.55 | 3.53 | 5.21 | 6.50 | 5.08 | 3.70 | 5.39 | 7.27 | 5.45 |
| Mean                   |              | 0.35 | 0.63 | 0.78 | 0.44 | 0.69 | 0.84 | 3.99 | 5.80 | 7.57 | 4.57 | 6.47 | 8.45 |

LSD 5%

- Humic acid 0.03 0.01 0.45 0.16
- Biofertilizer 0.01 0.02 0.25 0.18
- Phosphorus 0.01 0.02 0.16 0.17
- Humic*Bio 0.02 0.04 0.44 0.32
- Humic*Phosphorus 0.02 NS 0.27 0.29
- Bio*Phosphorus NS NS NS 0.20
- Humic*Bio*Phosphorus NS 0.04 NS 0.34

*P × HU= Interaction of Phosphorus treatment with humic acid treatments.
Table 11. Influence of humic acid, biofertilizers and phosphorus applications on average weight of seeds (g)/pod of pea and weight of seed yield (g)/m² of pea during 2016/2017 seasons

| Bacterial Inoculations | Phosphorus % | Average weight of seeds (g)/pod of pea | weight of seed yield (g)/m² of pea |
|------------------------|--------------|---------------------------------------|----------------------------------|
|                        |              | First Season                          | Second Season                    | First Season                          | Second Season |
|                        |              | Without 4 Kg/fed. 8 Kg/fed. Mean      | Without 4 Kg/fed. 8 Kg/fed. Mean | Without 4 Kg/fed. 8 Kg/fed. Mean      | Without 4 Kg/fed. 8 Kg/fed. Mean |
| Without                | 100          | 1.017 1.117 2.183 1.439 1.100 1.167 2.417 1.561 81.7 | 605.3 853.3 513.4 103.0 774.0 885.0 | 587.3 |
|                        | 90           | 0.840 0.970 1.917 1.242 1.017 1.083 2.083 1.394 75.0 | 507.3 735.0 439.1 94.3 708.3 815.0 | 539.2 |
|                        | 80           | 0.800 0.887 1.583 1.090 0.867 0.983 1.733 1.194 65.3 | 488.3 679.0 410.9 87.3 660.0 775.0 | 507.4 |
|                        | 70           | 0.683 0.767 1.307 0.919 0.717 0.917 1.383 1.006 63.0 | 261.7 655.3 326.7 82.3 418.3 738.3 | 413.0 |
| Mean                   |              | 0.835 0.935 1.748 1.173 0.925 1.038 1.904 1.289 71.3 | 465.7 730.7 422.5 91.8 640.2 803.3 | 511.8 |
| PDB                    |              | 1.150 2.483 4.050 2.561 1.200 2.667 4.317 2.728 124.3 | 1123.3 1356.7 868.1 171.3 1280.0 1473.3 | 974.9 |
|                        | 90           | 0.993 2.317 3.817 2.376 1.117 2.483 3.967 2.522 114.7 | 1046.7 1233.3 798.2 163.7 1220.0 1416.7 | 933.4 |
|                        | 80           | 0.887 2.107 3.267 2.087 1.033 2.167 3.667 2.289 95.0 | 745.3 1207.7 682.7 153.7 1161.7 1341.7 | 885.7 |
|                        | 70           | 0.823 1.883 2.817 1.841 0.933 1.983 3.450 2.122 86.7 | 694.0 1121.7 634.1 144.3 1121.7 1263.7 | 843.2 |
| Mean                   |              | 0.963 2.198 3.488 2.216 1.071 2.325 3.850 2.415 124.3 | 1123.3 1356.7 745.8 158.3 1195.8 1356.7 | 909.3 |
| P × HU                 | 100          | 1.083 1.800 3.117 2.000 1.150 1.917 3.367 2.144 103.0 | 864.3 1105.0 690.8 137.2 1027.0 1179.2 | 781.1 |
|                        | 90           | 0.917 1.643 2.867 1.809 1.067 1.783 3.025 1.958 94.8 | 777.0 984.2 618.7 129.0 964.2 1115.8 | 736.3 |
|                        | 80           | 0.843 1.497 2.425 1.588 0.950 1.575 2.700 1.742 80.2 | 616.8 943.3 546.8 120.5 910.8 1058.3 | 696.6 |
|                        | 70           | 0.753 1.325 2.062 1.380 0.825 1.450 2.417 1.564 74.8 | 477.8 888.5 484.0 113.3 770.0 1001.0 | 628.1 |
| Mean                   |              | 0.899 1.566 2.618 0.998 1.681 2.877 88.2 684.0 980.3 | 125.0 918.0 1088.6 |

