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EFFECT OF CYANOBACTERIA, AND PHOSPHATE DISOLING BACTERIA INOCULATION ON IMPROVING PEANUT PRODUCTIVITY IN PRESENCE OR ABSENCE OF DIFERENT RATES OF ROCK PHOSPHAE FERTILIZER UNDER SANDY SOIL CONDITION

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ABSTRACT

A field experiment was carried out in a sandy soil at EL- Ismailia Agric. Res. Station, EL- Ismailia Governorate, (A R C), Giza, Egypt, during the summer season of 2005 to study the effect of inoculation with cyanobacteria and phosphate dissolving bacteria (PDB) viz. *Bacillus megatherium var.* phosphaticum, each alone or both in combination and\or when the inoculation was accompanied with different rates of rock phosphate fertilizer as a natural source of phosphorus on peanut productivity, NP&K uptake of peanut seeds and foliage and the soil total count bacteria, actinomycetes and fungi. Results revealed that inoculation with cyanobacteria and\or PDB each alone or both in combination increased peanut pods weight, seeds and foliage yields, N, P and K contents for both peanut seeds and foliage compared to uninoculated treatments. Also, the combination of both microbial inoculation and rock phosphate fertilizer at any rate increased significantly these parameters than those received either inoculation or rock phosphate each alone. At flowering stage, generally, the inoculation with either cyanobacteria or *Bacillus* and\or their combination increased the soil total count of bacteria, actinomycetes and fungi compared to those recorded by uninoculated treatments and those recorded initially and harvest for all the other tested treatment. Generally, the use of 600 kg fed^{-1} rock phosphate fertilizer along with inoculation with cyanobacteria and *Bacillus* was superior to those received microbial inoculation only, or rock phosphate fertilizer at the rates of 200 and 400 kg fed^{-1} only and\or their combination with dual inoculation with cyanobacteria and *Bacillus*. This microbial inoculation/rock phosphate integration helps in the fast solubilization of the insoluble phosphate found in rock phosphate that may lead to reduce the cost and the environmental pollution due to the extensive use of the mineral fertilizers.

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INTRODUCTION

Peanut (*Arachis hypogaea* L.) is considered one of the most important legumeous and oil seed crops, which are cultivated and thrive in the newly reclaimed sandy soils in Egypt (Rashid and Ryan, 2004)..

The Egyptian deserts are wide extensions representing about 94% of the total area of Egypt. The remaining area represents about 6% of the total area is considered for agriculture and foundations. According to the annual increase of the Egyptian population, it requires tremendous efforts to increase food production. The government aims toward reclaiming desert area along both sides of the River Nile. The soils of these areas are mainly sands and need organic and inorganic fertilizers to improve their properties for agriculture use.

The drastic raising in the chemical fertilizer prices and their adverse effects on environment greatly incited the serious endeavors of many researchers to seek the relevant alternatives of synthetic fertilizers. These may be involving the extension in the practice of sustainable agriculture system, which relies mainly on the legume-*Rhizobium* symbiosis (Jensen and Hauggaard, 2003) in addition of utilizing the natural materials as sources of macro and micronutrients such as rock-phosphate, dolomite, feldspar, crushed lime stone and gypsum with efficient inoculants and organic materials (Conacher and Conacher, 1998; Abdel-Wahab *et al*., 2003 and Mekhemar *et al*., 2007).

Mineral nutrients deficiencies are major constraints limiting legume nitrogen fixation and yield (O'Hara *et al.*, 1988). Among the necessary nutrients, legumes need relatively large amounts of phosphorus Nodules formation and function are both adversely affected with phosphorus deficiencies (Van Schreven, 1958). However, phosphorus application gave a highly significant increase in faba bean yield (Hussein *et al.*, 1993). Also, it is very important element to plant growth and plays a key role in metabolic processes such as the conversion of sugar into starch and cellulose (Mengel and Kirkby, 1987). It is a constituent of nucleic acids (DNA and RNA) and is considered as a high strong energy compound (Miller and Donahue, 1995), stimulate, cell division and enhance root growth**,** nodulation and N_2-fixation (Knany *et al.,* 2004).

