# Maize(*Zea mays*) biofertilization with *B.megaterium* and chemo-fertilization with rock or soluble P: Available N,P,K,Fe,Mn,Zn and Cu residual in soil after harvest.

Ahmed S. Al-Ahmadi; Ali A. Abdel-Salam and M.A.Abdel-Salam
**Corresponding Author :** alahmadi_2014@yahoo.com

## ABSTRACT

Application of P-biofertilizer (*Bacillus megaterium* )and P-chemical fertilizers (rock phosphate and superphosphate) with and without organic farmyard manure was studied in a 3-factor field experiment on maize (*Zea mays* ). Factors being P-biofertilizer(B), P-chemical fertilizer(P) and organic manure(M). Treatments being: $B_0$ (no-biofertilizer), and $B_1$ (P-dissolving *B.megaterium* bacteria), $P_0$ (no P), $P_1$ (rock phosphate 70 kg Pha$^{-1}$) and $P_2$(calcium superphosphate 35 kg P ha$^{-1}$), $M_0$ (no manure), $M_1$ (24 Mg ha$^{-1}$) and $M_2$ (48 Mg ha$^{-1}$). Treatment not receiving any material gave 3.62 Mg grains ha$^{-1}$. Applying any or more of the materials increased grain yield by as low as 1% by $B_0P_0M_1$ to 13% by $B_0P_0M_2$ , up to 87% by $B_1P_2M_0$ and as high as 129% by $B_1P_2M_2$.Increase main effects were: B = 40.4% , P = 25.6% for $P_1$ and 20.0 % for $P_2$; although $P_2$ surpassed $P_1$ in presence of the biofertilizer which enhanced soluble P-fertilizer.M= 5.1% for $M_1$ and 20.0% for $M_2$ effictive in presence or in absence of the biofetilizer. N,P,K,Fe,Mn,Zn and Cu residual in soil after harvest increased were by up to , 38,84, 42, 112, 269, 78, and 83 % for each respectively ; and highest availble contents were 91, 9.8, 308, 4.94, 1.55,1.51 and 0.42 mgkg$^{-1}$ for each respectively.

**Key words :** Biofertilizer, *B.megaterium*, Zea mays,Rock P.,Organic manure.

## Introduction

Biofertilizers are preparations of living cells or latent cells of microorganisms which are applied to the soil-plant system and function actively causing plant nutrients to be available to plant roots (Wu *et al.*,2005). They can have significant effect in enhancing crop productivity through.There are biofertilizers of microorganisms' inocula specialized for availability of certain plant nutrient(s). Microorganisms used for increasing P availability in soil include *Bacillus megaterium* bacteria (Matson et *al*., 1977 and Bakhshandeh and, 2015). Soluble phosphate fertilizers are usually used for P application to crops. Despite phosphorus being widely and abundantly present in soils as inorganic and organic forms, many soils have it mainly in insoluble (or difficultly soluble) forms, even following its application as soluble phosphates (Miller and Donahue, 1997) , since it is transformed into insoluble forms (fixed) in most soils particularly calcareous and heavy clay soils due to different mechanisms(Di et al., 2013).For these reasons persistant application of soluble forms of orthophosphates is practiced by farmers.

Application of biofertilizers in agriculture, including P-dissolvers, could be practically applicable under field conditions for many crops (Abdel-Salam, 2014) including maize (Abdel-Salam et al., 2012), faba beans (Abdel-Salam et al., 2014) and sunflower (Abdel-Salam et al., 2015). Biofertilizers such as phosphate dissolving bacteria (e.g. *B. megaterium*) would help in satisfying, partly at least, the needs of P to crops (Attia and Badr, 1999). The micro-organisms of the biofertilizers need nutrients and organic substrates in order to live and function actively in the soil, therefore there must be enough organic substances in the soil for their needs (Berger et al., 2013 and Abdel-Salam et al., 2016). P-dissolving bacteria *Enterobacter agglomerans* were reported (Laheurte and Berthelin, 1988) to consume maize root exudates and promote plant growth. Phosphorus dissolving microorganisms release metabolites which include organic acids that dissolve insoluble phosphates and /or chelate cations bound them (Sagoe et al., 1998). Chuanqing and Weiyi (2004) reported that 7 days after applying *B. megaterium* in suspension cultures, volatile and non-volatile organic acids were detected in the culture including lactic, succinic, malic, citric and acetic acids ; all of which can dissolve and/or chelate metal ions, thus releasing P from phosphate rocks and causing solubilization of added rock phosphate. Hameeda et al., (2008) inoculated maize seeds using 4 different P-dissolvers of *Enterobacter asburaie* , *E. cloacae* , *Serratia marcescens* and *Pseudomonas* sp and grew the crop in a field experiment on a P-diffecient clay.They obtained grain yield increases of up to 85% .Veruil et al., (2014) used *Pseudomonas tolaasi* and *P. koreensis* inoculants on maize seeds and obtained up to 44% increase in grain yield; other traits were affected positively.

Inoculation of biofertilizers in combination with limited rates of rock phosphate or soluble superphosphate may prove practical in sustainable agriculture (Singhal et. al., (2012). The current study aims at assessing biofertilization of maize involving P-dissolving biofertilizer (PDB) with or without rock phosphate and soluble phosphate and the effect of organic manure.

## Materials and Methods

This investigation concerns assessment of using biofertilizers involving PDB (*Bacillus megaterium var. phosphaticum*) to enhance response of maize to rock phosphate, ordinary superphosphate and farmyard manure (FYM).

**3.1. The field experiment:**

The field experiment was conducted at the Faculty of agriculture Moshthor located at Moshtohor area, El-Qalubia Governorate, Egypt during 2014season . The crop was maize *"Zea Mays L."* Hi-tec 20/31.The soil was a heavy clay *torrifluvent* (Table 1), irrigated with Nile water (Table 2).Properties of fertilizers are in Tables 3 and 4.

**Table 1.** Properties of the soil of 0-30-cm soil of the experimental field of the Faculty of Agriculture Moshtohor Qalubia .

| **Property** | **Value** | **Property** | **Value** |
|---|---|---|---|
| Particle size distribution | | Soluble ions (mmolcL-1) | |
| Sand % | 12.7 | $Ca^{2+}$ | 4.7 |
| Silt % | 36.7 | $Mg^{2+}$ | 2.2 |
| Clay % | 50.6 | $Na^{+}$ | 6.8 |
| Texture class | Heavy Clay* | $K^{+}$ | 0.3 |
| Saturation percent (%) | 65.2 | $HCO_3^-$ | 1.3 |
| Moisture parameters | | $Cl^-$ | 8.2 |
| Field capacity (% w/w) | 41.2 | $SO_4^{2-}$ | 4.5 |
| Wilting point (% w/w) | 22.3 | Available NPK&Total P (mg $kg^{-1}$) | |
| Available water(%w/w) | 18.9 | Available N | 75 |
| Chemical properties | | ,, P | 8 |
| Organic matter (g $kg^{-1}$) | 13.1 | ,, K | 200 |
| | | Total P | 460 |
| $CaCO_3$ (g $kg^{-1}$) | 21.0 | | |
| pH(1:25 w:v soil/ water) | 8.2 | | |
| EC "paste extract" ($dSm^{-1}$) | 1.51 | | |
| CEC ($cmol_c$ $kg^{-1}$) | 28.7 | | |

* According to the International Soil Texture Triangle (Moeys, 2016).
** Extracts are : KCl (for N) ; DTPA and $NH_4HCO_3$. (P,K).