LSD 5%

|                        |              | Humic acid 0.546 0.476 45.096 56.976 | Biofertilizer 0.149 0.061 13.711 7.070 |
|                        |              | Phosphorus 0.070 0.046 12.427 11.236 | Humic*Bio 0.257 0.106 23.747 12.246 |
|                        |              | Humic*Phosphorus 0.122 0.080 21.523 19.502 | Bio*Phosphorus NS 14.579 13.210 |
|                        |              | Humic*Bio*Phosphorus NS 0.094 25.252 22.880 |

*P × HU: Interaction of Phosphorus treatment with humic acid treatments.
Table 12. Influence of humic acid, biofertilizers and phosphorus applications on nitrogen and phosphorus concentration in seeds of pea during 2016/2017 seasons

| Bacterial Inoculations | Phosphorus % | Nitrogen content in seeds of pea (%) | Phosphorus concentration (ppm) |
|-----------------------|--------------|-------------------------------------|-------------------------------|
|                       |              | First Season                        | Second Season                 |
|                       |              | Humic Acid                          | Second Season                 |
|                       |              | Without 4 Kg /fed.                  | 8 Kg /fed.                    |
|                       |              | Mean                                | Without 4 Kg /fed.            |
|                       |              | 1.387                               | 2.320                        |
|                       |              | 1.681                               | 1.91                          |
| Without 4 Kg /fed.    |              | 2.41                                | 3.01                          |
|                       |              | 2.44                                | 249.40                       |
|                       |              | 364.30                              | 457.65                       |
|                       |              | 357.12                              | 268.61                       |
|                       |              | 398.63                              | 487.19                       |
|                       |              | 384.81                              |                              |
|                       |              | 1.22                                | 2.22                         |
|                       |              | 188.40                              | 293.74                       |
|                       |              | 210.95                              | 349.90                       |
|                       |              | 427.65                              |                              |
|                       | 100          | 100                                 | 1.387                        |
|                       | 90           | 90                                  | 1.877                        |
|                       | 80           | 80                                  | 1.573                        |
|                       | 70           | 70                                  | 1.397                        |
|                       | Mean         | Mean                                | 1.453                        |
|                       |              | 2.18                                | 2.60                         |
|                       |              | 2.11                                | 203.36                       |
|                       |              | 316.24                              | 410.69                       |
|                       |              | 310.10                              | 229.23                       |
|                       |              | 358.73                              | 437.86                       |
|                       |              | 341.94                              |                              |
|                       | 100          | 100                                 | 2.487                        |
|                       | 90           | 90                                  | 3.633                        |
|                       | 80           | 80                                  | 2.056                        |
|                       | 70           | 70                                  | 2.850                        |
| PDB                   |              | Mean                                | 2.199                        |
|                       |              | 3.29                                | 3.86                         |
|                       |              | 3.01                                | 257.72                       |
|                       |              | 374.28                              | 549.70                       |
|                       |              | 393.90                              | 289.98                       |
|                       |              | 389.73                              | 594.28                       |
|                       |              | 424.66                              |                              |
|                       | 100          | 100                                 | 2.182                        |
|                       | 90           | 90                                  | 3.163                        |
|                       | 80           | 80                                  | 2.478                        |
|                       | 70           | 70                                  | 2.123                        |
| P × HU                |              | Mean                                | 1.753                        |
|                       |              | 2.94                                | 3.37                         |
|                       |              | 2.59                                | 217.60                       |
|                       |              | 331.37                              | 450.24                       |
|                       |              | 333.07                              | 245.43                       |
|                       |              | 335.55                              | 537.00                       |
|                       |              | 372.66                              |                              |
|                       | 100          | 100                                 | 1.508                        |
|                       | 90           | 90                                  | 1.882                        |
|                       | 80           | 80                                  | 1.633                        |
|                       | 70           | 70                                  | 1.363                        |
|                       | Mean         | Mean                                | 1.765                        |
|                       |              | 2.627                               | 3.23                         |
|                       |              | 2.305                               | 480.19                       |
|                       |              | 259.60                              | 516.07                       |