Biological fertilization becomes an important factor in increasing availability of P and micronutrients as well as to improve their plant uptake**.** El-Habbasha *et al.* (2005) reported that phosphate dissolving bacteria has an important role in solubilizing of P and its absorption which, in turn, improves seed germination and yield of plant, which could be attributed mainly to N_2-fixation. There is a report for Hedge et al. (1999) who noted that cyanobacteria also have some soil phosphate solubilizing species.

The current work aims to evaluate the effect of inoculation with cyanobacteria and phosphate dissolving bacteria (PDB) viz. *Bacillus megatherium var.* phosphaticum, each alone or both in combination and\or when the inoculation was accompanied with different rates of rock phosphate fertilizer as a natural source of phosphorus on peanut productivity, NP&K percentages of peanut seeds and foliage and the soil total count bacteria, actinomycetes and fungi.

MATERIALS AND METHODS

A field experiment was carried out in a sandy soil at EL- Ismailia Agric. Res. Station during the summer season of 2005 to study the effect of inoculation with cyanobacteria and phosphate dissolving bacteria (PDB) viz. *Bacillus megatherium var.* phosphaticum, each alone or both in combination and\or when the inoculation was accompanied with different rates of rock phosphate fertilizer as a natural source of phosphorus on peanut productivity, NP&K uptake of peanut seeds and foliage and the soil total count bacteria, actinomycetes and fungi.

The main physical and chemical properties of the experimental soil and the analyses of the organic compost are presented in Tables (1 & 2), and determined according to the standard methods described by Jackson (1976) and Page et al. (1982).

The experimental design was split-plot with three replicates, where the main plots were assigned to rates of Rock phosphate (PR) as follows:

1- Control (without RP)
2- Rock phosphate at the rate of 200 kg/fed (RPI).
3- Rock phosphate at the rate of 400 kg/fed (RPII).
4- Rock phosphate at the rate of 600 kg/fed (RPIII).

The sub plots were inoculation with bacteria as follows:-

1- A= Control without inoculation
2- B = Cyanobacteria
3- C = phosphate dissolving bacteria.
4- D= Cyanobacteria + phosphate dissolving bacteria.

The plot area was 3m x 3.5 m =10.5 m^2 (1/400 fed.).

Peanut (*Arachis hypogaea* L.) seed cv. Giza 6 was sowed in hills at 20 cm apart on rows of 60 cm apart, sprinkler irrigation was carried out four days intervals.

The recommended chemical fertilizers were applied at rates of 40, 15 and 24 kg for N, P_2O_5 and K_2O per faddan, in the form of ammonium sulphate (20.5 %N), superphosphate (15.5 % P_2O_5) and potassium sulphate (48% K_2O), respectively. Both phosphorus and potassium were added before sowing, while nitrogen was added after 10 days from planting. Cyanobacteria at the rate of 10 kg fed^{-1} were inoculated to peanut seeds using the soil based inoculum (10^9 cfu g $soil^{-1}$) cyanobacteria. The cyanobacteria inoculum was prepared according to the method described by Venkataraman (1972). The Inoculum containing the following cyanobacteria strains ,i.e., *Nostoc muscorum, Nostoc calcicola, Anabaena oryzae and Clyndrospermum muscicola.* While, *Bacillus megatherium* var. Phosphaticum supplied by Department of Microbiology, SWERI, ARC, Giza, was the phosphate dissolving bacteria inoculum. Vermiculate supplemented with 10% Iresh peat was packed in polyethylene bag (300 g carrier per bag), then sealed and sterilized by gamma irradiation (5 x 10^6 rads). The carrier bags were injected with *Bacillus megatherium* var. Phosphaticum (5 x 10^8 cfu/mL) culture to satisfy 60% of the maximal water holding capacity. Cyanobacteria inoculum was applied after three weeks from sowing, while phosphate dissolving bacteria inoculum was applied to peanut seeds before sowing by seed coating using Arabic gum as an adhesive agent.

All agricultural practices were carried out as recommended in this district by the Egyptian Ministry of Agriculture and Land Reclamaition. Soil was sampled at different intervals, i.e., initial time, flowering time and at harvest to determine total bacteria count (Allen, 1959), total Actinomycetes count (Williams and Davis, 1965) and total fungi count (Martin. 1950) as index for soil biological activity.