**Table 2.** Properties of the Nile irrigation water (used for irrigating the maize crop).

| pH | EC $dSm^{-1}$ | Soluble ions ($mmol_c$ $L^{-1}$) | | | | | | | SAR |
|---|---|---|---|---|---|---|---|---|---|
| | | $Ca^{2+}$ | $Mg^{2+}$ | $Na^{+}$ | $K^{+}$ | $HCO_3^-$ | $Cl^-$ | $SO_4^{2-}$ | |
| 7.20 | 0.56 | 1.90 | 1.10 | 2.00 | 0.99 | 1.21 | 3.02 | 1.76 | 1.33 |

SAR: Sodium adsorption ratio.

**Table 3**. Analysis of Ca-superphosphate (CSP), and rock phosphate (RP)

| Source | P (g $kg^{-1}$) | Contents of total micronutrients (mg $kg^{-1}$) | | | |
|---|---|---|---|---|---|
| | | Fe | Mn | Zn | Cu |
| CSP | 65 | 26 | 147 | 180 | 4 |
| RP | 130 | 4088 | 254 | 793 | 11 |

**Table 4.** Aggregates diameter(mm) of superphosphate (CSP)and rock phosphate(RP).

| Source | Aggregate diameter(mm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 10-2 | 2-1 | 1-0.5 | 0.5-0.25 | 0.25-0.125 | 0.125-0.063 | <0.063 |
| CSP | 24.33 | 9.20 | 18.45 | 30.26 | 14.85 | 2.71 | 0.20 |
| RP | 1.14 | 0.62 | 2.70 | 17.12 | 43.56 | 30.55 | 4.31 |

**Table 5.** Properties of the organic manure used in the study.

| Property | Value | Total nutrient | Value |
|---|---|---|---|
| EC dS/m (1: 5 water extract) | 8.2 | N (g $kg^{-1}$) | 7.7 |
| pH (1: 5 water extract) | 7.23 | P (g $kg^{-1}$) | 10.2 |
| Organic matter (g $kg^{-1}$) | 310 | K (g $kg^{-1}$) | 12.1 |
| Organic carbon g ($kg^{-1}$) | 182 | Fe (g $kg^{-1}$) | 3.22 |
| C/N ratio | 23.6 | Mn (mg $kg^{-1}$) | 152 |
| Moisture content (g $kg^{-1}$) | 14.4 | Zn (mg $kg^{-1}$) | 110 |

**3.2. The Experiment:**

The experiment was conducted in a randomized complete block (RCB) design, factorial, in 3 replicates , The 3 factors are bio-fertilization, P-fertilization and manuring .

**3.2.1. Factors and their treatments are :**

I.Bio-fertilization: 2 treatments i.e. $B_0$: no biofertilization; $B_1$: PDB biofertilization.

II. P-fertilization: 3 treatment i.e.$P_0$: no P-fertilization ; $P_1$: RP at 70kg P $ha^{-1}$ and $P_2$ SP at 35 kg P $ha^{-1}$ (RP rate being 2 times SP in view of insolubility of the former.

III. Organic manuring: 3 treatments i.e. $M_0$: no manure ; $M_1$: FYM at 24Mg $ha^{-1}$ $M_1$:FYM at 48 Mg $ha^{-1}$. All plots received N (250 kgN$ha^{-1}$ as urea "460 g N $kg^{-1}$") and K (100 kgK$ha^{-1}$ as K-sulphate 400 g K $kg^{-1}$"). Main properties of the manure are in Table 5. Plot size was 10.5 $m^2$.Thus total number of treatment combinations=2x3x3= 18. Treatment codes are shown in Table 4. The total overall number of the experimental plots was 54. The crop was harvested 120 days after seeding. Samples of soil and plant were taken after harvest for analysis. Soil samples were air dried while plant samples were oven-dried at 70ºC for 24 h. All plots received N and K fertilizers. Manure, P and K were applied during land preparation while N was added in 2 equal splits with 1st and 2nd irrigations.

**3.4. Soil , plant and water analyses:**

Analyses of soil water and plant were done by methods cited by USDA (1954), Chapman and Pratt, (1961), Page et al., (1982) and Klute (1986). Available N was extracted by KCl, available P was extracted by Na-bicarbonate and available K was extracted by ammonium acetate. Measurement of P in extract was done calorimetrically by the ascorbic acid method of Murphy and Riley (1962) while that of K was by flame photometry. Measurement of available micronutrients were done by spectrophotometry ,

**Results And Discussion**

**Maize grain yield (Table 6):**

Grain yield was increased by application of any or more of the biofertilizer (B), chemical fertilizers (P) or the manure (M). The lowest grain yield of 3.62 Mg$ha^{-1}$, increased by a very slight non-significant 1% due to the low rate of manure $M_1$ ($B_0P_0M_0$), but to a significant increases starting from 12.7 by the high rate of manure $M_2$ ($B_0P_0M_2$) to as high as 129% due to biofertilization combined with superphosphate and the high rate of manure i.e. $B_1P_2M_2$.. The second highest yield surpassed the lowest by 87% was given by biofertilization combined with superphosphate i.e.$B_1P_2M_0$ .The considerable high increase given by PDB and the SP when combined with manure demonstrates enhancement of PDB to the positive effect of superphosphate. Abdel-Salam (2014) mentioned that biofertilization could result in increased yields reaching practical levels under some field conditions, and that in some field trials on maize under salinity conditions Abdel-salam et al., (2012) obtained maize grain yield increases of up to 30% by P-biofertilization. Hameeda et al (2008) reported up to 85% yield increase in maize grain under field conditions. EL-Assiouty and Abo-sedera (2005) reported increased seed yield of spinach (*Spinacia oleracea* ) by biofertilization. Bakhshandeh, et al.,(2015) obtained increased yield in rice grains upon biofertilization with different strains of PDB bacteria. Laheurte and Berthelin (1988) reported that PDB *Enterobacter agglomerans* benefit from exudates by maize roots and showed high efficiency in dissolving insoluble P.

**I- Response to biofertilization:**

The main effect of the biofertilization shows 40.4% average increase, The increase was most marked where no P-fertilizer was present (54.0%) or in the presence of SP (50.4%) , more than in presence of RP (21.4% ).On the other hand , the increases were more in presence of manure (45%) in presence of $M_1$ and 39.5% in presence of $M_2$ than in absence of manure (36.7%).Yazdani et al.(2012) obitained marked yield increase upon applying PDB to maize .