LSD 5%

- Humic acid: 0.3865 0.2502 18.253 19.045
- Biofertilizer: 0.3062 0.0880 15.460 17.722
- Phosphorus: 0.0711 0.0690 14.847 17.112
- Humic*Bio: 0.5303 0.1525 26.777 30.695
- Humic*Phosphorus: 0.1232 0.1196 25.717 NS
- Bio*Phosphorus: 0.0835 NS NS NS
- Humic*Bio*Phosphorus: 0.1446 NS 30.171 NS

* P × HU = Interaction of Phosphorus treatment with humic acid treatments.
Table 13. Influence of humic acid, biofertilizers and phosphorus applications on potassium concentration in seeds of pea during 2016/2017 seasons

| Bacterial Inoculations | Phosphorus | Potassium concentration (%) | Potassium concentration (%) |
|------------------------|------------|-----------------------------|-----------------------------|
|                        |            | First Season                | Second Season               |
|                        |            | Without 4 Kg/fed. | 8 Kg/fed. | Mean | Without 4 Kg/fed. | 8 Kg/fed. | Mean |
| Without                | 100        | 0.91  1.28  1.37   | 1.19  1.38  1.76   | 1.94 | 1.69 |
|                        | 90         | 0.84  1.18  1.28   | 1.10  1.14  1.40   | 1.70 | 1.41 |
|                        | 80         | 0.77  1.11  1.24   | 1.04  1.01  1.17   | 1.42 | 1.20 |
|                        | 70         | 0.73  1.02  1.14   | 0.97  0.94  1.05   | 1.19 | 1.06 |
| Mean                   |             | 0.81  1.15  1.26   | 1.07  1.12  1.35   | 1.56 | 1.34 |
| PDB                    | 100        | 1.13  1.66  2.02   | 1.60  1.73  2.12   | 2.56 | 2.13 |
|                        | 90         | 1.08  1.54  1.95   | 1.52  1.47  1.85   | 2.28 | 1.87 |
|                        | 80         | 1.03  1.45  1.86   | 1.45  1.17  1.49   | 1.98 | 1.55 |
|                        | 70         | 0.92  1.31  1.74   | 1.33  1.05  1.78   | 1.34 | 1.39 |
| Mean                   |             | 1.04  1.49  1.89   | 1.47  1.36  1.70   | 2.15 | 1.74 |
| P × HU                 | 100        | 1.02  1.47  1.69   | 1.40  1.55  1.94   | 2.25 | 1.91 |
|                        | 90         | 0.96  1.36  1.61   | 1.31  1.31  1.63   | 1.99 | 1.64 |
|                        | 80         | 0.90  1.28  1.55   | 1.24  1.09  1.33   | 1.70 | 1.37 |
|                        | 70         | 0.83  1.17  1.44   | 1.15  1.00  1.19   | 1.49 | 1.22 |
| Mean                   |             | 0.93  1.32  1.58   | 1.24  1.52  1.86   |       |       |

LSD 5%

Humic acid 0.033 0.069
Biofertilizer 0.016 0.149
Phosphorus 0.023 0.083
Humic*Bio 0.028 NS
Humic*Phosphorus 0.040 NS
Bio*Phosphorus 0.027 NS
Humic*Bio*Phosphorus NS NS

*P × HU = Interaction of Phosphorus treatment with humic acid treatments.