At maturity, plants were picked, pods were separated, air dried, weighted and pealed into seeds and husks. Samples of seeds and foliage were oven dried, weighed and ground. N, P and K content in both seed and foliage were determined according to methods mentioned by Chapman and Pratt (1961) and Jackson (1976).

All obtained data were statistically analyzed according to Gomez and Gomez (1984).

Table (1): Some physical and chemical properties for the experimental soil

Properties	Value	Properties	Value
Particle size distribution %		**Chemical analysis**	
Coarse sand	10.25	pH (1:2.5)	7.7
Fine sand	79.20	EC dSm^{-1}	1.25
Silt	5.15	**Soluble ions (meq/l)**	
Clay	5.40	Ca^{++}	4.10
Texture class	sandy	Mg^{++}	2.00
$CaCO_3$%	1.50	Na^{+}	6.20
Organic matter %	0.40	K^{+}	0.30
Available nutrients (mg/kg)		$CO_3^{=}$	0.00
N	21.3	HCO_3^{-}	2.40
P	4.2	Cl^{-}	7.80
K	62.0	$SO_4^{=}$	2.40

RESULTS AND DISCUSSION

Peanut yield and its components:

Data presented in Table (2) indicate peanut yield and its components as affected by different rates of rock phosphate fertilizer and inoculation with cyanobacteria and phosphate dissolving bacteria (PDB). Results revealed that inoculation with cyanobacteria and\or PDB each alone or both in combination increased peanut pods weight, seeds and foliage yields compared to uninoculated treatments. Inoculation with *Bacillus* only gave significantly higher pods, seeds and foliage yields compared to those inoculated with cyanobacteria only. On the other hand, raising the rate of rock phosphate from 200 up to 600 kg fed^{-1} increased in gradual trend significantly pods weight, seeds and foliage yields compared to the treatments received no rock phosphate. However, also the combination of both inoculation and rock phosphate fertilizer at any rate increased significantly these parameters than those received either microbial inoculation or rock phosphate each alone. Relatively, the highest recorded values of 4166.70, 3367.07 and 3493.30 kg fed^{-1} in corresponding to pods, seed and foliage yields due to the treatment received dual inoculation with both cyanobacteria and *Bacillus megatherium* combined with 600 kg fed^{-1} rock phosphate. These high values were not significantly different from those obtained by the treatments received 600 kg fed^{-1} rock phosphate combined with *Bacillus* inoculation. Due to peanut 100-seeds weight, the values were fluctuated between 87.15 and 110.30 g in corresponding to control treatment (without rock phosphate and\or microbial inoculation) and the treatment of 600 kg fed^{-1} rock phosphate combined with dual inoculation with cyanobacteria and *Bacillus megatherium.* These results are in line with those obtained by Saleh *et al.* (2000) who reported that phosphorus fertilization combined with bacterial inoculation resulted in better nodulation, nitrogenase activity and high increases in yield of soybean and faba bean crops. Recently, there is a great deal of interest in creating novel association between agronomical important plants, particularly the strategic crops such as wheat, maize and peanut and N_2-fixing microorganisms including cyanobacteria (Spiller et al., 1993). The heterocystous cyanobacterium *Nostoc* sp. is usually among characterized cyanobacteria in its ability to form tight association with the roots of these crops and other crops in which they penetrate both roots epidermis and cortical intracellular space (Gantar et al., 1995). Consequently, in this work the treatments inoculated with cyanobacteria and\or dual inoculation with *Bacillus megatherium* and cyanobacteria in combination with different rates of rock phosphate fertilizer gave peanut seed and foliage yields significantly higher than those obtained without inoculation. Aref and AL-Kassas (2006) explained that the nitrogen released to soil through nitrogen fixed by cyanobacteria inoculated to soil becomes available to the cultivated plants. Moreover, cyanobacteria are known to excrete extra-cellularlly a number of compounds like polysaccharides, peptides, lipids…etc. during their growth in soil, these compounds hold or glue soil particles together in the form of micro-aggregates and hence improve nutrient availability and consequently enhanced the plant growth parameters.