**II- Response to P application:**

The main effect shows 20.0 and 25.6 % increases due to RP and SP respectively. However, the RP source surpassed the SP one where no biofertilization was done (37.6% increase by RP and 27.5%increase by SP). On the other hand SP surpassed RP in the presence of the biofertilizer (only 8.4 % increase by RP ,and 24.6% increase by SP) indicating that the P-dissolving bacteria augmented the positive effect of SP. Biofertilization using *Bacillus megaterium* phosphate dissolving bacterial inocula was noted by Chuan-quing et al., (2014) to have a high positive effect particularly in soils of high total P.

**III- Response to organic manure:**

The main effect of organic manure treatments shows a progressive increase with increased rate of manure application with averages of 5.1 and 20.0% due to $M_1$ and $M_2$ respectively.The manure was equally effictive in presence as well as in absence of the biofetilizer. In absence of P , the high manure rate was effective ( 18.3% increase) whereas the low rate was not effective. In presence of RP both manure rates were effective (13.4and 27.9% increases by $M_1$ and $M_2$ respectively), but in presence of SP it was the high manure rate which gave a positive response.This shows a high effeciency of manure application where rock phosphate is used. Enujeke (2013) obtained up to 300% increase in grain yield of maize grown on a loamy soil by the application of 30 Mg organic manure $ha^{-1}$.

Available N after maize harvest mg $kg^{-1}$ soil (Table 6):

Available N was increased by biofertilization combined with P-and organic manure. The 66.0 mg N $kg^{-1}$ soil , given by the non-treated $B_0P_0M_0$ increased by up to 38.3% due to the $B_1P_0M_2$ treatment; indicating a positive cumulative effect of biofertilization with manure and P application.

**I. Response to biofertilization:**

Contents of available N due to biofertilization was very slight , most mossibly due to removal of high contents of N from soil treated with PDB. The high available N reported by Elkholy et al., (2010) due to PDB was in soils was most probably in midseason of the crop.

**II. Response to P application:**

There was no significant differences between P fertilizers in the contents of available N in soil after harvest. However there was a moderate increase in available N in soils receiving chemical P where no PDB biofertilizer was applied.

**III. Response to organic manure:**

The main effect of organic manure was average increases of 7.9% and 30.6% due to $P_1$ and $P_2$ respectively. The pattern of such increase occurred in presence as well as in absence of PDB . It also occurred more under no P application. El-Naggar (1996) , Gami et al., (2001), Slattery et al., (2002) , Saeid (2002), Mahdy (2003), Ahmed (2007), Kavitha and Subramanin (2007) mentioned that composted cattle manure increased soil nutrients.

**Table 6.** Effect of Bio-, chemical P-fertilization and manure addition on maize grain yield and available N residual in soil after harvest.

| Bio-P-fertilizer (B) | P-fertilizer (P) | Manure application (M) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $M_0$ | $M_1$ | $M_2$ | Mean | $M_0$ | $M_1$ | $M_2$ | Mean |
| | | Yield (Mg $ha^{-1}$) | | | | Available N ($mgkg^{-1}$) | | | |
| $B_0$ | $P_0$ | 3.62 | 3.65 | 4.08 | 3.78 | 66.0 | 74.0 | 89.0 | 76.3 |
| | $P_1$ | 4.45 | 4.88 | 6.26 | 5.20 | 69.7 | 74.3 | 89.0 | 77.7 |
| | $P_2$ | 4.85 | 4.59 | 5.02 | 4.82 | 69.0 | 74.7 | 90.3 | 78.0 |
| Mean | | 4.30 | 4.38 | 5.11 | 4.60 | 68.2 | 74.3 | 89.44 | 77.3 |
| $B_1$ | $P_0$ | 5.23 | 5.82 | 6.41 | 5.82 | 68.7 | 76.3 | 91.3 | 78.8 |
| | $P_1$ | 5.66 | 6.60 | 6.67 | 6.31 | 69.7 | 74.3 | 89.0 | 77.2 |
| | $P_2$ | 6.78 | 6.65 | 8.30 | 7.25 | 69.7 | 72.3 | 89.7 | 77.0 |
| Mean | | 5.88 | 6.35 | 7.13 | 6.46 | 69.1 | 73.9 | 90.0 | 77.7 |
| G.Mean | | 5.10 | 5.36 | 6.12 | | 68.7 | 74.1 | 89.7 | |
| Mean of chemical P-fertilization | | | | | | | | | |
| | $P_0$ | 4.43 | 4.73 | 5.24 | 4.80 | 67.3 | 75.2 | 90.2 | 77.6 |
| | $P_1$ | 5.06 | 5.74 | 6.47 | 5.76 | 69.7 | 73.7 | 89.0 | 77.4 |
| | $P_2$ | 5.81 | 5.62 | 6.66 | 6.03 | 69.0 | 73.5 | 90.0 | 77.5 |
| LSD 0.05 | | B=ns. P=ns. M=1.01 BP=1.43 BM=N.S. PM=1.75 BPM=n.s. | | | | B=ns. P=ns. M=1.01 BP=1.43 BM=N.S. PM=1.75 BPM=n.s. | | | |

Notes: $B_0$ : no biofertilization; $B_1$: P-dissolving bacteria (PDB) *Bacillus megaterium*-- $P_0$: no-P addition; $P_1$: 70kg P $ha^{-1}$ as rock phosphate (RP); and $P_2$: 35 kg P $ha^{-1}$ as calcium superphosphate (SP) - $M_0$: no manure $M_1$: 24Mg FYM $ha^{-1}$ ; $M_2$: 48 Mg FYM $ha^{-1}$ ..Available N extacted by KCl

**Available P after maize harvest (Table 7):**

Available P was increased by biofertilization combined with P-and organic manure. The 5.33 mg P $kg^{-1}$ soil , given by the non-treated $B_0P_0M_0$ increased by up to 83.8% due to the $B_1P_2M_2$ treatment; indicating a positive cumulative effect of biofertilization with manure and P application.

**I. Response to biofertilization:**

Although the increase in available P due to biofertilization was not high averaging 8.8% , it was significant. The positive effect of biofertilization was particularly where no fertilizer P was applied.Elkholy et al., (2010)and LinZhao, et. al., (2014) determined available P in soil following harvest of maize biofertilized with PDB *Burkholderia* sp .They found that availability P in the soil increased in the biofertilized treatment and also noted soil pH decreased upon PDB biofertilization

**II. Response to P application:**

The main effect of P-fertilizers shows that they increased available P by averages of 8.3% and 10.4% due to $P_1$ and $P_2$ respectively. The increase was particularly where no PDB were applied. The increase was also where no organic manure was given. Robbins et. al., (2000) stated mineralization of organic P during organic matter decomposition releases P slowly, resulting in more available P in soil.