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الملخص العربي

تأثير حمض الهيوميك والاسمدة الحيوية والفوسفات المعدني على النشاط الميكروبي بالتربة

إنجاحية نباتات البسلة تحت ظروف توشكا

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أجريت دراسة çıحيلية خلال الموسم الشتوي لعامي 2015/2016 و 2016/2017 في محطة بحوث توشكا مركز بحوث الصحراء، لدراسة تأثير الأحماض الديبالية (حمض الهيوميك) ، ثلاث معاملات - بدون إضافة ، 4، 8 كجم/فدأم مع معاملتين من التسميد الحيوى (بدون لقاح + البكتريا المذيبة للفوسفات) مع أربع معاملات من التسميد الفوسفاتى 15.5 % ( 100، 90، 80، 70 %) فوق 20 % من المعدل الموصى به في الإنتاج التجاري على نباتات البسلة. أوضحح الدراسة إن زيادة معدل التسديد بحامض الهيوميك إلى 8 كجم/فدأم، مع التلقيح بالبكتريا المذيبة للفوسفات، كان له أثر بالغ في زيادة الأعداد الكلية للميكروبات البكتريا المذيبة للفوسفات وانبعاث ثاني أكسيد الكربون والمادة العضوية بالتربة. بالإضافة إلى زيادة نشاط الإنزيمات المرتبطة بيميقاربات النترة مثل إنزيم الفوسفانتاز والديهدروجيناز. كما أن المحتوى المغذي في النبات مثل النيتروجين والكربون والفسفور الميسر ونسبة الكربون إلى النيتروجين والفسفور الميسر نسباً الكربون إلى (C/N ratio) ونسبة النيتروجين إلى (C/P ratio) في التربة أظهرت استجابة معينة مرتفعة لجميع عوامل الدراسة خصوصاً التكاثرات المرتبطة بتربة وفوسفات الفوسفات. ولقد أظهرت معايير مثالية للتنمو الخضري للمبناي المعدني ونواتج المحصولي للنباتات البسلة في الأراضي الحديثة. }

مقارنة بنتائج إستعمال خليط من حامض الهيوميك والسوبر فوسفات فقط. كما أشارت الدراسة أيضاً إلى أن معدلات الإضافة من حامض الهيوميك والسوبر فوسفات مع وجود البكتريا المذيبة للفوسفات أدت إلى تحسين مجموع صفات النمو الخضري للنباتات والمتضمنة في (ارتفاع النبات، عدد الأوراق/نبات، الوزن الأخضر والجاف/نبات، نسبة الكلوروفيل). كما أن النتائج المحصولية المبينة في (عدد القرن الجافة على النباتات، طول القرن، سم قطر القرن، متوسط وزن البذور/مليون/سم، نصف القرون والفروع بين النباتات، وزن البذور في القرن، متوسط وزن البذور في البذور) قد استجابة للزيادة المستخدمة من تلك الإضافة مع البكتريا المذيبة للفوسفات. وتعتبر نسب عناصر النيتروجين والفسفور والبوتاسيوم في البذور نسب أعلى تركيز لكل العناصر مع استخدام حمض الهيوميك ( 8 كجم/فدأم) مصحوبة بتثبيح الحيوى بالبكتريا المذيبة للفوسفات وإضافة نسبة 100 % من التسميد الفوسفاتي فو 2أ % الموصى به في الإنتاج التجاري.

أوصت الدراسة بجوب هذا التطبيق باستخدام (HA + PDB + فو 2أ %) كتطبيق سامل لتحسين خواص النترة والنمو الخضري والمحتوى المغذي والنتائج المحصولية لنباتات البسلة في الأراضي الحديثة.