Nitrogen, phosphorus and potassium contents of peanut seeds and foliage:

Data in Table (3) indicate the values of N, P and K contents for both peanut seeds and foliage as affected by different rates of rock phosphate fertilizer and inoculation with cyanobacteria and phosphate dissolving bacteria (PDB). Results revealed that generally, the inoculation of peanut with both cyanobacteria and *Bacillus megatherium* each applied alone and\or as dual inoculation increased N, P and K contents for both peanut seeds and foliage. Same trend was also observed when the use of biofertilizers was combined with any rate of rock phosphate fertilizer. On the other hand, increasing the rate of rock phosphate fertilizer increased the N, P and K contents for both peanut seeds and foliage compared to those recorded by the non-fertilized treatments. This trend was more pronounced with treatments fertilized with rock phosphate at the rate of 600 kg fed^{-1}. The corresponding N, P and K values were respectively, arranged as 4.75. 0.51 and 0.43 mg kg^{-1} seeds and 1.55, 0.17 and 0.59 mg kg^{-1} foliage. However, the highest N, P and K values for both peanut seeds. However, the highest N, P and K values for both peanut seeds and foliage were achieved due the combination between 600 kg fed^{-1} rock phosphate fertilizer and the dual inoculation with both cyanobacteria and *Bacillus megatherium.* The corresponding values were 6.86, 0.71 and 0.56 mg kg^{-1} seeds against 1.94, 0.29 and 072 mg kg^{-1} foliage.

Table (2): Effect of different rock phosphate fertilizer levels and inoculation with cyanobacteria and\or phosphate dissolving bacteria on peanut yield and its components

Treatments Rate of rock phosphate	Inoculation	Pods kg/fed	Seeds kg/fed	Foliage kg/fed	100 –seed Weight (g)	Shelling %
Control	*A	730.42	560.00	840.00	87.15	76.67
	B	1193.30	998.70	1566.60	96.80	83.69
	C	1646.60	1386.70	1800.00	88.90	84.22
	d	1733.30	1545.80	1893.30	104.30	89.19
200 kg fed^{-1}	A	1140.82	969.70	1560.00	94.80	85.00
	B	2150.70	1821.64	1693.30	100.20	84.70
	C	2166.70	1828.42	2200.70	102.90	84.39
	d	2966.70	2399.98	2266.00	101.40	80.83
400 kg fed^{-1}	A	1650.84	1421.70	1815.86	100.65	86.12
	B	2280.00	1928.88	1960.00	105.60	84.60
	C	2600.00	2223.00	2533.30	106.20	85.50
	d	3466.70	2975.47	2866.70	108.50	85.83
600 kg fed^{-1})	A	1988.18	1633,49	2216.28	101.60	82.16
	B	2533.30	2045.54	2786.70	107.20	80.75
	C	3833.30	3105.74	3206.70	108.40	81.02
	d	4166.70	3367.07	3493.30	110.30	80.81
L.S.D. at 0.05						
Rock phosphate		254.35	261.457	229.04		
Inoculation		245.23	275.12	198.36		
Rock phosphate x Inoculation		3435	467.40	315.40		

*A= uninculated (control) B= Cyanobacteria C= Bacillucs megatherium D= B + C

Table (3): Effect of different rock phosphate fertilizer levels and inoculation with cyanobacteria and\or phosphate dissolving bacteria on NPK-uptake by peanut seeds and foliage

Treatments		Seeds (mg kg^{-1})			Foliage (mg kg^{-1})		
Rate of rock phosphate	Inoculation	N	P	K	N	P	K
Control	*A	4.20	0.30	0.39	1.51	0.12	0.59
	B	5.00	0.34	0.42	1.70	0.14	0.63
	C	4.45	0.44	0.43	1.54	0.16	0.60
	D	5.12	0.49	0.45	1.82	0.18	0.66
200 kg fed^{-1}	A	4.31	0.35	0.40	1.52	0.13	0.58
	B	5.16	0.42	0.44	1.73	0.16	0.65
	C	4.88	0.52	0.50	1.62	0.19	0.59
	D	5.88	0.58	0.54	1.85	0.21	0.67
400 kg fed^{-1}	A	4.51	0.43	0.40	1.55	0.14	0.58
	B	5.92	0.50	0.46	1.74	0.20	0.67
	C	5.62	0.58	0.49	1.64	0.22	0.60
	D	6.65	0.63	0.54	1.88	0.25	0.68
600 kg fed^{-1}	A	4.75	0.51	0.43	1-55	0.17	0.59
	B	6.76	0.60	0.52	1.77	0.22	0.67
	C	5.78	0.65	0.52	1.66	0.25	0.62
	D	6.86	0.71	0.56	1.94	0.29	0.72