**III. Response to organic manure:**

The main effect of P-fertilizers shows that they increased available P by averages of 8.9% and 15.4% due to $P_1$ and $P_2$ respectively. The organic manure was of marked effect only where no chemical P was present. It was also marked where no PDB was given . Jang et al., (1994) and Carrie et al., (2003) reported that compost application increased available P content after maize harvest.

Available K after maize harvest (Table 7):

Almost all biofertilized treatments contained more available K then the unfertilized. Lowest available K of 214.5 mg K kg$^{-1}$ was shown by the $B_1P_1M_0$ treatment followed by the nonfertilized $B_0P_0M_0$ which showed 220.3 mg K kg$^{-1}$ .The highest increase was given by the $B_1P_2M_2$ , the biofertilized combined with SP-and manure causing an increase of 44% , indicating a positive cumulative effect of biofertilization+soluble P +manure.

**I. Response to biofertilization:**

Though the main effect of the biofertilization was small , it was statistically significant .Higher available K caused by biofertilization was more where superphosphate was given. On the other hand the increase occurred whether manure was applied or not. Elkholy et. al., (2010) showed that the available K in the soil increased by PDB.

**II. Response to P application:**

The main effect of P-fertilizers shows that treatments which received soluble P in particular showed lower available K after harvest. This may indicate a greater uptake of K by plants which received superphospahate due to increased root system caused by applied calcium superphosphate.

**III. Response to organic manure:**

The main effect of manure addition shows that increases in available K averaging 14.8% and 39.4% due to $M_1$ and $M_2$ respectively. The positive effect of manure was in presence as well as in absence of PDB, and also in presence or absence of P sources. Increase in available K due to organic manures was reported by many reaseardhers (El-Naggar ,1996,, Gami et al., ,2001,, Slattery et al., ,2002,, Saeid 2002, Mahdy 2003, Ahmed, 2007 and Kavitha and Subramanin ,2007).

**Table 7.**Effect of Bio-, chemical P-fertilization and manure addition on available P and K residual in soil after harvest

| Bio-P-fertilizer (B) | P-fertilizer (P) | Manure application (M) $M_0$ | $M_1$ | $M_2$ | Mean | $M_0$ | $M_1$ | $M_2$ | Mean |
|---|---|---|---|---|---|---|---|---|---|
| | | Available P (mgkg$^{-1}$) | | | | Available K (mgkg$^{-1}$) | | | |
| $B_0$ | $P_0$ | 5.33 | 8.27 | 8.50 | 7.37 | 220.3 | 249.5 | 301.8 | 257.2 |
| | $P_1$ | 7.83 | 8.40 | 8.57 | 8.27 | 217.3 | 248.9 | 304.8 | 257.0 |
| | $P_2$ | 8.33 | 8.40 | 9.00 | 8.58 | 218.4 | 251.6 | 306.0 | 258.7 |
| Mean | | 7.16 | 8.36 | 8.69 | 8.07 | 218.7 | 240.0 | 304.2 | 257.6 |
| $B_1$ | $P_0$ | 8.27 | 8.50 | 8.70 | 8.49 | 218.8 | 249.2 | 306.2 | 258.1 |
| | $P_1$ | 8.53 | 8.80 | 9.40 | 8.91 | 214.5 | 253.4 | 303.6 | 257.2 |
| | $P_2$ | 8.43 | 8.57 | 9.80 | 8.93 | 223.6 | 245.9 | 308.0 | 262.2 |
| Mean | | 8.41 | 8.62 | 9.30 | 8.78 | 218.9 | 252.5 | 305.9 | 259.1 |
| G.Mean | | 7.79 | 8.49 | 8.99 | | 218.8 | 251.3 | 305.1 | |
| Mean of chemical P-fertilization | | | | | | | | | |
| | $P_0$ | 6.80 | 8.38 | 8.60 | 7.93 | 219.6 | 249.4 | 304.0 | 257.7 |
| | $P_1$ | 8.18 | 8.60 | 8.98 | 8.59 | 215.9 | 251.2 | 304.2 | 257.1 |
| | $P_2$ | 8.38 | 8.48 | 9.40 | 8.76 | 221.0 | 253.2 | 307.0 | 260.4 |
| LSD 0.05 | | B=0.09 P=0.11 M=0.11 BP=0.15 BM=0.15 PM=0.18 BPM=0.26 | | | | B=1.02 P=1.25 M=1.25 BP=1.77 BM=N.S. PM=2.17 BPM=3.07 | | | |

Notes: $B_0$ : no biofertilization; $B_1$: P-dissolving bacteria (PDB) *Bacillus megaterium*-- $P_0$: no-P addition; $P_1$: 70kg P ha$^{-1}$ as rock phosphate (RP); and $P_2$: 35 kg P ha$^{-1}$ as calcium superphosphate (SP) - $M_0$: no manure $M_1$: 24Mg FYM ha$^{-1}$ ; $M_2$: 48 Mg FYM ha$^{-1}$ ..Available P&K extacted by DTPA.

**Available Fe after maize harvest (Table 8):**

Available Fe was increased by biofertilization combined with P-and organic manure. The 2.33 mg kg$^{-1}$ soil , given by the non-treated $B_0P_0M_0$ increased by up to 112 % due to the $B_1P_2M_2$ treatment; indicating a positive cumulative effect of biofertilization +manure + P application.

**I.Response to biofertilization:**

The main effect of the biofertilization was a significant increase averaging 9.4%. Biofertilization gave more available Fe where P was applied , but not where no P was applied.This may be an outcome of the existence of iron compounds in the P fertilizers. Where no manure was added , or where low manure was applied, the increase in available Fe was significant ; but in presence of the high manure , no difference was shown by the biofertilized treatment in available Fe.This indicates presence of high available Fe in the high rate of organic manure. Gayatri at al., (2007) and LinZhao, et. al., (2014) reported increased available Fe upon applying PDB and Hider and Kong, (2010) mentioned that PDB produce siderophores which solubilize insoluble iron in soils .

II. Response to P application:

The main effect of P-fertilizers showed an average increase of 10.5% only with application of the superphosphate . In absence of the biofertilizer , the positive action of the two P-fertilizers was more than in presence of it , and in presence of organic manure, their positive effect was much greater than in the manure's absence.

III. Response to organic manure:

The main effect of P-fertilizers shows that they increased aavailable Fe by averages of 43.6% and 59.9% due to $P_1$ and $P_2$ respectively. In absence of the biofertilizer , the positive action of the two P-fertilizers was more than in its presence , and in presence of organic manure, their positive effect was more than in manure's absence. Using organic manures many researchers noted increases in available iron (Dahdoh et al., 2001 , Mostafa et al., 2001, Bonde et al., 2004, Modaihsh et al., 2005 and Hammad et al., 2006).

**Available Zn after maize harvest (Table 8):**

Available Zn was increased by biofertilization combined with P-and organic manure. Lowest available Zn of 0.85 mg Zn $kg^{-1}$ was shown by the $B_0P_1M_0$ treatment followed by 0.90 mg Zn $kg^{-1}$ given by $B_1P_1M_0$ .The nonfertilized $B_0P_0M_0$ showed 0.94 mg Zn $kg^{-1}$ .The highest treatment which showed highest available Zn was that of $B_1P_2M_2$ treatments which surpassed the non-treated by 78% concerning available Zn after harvest. This reflects the apparent cumulative effect of combining biofertilization with organic manure and p-fertilizers.Treatments receiving

**I.Response to biofertilization:**

The main effect of the biofertilization was a significant increase averaging 8.0%.The higher available Zn caused by PDB occurred more in presence of manure. Therefore, the PDB activity was enhanced by organic matter. Johnstone and Nolan, (2014) reported that bacteria may produce substances called *zincophores* or *tsinkosphores* which solubilize Zn.

**II. Response to P application:**

Applying P in either forms caused increase in available Zn only where biofertilization was done. Applying P in either form in presence of no-biofertilization showed a decrease in available Zn; but under biofertilization an increase occurred sue to superphosphate in particular. The only P treatment cauing increase by manure was the high manure.Hhigh manure must have facilitated solubilization of Zn in soil under the effect of decomposing organic matter (Dahdoh et al.,2001 and Mostafa et al.,2001).

**III.Response to organic manure:**

The main effect of P-fertilizers shows increases averaging of 39.1% and 55.4% due to $M_1$ and $M_2$ respectively. Increases due to manure occurred in presence as well as in absence of biofertilization and also under no p or in presence of each of the P sources.

Dahdoh et al., (2001) , Mostafa et al., (2001 , Bonde et al., (2004) , Modaihsh et al.,(2005) and Hammad et al., (2006) noted a rise in available Zn by manuring.

**Table 8**. Effect of Bio-, chemical P-fertilization and manure addition on Available Fe and Zn residual in soil after harvest.

| Bio-P-fertilizer (B) | P-fertilizer (P) | Manure application (M) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $M_0$ | $M_1$ | $M_2$ | Mean | $M_0$ | $M_1$ | $M_2$ | Mean |
| | | Available Fe ($mgkg^{-1}$) | | | | Available Zn ($mgkg^{-1}$) | | | |
| $B_0$ | $P_0$ | 2.33 | 3.50 | 4.29 | 3.37 | 0.94 | 1.28 | 1.29 | 1.17 |
| | $P_1$ | 2.70 | 3.64 | 4.58 | 3.64 | 0.85 | 1.15 | 1.23 | 1.08 |
| | $P_2$ | 2.51 | 4.44 | 4.59 | 3.85 | 0.92 | 1.09 | 1.35 | 1.12 |
| Mean | | 2.51 | 3.86 | 4.49 | 3.62 | 0.90 | 1.18 | 1.29 | 1.12 |
| $B_1$ | $P_0$ | 3.42 | 4.46 | 4.16 | 4.01 | 0.93 | 1.30 | 1.43 | 1.22 |
| | $P_1$ | 2.59 | 3.63 | 4.49 | 3.57 | 0.90 | 1.23 | 1.35 | 1.16 |
| | $P_2$ | 3.37 | 4.62 | 4.94 | 4.31 | 0.97 | 1.30 | 1.51 | 1.26 |
| Mean | | 3.13 | 4.24 | 4.53 | 3.96 | 0.93 | 1.28 | 1.43 | 1.21 |
| G.Mean | | 2.82 | 4.05 | 4.51 | | 0.92 | 1.28 | 1.43 | |
| Mean of chemical P-fertilization | | | | | | | | | |
| | $P_0$ | 2.88 | 3.98 | 4.22 | 3.69 | 0.93 | 1.29 | 1.36 | 1.19 |
| | $P_1$ | 2.65 | 3.64 | 4.54 | 3.61 | 0.87 | 1.19 | 1.29 | 1.12 |
| | $P_2$ | 2.94 | 4.53 | 4.77 | 4.08 | 0.95 | 1.20 | 1.43 | 1.19 |
| LSD 0.05 | | B=0.12 P=0.15 M=0.15 BP=0.21 BM=0.21 PM=0.26 BPM=0.37 | | | | B=0.03 P=0.04 M=n.s. BP=0.05 BM=0.05 PM=0.07 BPM=n.s. | | | |

Notes: $B_0$ : no biofertilization; $B_1$: P-dissolving bacteria (PDB) *Bacillus megaterium*-- $P_0$: no-P addition; $P_1$: 70kg P $ha^{-1}$ as rock phosphate (RP); and $P_2$: 35 kg P $ha^{-1}$ as calcium superphosphate (CSP) - $M_0$: no manure $M_1$: 24Mg FYM $ha^{-1}$ ; $M_2$: 48 Mg FYM $ha^{-1}$ ..Available Fe and Zn extacted by DTPA.

**Available Mn after maize harvest (Table 9):**

The pattern of change regarding available Mn was very much comparable with that of Fe. Lowest available Mn of 0.42 was that which received superphosphate only, followed by the treatment which received non-treated.Other treatments showed increases in available Mn ranging from 84.8% by each of $B_0P_0M_1$ and $B_0P_1M_1$ to as high as 269% by $B_0P_1M_2$. A cumulative effect of combining high manuring and rock phosphate demonstate the positive effect of decomposing organic manure in combination with rock phosphate (Dahdoh et al.,2001 and Mostafa et al., 2001).

**I.Response to biofertilization:**

The main effect of biofertilization was 28.5%. The high response to biofertilization in increasing the contents of available Mn (as done with available Fe) was apparent where no manure or medium manure was added .It was also more evident where any of the two P chemical fertilizers was given , particularly the superphosphate P. Increase in available Mn by PDB bacteria indicates solubilization of insoluble Mn by substances such as siderophores and coproporphyrin III which solubilize insoluble iron in soils (Hider and Kong, 2010 , Johnstone and Nolan, 2014).

**II.Response to P application:**

The two P-fertilizers increased available Mn and the positive effect occurred particularly in presence of biofertilization. It also occurred in absence of no manure or under the low rate of it.

**III.Response to organic manure:**

Available Mn was greater in the manured than the non-manured treatments giving averages of 95.7 and 108 % due to $M_1$ and $M_2$ respectively. The increase occurred in both non-biofertilized and the bio-fertilized, but more in presence of the biofertilized. Also the increase occurred under no-P as well as under P addition , but more where the rock P was present. Dahdoh et al., (2001 , Mostafa et al., (2001) , Bonde et al., (2004) , Modaihsh et al., (2005) and Hammad *et al*., (2006) reported increases in available Mn in the soil upon applying organic manures.

**Available Cu after maize harvest (Table 9):**

Available Cu increased by most treatments which received any one or more of the added fertilizers or manure. The lowest available Cu of 0.23 mg Cu $kg^{-1}$ was shown by the nonfertilized non manured $B_0P_0M_0$ treatment as well as each $B_0P_1M_0$ , $B_1P_1M_0$ and $B_1P_2M_0$ , all of which received no manure. Increases in contents of available Cu after maize harvest ranged between 17.4% by $B_0P_2M_0$ to 82.3 by each of $B_1P_1M_2$, $B_1P_1M_2$ and $B_1P_2M_2$ of which received manure.This shows th positive effect of manure in particular in increasing available Cu in soil along with other nutrients (Hafez et al., 1992, EI-Maghraby, 1996 and. Mekail 1998 , Carrie et al., 2003, Bonde et al., 2004 , Modaihsh et al., 2005 and Hammad et al., 2006).