*A= uninculated (control) B= Cyanobacteria C= Bacillucs megatherium D= B + C

The present results are confirmed by those achieved by EL-Sawy et al. (2006) who found that dual inoculation with cyanobacteria and rhizobcteria increased significantly N, P and K contents for peanut seeds over uninoculated plants. They explained that both cyanobacteria and rhizobacteria fix nitrogen, excrete organic acids that help in dissolving both insoluble soil phosphorus and potassium, which in turn be made available to the cultivated plants. Mandal et al. (1999) reported that cyanobacteria play an important role in soil phosphorus transportation; they explained that cyanobacteria, like P-solubilizing bacteria, are known to have the ability to mobilize bound phosphate. They have been shown to solubilize insoluble $(Ca)_3 (PO_4)_2$, Al PO_4, Fe PO_4 and hydroxyapatite in soil, sediments or in pure cultures. There are mainly two hypotheses, proposed by two groups, to explain how cyanobacteria solubilize such bound phosphates. One group suggested that they might synthesize a chelator (chelators?) for Ca^{2+} and then liberate phosphate into the soil. The other group suggested that H_2CO_3 and other organic acids released by cyanobacteria during their growth cold solubilize P from the insoluble P form in soil. They also reported another opinion and believed that once PO_4 librated from Ca due to the action of H_2CO_3 {$Ca3 (PO_4)_2 + 2 H_2CO_3 = 2 CaHPO_4 + Ca (HCO_3)$}, the $PO_4{}^{3+}$ is taken up by the growing cyanobacteria cells for their nutrition. After completing their growth cycle, when the cells undergo lysis the cell bound $PO_4{}^{3+}$ is released to the soil and becomes available to the plants on mineralization. On the other respect, Hanna et al. (2004) also attributed the increases in N, P and K uptake of wheat inoculated with cyanobacteria to the ability of cyanobacteria inoculant to improve the availability of nitrogen in soil through nitrogen fixation and also its ability to dissolve both insoluble phosphate and potassium.

Soil total count of bacteria, actinomycetes and fungi:

Data in Table (4) indicate the values of soil total count of bacteria, actinomycetes and fungi as affected by different rates of rock phosphate fertilizer and inoculation with cyanobacteria and phosphate dissolving bacteria (PDB) compared to uninoculated treatments. Results pointed out that in all tested treatments, increasing the time of soil sampling from initial to flowering time increased the count of all tested microorganisms, while at harvest the counts started to decline. Due to the effect of the tested treatment of either microbial inoculation or rock phosphate rates and their combination, initially, no definite trend was detected, since the count of bacteria, actinomycetes and fungi, slightly increased in response of these treatments. However, at flowering stage, generally, the inoculation with either cyanobacteria or *Bacillus* and\or their combination increased the count of all tested microorganisms compared to those recorded by uninoculated treatments. Same behavior was observed for the count of bacteria, actinomycetes and fungi, when they influenced by different rates of rock phosphate fertilizer. Usually, the dual inoculation with cyanobacteria and *Bacillus* in combination with any rate of rock phosphate fertilizer resulted in higher count of bacteria, actinomycetes and fungi than those obtained by the treatments received either microbial inoculation or different rates of phosphorus fertilizer each applied alone. The highest count of bacteria, actinomycetes and fungi was achieved by the use of rock phosphate fertilizer at the rate of 600 kg fed^{-1} in combination with dual inoculation with both cyanobacteria and *Bacillus* at the flowering time. The corresponding count numbers were 127.67, 86.00 and 65.67 cfu g^{-1} dry soil.

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In this Approach, this trend due to the microorganisms count is true because at the flowering stage, plants reached their maximum physiological activity that increased the root exudates in the rhizosphere area and consequently in soil, which in turn promote the microbial proliferation in soil and increased their numbers. These conditions are not saved in the other two tested stages (initial and harvest).