**Table 9.** Effect of Bio-, chemical P-fertilization and manure addition on Available Mn and Cu residual in soil after harvest.

| Bio-P-fertilizer (B) | P-fertilizer (P) | Manure application (M) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $M_0$ | $M_1$ | $M_2$ | Mean | $M_0$ | $M_1$ | $M_2$ | Mean |
| | | Available Mn ($mgkg^{-1}$) | | | | Available Cu ($mgkg^{-1}$) | | | |
| $B_0$ | $P_0$ | 0.46 | 0.85 | 1.49 | 0.93 | 0.23 | 0.30 | 0.33 | 0.28 |
| | $P_1$ | 0.60 | 1.18 | 1.55 | 1.11 | 0.23 | 0.29 | 0.29 | 0.27 |
| | $P_2$ | 0.42 | 0.85 | 1.44 | 0.90 | 0.27 | 0.38 | 0.35 | 0.33 |
| Mean | | 0.49 | 0.96 | 1.49 | 0.98 | 0.24 | 0.32 | 0.32 | 0.30 |
| $B_1$ | $P_0$ | 0.64 | 1.25 | 1.51 | 1.14 | 0.26 | 0.34 | 0.33 | 0.31 |
| | $P_1$ | 0.89 | 1.46 | 1.41 | 1.25 | 0.23 | 0.34 | 0.42 | 0.33 |
| | $P_2$ | 1.22 | 1.46 | 1.50 | 1.39 | 0.23 | 0.42 | 0.42 | 0.36 |
| Mean | | 0.92 | 1.39 | 1.48 | 1.26 | 0.24 | 0.37 | 0.39 | 0.33 |
| G.Mean | | 0.71 | 1.39 | 1.48 | | 0.24 | 0.34 | 0.36 | |
| Mean of chemical P-fertilization | | | | | | | | | |
| | $P_0$ | 0.55 | 1.05 | 1.50 | 1.03 | 0.25 | 0.32 | 0.33 | 0.30 |
| | $P_1$ | 0.75 | 1.32 | 1.48 | 1.18 | 0.23 | 0.32 | 0.36 | 0.30 |
| | $P_2$ | 0.82 | 1.15 | 1.47 | 1.15 | 0.25 | 0.40 | 0.39 | 0.34 |
| LSD 0.05 | | B=0.02 BM=0.04 | P=0.03 PM=0.05 | M=0.03 BPM=0.07 | BP=0.04 | B=0.01 BM=0.02 | P=0.02 PM=0.03 | M=0.02 BPM=0.04 | BP=0.03 |

Notes: $B_0$ : no biofertilization; $B_1$: P-dissolving bacteria (PDB) *Bacillus megaterium*-- $P_0$: no-P addition; $P_1$: 70kg P $ha^{-1}$ as rock phosphate (RP); and $P_2$: 35 kg P $ha^{-1}$ as calcium superphosphate (CSP) - $M_0$: no manure $M_1$: 24Mg FYM $ha^{-1}$ ; $M_2$: 48 Mg FYM $ha^{-1}$ ..Available Mn and Cu extacted by DTPA.

**I.Response to biofertilization:**

The main effect of the biofertilization was a significant increase averaging 10%. , and the increase was apparent where P was given , and where manure was added. Upon application of PDB, LinZhao, et al., (2014) noted increases in soil available Cu , and

II.Response to P application:

Available Cu increased by P particularly in presence of manure , and also under conditions of biofertilization.

**III.Response to organic manure:**

Manure showed average increase of 41.7 and 50.0 % by $M_1$ and $M_2$ respectively.. In absence of the biofertilizer , the positive effect P-fertilizers was more than in presence of it , and in presence of organic manure, their positive effect was much greater than in manure's absence.

## Conclusion

Applying any or more of PDB biofertilizer of *B . megaterium* , chemical P-fertilizers : rock phosphate "RP"at 70kg P $ha^{-1}$ or superphosphate"SP" at 35 kg P $ha^{-1}$ without or with farmyard manure at 24Mg $ha^{-1}$ or 48 $Mgha^{-1}$ increased grain maize yield .Non treated plants gave 3.62 $Mgha^{-1}$ and treated ones gave increases from as low as 1% by the low manure treatment to 13% by the high manure one to a highest increase of 129% by The PDB,SP, high hanure treament.The second highest increase of 87% was by the PDB , SP treatment. Main effect of biofertilization is an average 40 % increase .Main effect of P : 26% by RP and 20.0 % by SP . The SP was particularly superior to RP in pjresence of PDB..Main e ffect of manure : 5 % and 20 % by the low and high rates respectivy.Uptake of N , P and K in grains increased by PDB reaching 40% to more than 100%. Rock phosphate proved of practical use in combination with biolertilization and organic manure for maize under field conditions. N,P,K,Fe,Mn,Zn and Cu residual in soil after harvest increased were by up to , 38, 84, 44, 112, 269, 78, and 83 % for each respectively ; and highest availble contents were 91, 9.8, 308, 4.94, 1.55,1.51 and 0.42 $mgkg^{-1}$ respectively. .

## References

Abdel-Salam,A.A.; Elhosainy, O.H.; Zahra, W.R.; Abdel-Salam, M.A. and Hashem, I.A. 2016. Effeciency of P and K biofertilizers in utilizing soil and rock P and K by sorgum ( *Sorghum bicolor* ) grown on a light clay *torrhfluvent* soil. 3rd Int. Conf. Biotech. Appln. Agric., Sarm-Elsheik, Benha Univ., Moshtohor and Hurghada, Egypt,5-9 Apr. 2016.

Abdel-Salam , A.A.; Noufal, E.H.; Shaban, K. A. and Ahmed, M.A. 2012 . Bio-fertilization and efficient productivity of maize grown on a newly reclaimed saline sandy clay soil. 1st Int. Conf. Biotech. Appln. Agric., Benha Univ., Moshtohor and Hurghada, Egypt 18-22 Feb. 2012.

Abdel-Salam, A. A. 2014. Bio-organo-fertilization of organic farming :Viability and practicality. 2nd. Int. Conf. Biotech. Appln. Agric., Benha University, Moshtohor and Hurghada, Egypt 8-12 Apr. 2014.

Abdel-Salam, A. A.; Soliman, S. M.; Galal, Y. G. M.; Zahra, W. R.; Moursy, A. A. and Hekal, M. A. 2015: Response of sunflower (*Helianthus annuus* L.) to N-application and biofertilization with assessment of fertilizer N recovery by 15N versus subtraction methods. J. Nucl. Tech. Appl. Sci. 3:157-169.

Abdel-Salam, A.A.; El-Maghraby, T.A.; Farid, I.M; Abdel-Salam, M.A. and El-Shahid, S.A. 2014. Biofertilization of faba beans (*Vicia faba*) grown on a clay loam *Typic Torrifluvent* soil, using inocula of $N_2$-fixing *Rhizobium leguminosarum* and P-dissolving *Bacillus megaterium* under field conditions. Proc. 2nd Int.Conf. Biotech. Appl. Agric. Vol. 1, Benha Univ., Moshtohor and Hurghada, Egypt, 8-12 Apr. 2014.

Ahmed, M.A. 2007. Evaluation of some amendments in newly reclaimed soils. MSc Thesis, Fac. of Agric. Zagazig Univ., Egypt.

Attia, M. and Badr El Din, S.M. 1999. The interaction between arbuscular mycorrhizal fungi as nutrient uptake of maize plants grown in a clay loamy soil. Egypt Microbiol., 34: 479-487.

Bakhshandeh,E.; Rahimian, H.; Pirdashti, H.; Nematzadeh, G. A..(2015) Evaluation of phosphate-solubilizing bacteria on the growth and grain yield of rice (*Oryza sativa L.*) cropped in northern Iran. J. Appl. Microb. 119(5): 1371-1382.

Berger, L.R.; Stamford, N.P.; Santos, C.E.R.S.; Freits, A.D.S.;, Franco, L.O. and Stamford, T.C.M.2013. Plant and soil characteristics affected by biofertilizers from rocks and organic matter inoculated with diazotrophic bacteria and fungi that produce chitosan. J.Soil Sci. Plant Nutr., 13(3):592-603.

Bonde, A.N.; Karle, B.G.; Deshmukh, M.S.; Tekale, K.U and Patil, N.P. 2004. Effect of different organic residues on physico-chemical properties of soil in cotton soybean –intercropping in vertisol. J. Soils Crops, 14 (1): 112-115.

Carrie, A.M.; Labos, K. and Lamb, J. A. 2003. Changes in soil test phosphorus concentration after application of manures or fertilizer Soil Sci.Soc.Am., J., 67:544-554.

Chapman , H.D and Pratt P. P. 1961. Methods of analysis for soil, plant and waters. Univ. of California Division of Agric. Sci.

Chuanqing, Z. and Weiyi, H. 2004 .Effects and mechanism of P-solubilizing *Bacillus*

P17 strain on phosphorus solubilization of different phosphate rocks. Acta Pedologica Sinica 41(6):931-937.

Chuan-qing, Z.; Guang-xiang, C.; Wei-yi,H.; Xing-she, L. and Yi-fei,Y. 2014

Dissolving mechanism of strain P17 on insoluble phosphorus of yellow-brown soil. Braz J. Microbiol. 45(3): 937–943.

Dahdoh, M. A. S.; El-Maghrby, S. E. and Mousa, B.I. 2001. Chicken manure as natural soil conditioner for controlling the hazards of irrigating calcareous soil with sludge effluents.Soil Fertility,51,(2):320-334.

Di, A.; Ling , Y.; Ling, W.; Rui, L.; Tingjie,W. and Yang, J. 2013 Mechanisms of phosphorus fixation in soils and efficient utilization of phosphate fertilizer. J. Chem. Industry and Engin. Progree 32(08):1967-1973.

El-Assiouty, F.M.M. and Abo-sedera, S.A. 2005. Effect of bio and chemical fertilizers on Sseed production and quality of spinach (*Spinacia oleracea* L.). Intl. J. Agric. Biology. 6:947-952.

Elkholy,M.M.; Mahrous, S.E. and El-Tohamy,S.A. 2010. Integrated effect of mineral, compost and biofertilizers soil fertility and tested crops productivity. Res. Jour.of Agric. and Biolo.Sci. 6(5):670-682.

El-Magraby, S.E.; Hashem, F.A. and Wassif, M.M. 1996. The use of sulpher and organic manure for controlling soil salinity pollution under high saline water irrigation. Egypt. J. Soil Sci., 36: 269-288.

El-Naggar, E.M.A. 1996. Effect of application some organic residues to sandy and calcareous soils on growth and composition of some plants. M.Sc. Thesis Fac. Agric. Mansoura Univ.

Enujeke, E.C. 2013. Nutrient content (% dry matter) of maize as affected by differnet levels of fertilizers in Asaba area of Delta State. Sustainable Agric. Res. 2(3): 76-85.

Gami, SK.; Ladha, JK.; pathak, H.; Shah, MP.; Pasuquin, E.; Pandey, SP.; Hobbs, PR.; Joshy, D. and Mishra, R. 2001. Long term changes in yield and soil fertility in a twenty year rice – wheat experiment in Nepal, Biology and Fertility of soils , 34(1): 73-78.

Gayatri,V.,Mathur,A.K. 2007. Effect of continuos application of organic fertilizers on micronutrient status in maize-wheat system on Typic Ustochrept.Asian J. Soil Sci. 2(2):146-149.

Hafez, I.W.; Abdel-Hamid, E.A.; Tag-El-Dein, A.S. and El-Aaser, N.M. 1992. Available iron and manganese as affected by soil variables in calcareous soil. Egypt, J. Soil Sci. 32: 423-436.

Hameeda,B.; Harini,G.; Rupela,O.P.; Wani S.P. and Reddy, G. 2008. Growth promotion of maize by phosphate-solubilizing bacteria isolated from composts and macrofauna Microb. Res. 163(2): 234–242.

Hammad, S.A.; El-Hamdi, K.H.; Ghanem, S.A. and Naeem, E.S. 2006. Impact of rice straw on availability of some nutrient elements in flooded rice soils. J. Agric. Sci. Mansoura Univ. 31 (6): 4007-4015.

Hider, RC, Kong, X . 2010 . Chemistry and biology of siderophores. Nat. Prod. Rep. 27(5):637–657.

Jang, T.C.; Shamsuddin, Z.H.; Ahmed, M.H.and Anuar, A.R. 1994. Effect of compbined compost chemical fertilizer application on soil fertility and crop yield under rice-corn rotation. Combined use of chemical and organic fertilizers Proceeeding Malaysia, 1992,1994, 110-134.

Johnstone, T. C. and Nolan, E. M.2014. Beyond iron: Non-classical biological functions of bacterial siderophores. Dalton Trans. 44(14):6320–6339.

Kavitha, R. and Subramanin, P. 2007. Effect of enriched municipal solid waste compost application soil available macronutrients in rice field .Agronomy and Soil Science. 53 (5) 497-506.

Klute, A.E. 1986. Methods of Soil Analysis, Part1 Pysical and mineralogical Properties. (2$^{nd}$ Ed), Amer.Soc.Agron. Monograph No. 9, Madison, WI, U.S.A.

Laheurte, F. and Berthelin,J. 1988. Effect of a phosphate solubilizing bacteria on maize growth and root exudation over four levels of labile phosphorus. J. Plant Soil 105: 11(1):11-17.

LinZhao,Q.; MingBo,G.; JinGang,G.; SheGuy,L and Qiang, W. 2014. Effect of phosphate-solubilizing microbial inoculums on soil nutrients and corn growth. Journal of Agric. Res. and Environ.31(5):425-431.

Mahdy, H.A.A. 2003. Effect of some organic conditioners on plant growth and some nutrients uptake of sandy soil under drip irrigation. M.Sc. Thesis, Fac. Agric. Moshtohor, Zagazing Univ. Egypt.

Matson, R.S.; Hare,R.S. and Fulco, A.J. 1977. Characteristics of a cytochrome P-450-depwndent fatty acid w-2 hydroxylase from Bacillus megaterium. Biochemica et Biophysica Acta (ABBA)-Lipid and Liped Metabolism 487(3):487-494.

Mekail, M.M. 1998. Evaluation of some natural organic wastes as amendments for virgin coarse textured soils. 1. Effect of filter mud (Press mud) and nitrogen application on some soil .properties and wheat yield J. Agric.Sci. Mansoura Univ. 23 (12): 5749- 5762.

Miller,R.W.and Donahue,R.L.1997.Soil in our environment.7thEd. Printice-Hall of India, Private Ltd.,New Delhi,India.

Modaihsh, A.S.; Taha, A.A. and Mahjoub, M.O. 2005. Impact of some compost on wheat plant grown in calcareous soils. J. Agric. Sci. Mansoura Univ. 30 (12) 8313-8321.

Mostafa, M.A.; Gawish, Sh.M. and Basyouny, E.A. 2001. Effect of enriched organic manures with Fe and Zn on the availability of Fe and Zn in newly reclaimed soils. Minufiya J. Agric. Res. 26 (6): 1667-1680.

Murphy,J. and Riley,J.P. 1962. A modified single solution method for the determination of phosphate in natural waters.Analytica Chimica Acta.

Page, A.L.; Miller,R.H and Keeny, D.R. 1982. Methods of Soil Analysis, Part2 Chemical and Microbiological Properties. (2nd Ed), Amer. Soc. Agron. Monograph No. 9, Madison, Wisconsin. U.S.A.

Robbins, C.W.; Freeborn, I.I and Westermann, D.T . 2000. Organic phosphorus source effects on calcareous soil phosphorus and organic carbon. J. Environ. Qual. 29:973-978.

Saeid, H.S. 2002. Studies on reclamation of sodic soils. M.Sc. Thesis, Fac. Agric Moshtohor, Zagazig Univ. Egypt.

Sagoe, C.I.; Ando,T.; Kouno,K. and Nagaoka,T. 1998. Relative importance of protons and solution calcium concentration in phosphate rock dissolution by organic acids .Soil Sci. Pl. Nutr. 44:617-625.

Singhal, S.k.; Sharma, V.K. and Singh, R.D. 2012. Effect of inorganic and biofertilizers(VAM and PSB) on yield maize and wheat cropping sequence and soil fertility. Ind. J. Agric.Res. 46(2):167-172.

Slattery, WJ.; Christy, B.; Carmody, BM. and Gales, B. 2002. Effects of composted feedlot manure on the chemical characteristics of duplex soils in north eastern Victoria, Australian J. experi. Agric. 42(3). 369-377.

Veruel, E.; Erazzu, L.E.; Martinez Calsina, L.; Ferrero, M.A.; Lucca, M.E. and Sineriz, F. 2014. Inoculation of maize with phosphate solubilizing bacteria: effect on plant growth and yield. J. Sci. and Plant Nutri.14(4): 819-831.

Wu, S.C.; Cao,Z.H. L.Z. G.; Cheung, K. C.and Wong,M.h. 2005. Effects of biofertilizer containing N-fixer, P and K solubilizers and AM fungi on maize growth: A greenhouse trial. Geoderma 125(1/5):155-188.

Yazdani,M.; Rahdari,P. and Motevalli, S. 2012. Effect of organic manure and biological fertilizers on macronutrient uptake of corn (*Zea mays*.L). Advances in Environ. Biology.5(13):3761-3767 .

**التسميد الحيوي بلقاح بكتيريا*B.megaterium* مع التسميد الفوسفاتي الصخري والفوسفاتي الذائب : محتوى العناصر Zn,Mn,Fe,K,P,N و Cu المتبقي في التربة بعد الحصاد**

احمد سيف الاحمدي وعلي احمد عبدالسلام ومحمد علي عبدالسلام

أجريت تجربة حقلية لدراسة التسميد الحيوي بلقاح بكتيريا بسلس ميجاتيريم B.megaterium المذيبة للفوسفات مقارنة بالتسميد الكيماوي بصخر الفوسفات وبالسوبر فوسفات مع او بدون التسميد العضوي بالسماد البلدي للذرة الشامية (Zea mays)بتصمبم قطاعات كاملة العشوائية ٣ مكررات تجربة عاملية ذات ٣ عوامل هي:تسميد حيوي(بدون وبتسميد حيوي) وتسميد فوسفاتي(بدون وبصخر فوسفاتي ٧٠ كجم فسقور/هـ وبسوبر فوسفات ٣٥ كجم/هـ – ومعدل الفوسفات الصخري ضعف الفوسفات الذائب بالنظر لذوبان الثاني) وتسميد عضوي (بدون وبتسميد منخفض ٢٤ ميجاجرام/هـ ومرتفع ٤٨ ميجاجرام/هـ). استجاب المحصول للتسميد بكافة انواعه.بلغ محصول حبوب المعاملة غير المسمدة ٣,٦٢ ميجاجرام/هـ ارتفع بنسب تراوحت من ١% بتسميد عضوي منخفض فقط الى ١٣% بتسميد عضوي مرتفع فقط الى ٨٧ % بتسميد حيوي مع سوبر فوسفات الى اقصى زيادة ١٢٩ % بتسميد حيوي مع سوبر فوسفات مع معدل مرتفع عضوي. ازداد الاثر العام للتسميد الحيوي ٤٠ % وللتسميد الفوسفاتي ٢٦ % للسوبر فوسفات و ٢٠ % للصخر الفوسفاتي. على الرغم من تفوق السوبر فوسفات على الصخر الفوسفاتي عززالتسميد الحيوي الفوسفاتي .والاثر العام للتسميد العضوي ٥ % للمدل المنخفض و٢٠ % للمعدل المرتفع. وزاد محتوى التسميد للعناصر Zn,Mn,Fe,K,P,N و Cu في التربة بعد الحصاد بالنسب المئوية التالية: ٣٨, ٨٤ , ٤٢, ١١٢, ٢٦٩, ٧٨, و٨٣ % على التوالي .وكان اعلى محتوى لكل منها ٩١ ,٩,٨ ,٣٠٨ ,٤,٩٤ ,١,٥٥, ١,٥١, و ٠,٤٢ مليجم/كجم على التوالي.