For Soil microbial community, the used treatments led increase the number of the tested microorganisms, i.e., bacteria, actinomycetes, fungi and cyanobacteria at peanut flowering stage compared to both initial and harvest stages. This trend is true because at the flowering stage, plants reached it maximum physiological activity that increased the root exudates in the rhizosphere area, which in turn promote the microbial proliferation in soil and increased their number. These conditions are not saved in the other two tested stages. AL- Kassas, (2002) Reported that wheat Inoculation with the nitrogen fixing diazotrophs including cyanobacteria increased the soil *Azospirilla* and other soil microbial population including fungi, actinomycetes, *Azotobacter* and cyanobacteria. The decomposition of the inoculated cyanobacteria in soil led to accumulate the organic matter in soil, which, is consequently increased the soil microbial population (Mandal et al., 1999).

From the abovementioned results, it could be recommended that the integration between cyanobacteria phosphate dissolving bacteria inoculation in presence of rock phosphate as a cheap natural source of phosphorus fertilizer in peanut cultivation under sandy soil condition is more beneficial than the use of any of them individually. This integration also helps in the fast solubilization of the insoluble phosphate found in rock phosphate that may lead to reduce the cost and the environmental pollution due to the extensive use of the mineral fertilizers. However, this work needs to be repeated with peanut and some other cereal crops to be confirmed and actually recommended. This microbial inoculation/rock phosphate integration helps in the fast solubilization of the insoluble phosphate found in rock phosphate that may lead to reduce the cost and the environmental pollution due to the extensive use of the mineral fertilizers.

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أثر التلقيح بالسيانوبكتريا والبكتريا المذيبة للفوسفات عل تحسين انتاجية الفول السودانى فى وجود أو عدم وجود مستويات مختلفة من صخر الفوسفات تحت ظروف التربة الرملية

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معهد بحوث الأراضى والمياة والبيئة – مركز البحوث الزراعية – الجيزة – مصر

أجريت تجربة حقلية بمحطة بحوث الاسماعيلية التابعة – محافظة الاسماعيلية - مركز البحوث الزراعية وذلك لدراسة أثر التلقيح بالسيانوبكتريا والبكتريا المذيبة للفوسفات على تحسين انتاجية الفول السودانى فى وجود أو عدم وجود مستويات مختلفة من صخر الفوسفات تحت ظروف التربة الرملية. وقد استخدم سماد صخر الفوسفات الطبيعى بمستويات مختلفة هى 200 و 400 و600 كجم/ للفدان بدون التلقيح البكتيرى أو بمصاحبة التلقيح البكتيرى. هذا وقد كانت أهم النتائج مايلى:

1- أدى التلقيح بالسيانوبكتريا والبكتريا المذيبة للفوسفات كل منفردة أو مجتمعتين الى زيادة محصول الفول السودانى ومكوناته معنويا بالمقارنة مع النباتات غير الملقحة.

2- أدى التلقيح بالسيانوبكتريا والبكتريا المذيبة للفوسفات كل منفردة أو مجتمعتين الى زيادة محتوى الفول السودانى من النيتروجين والفوسفور والبوتاسيوم معنويا بالمقارنة مع النباتات غير الملقحة.

3- أدى التلقيح بالسيانوبكتريا والبكتريا المذيبة للفوسفات كل منفردة أو مجتمعتين بمصاحبة مستويات مختلفة من سماد صخر الفوسفات الى زيادة محصول الفول السودانى ومكوناته معنويا بالمقارنة مع النباتات غير الملقحة.

4- أدى التلقيح بالسيانوبكتريا والبكتريا المذيبة للفوسفات كل منفردة أو مجتمعتين الى زيادة العدد الكلى للبكتريا والأكتينوميسيتات والفطريات بالتربة عن النباتات الغير ملقحة وذلك عند مرحلة التزهير لنباتات الفول السودانى بالمقارنة مع فترتى البداية والحصاد.

5- تحققت افضل النتائج لمحصول الفول السودانى ومكوناته - محتوى الفول السودانى من النيتروجين والفوسفور والبوتاسيوم - الكلى للبكتريا والأكتينوميسيتات والفطريات بالتربة عند استخدام 600 كجم/ للفدان من سماد صخر الفوسفات الطبيعى بصاحبة التلقيح المزدوج بالسيانوبكتريا والبكتريا المذيبة للفوسفات.

Table (4): Effect of different rock phosphate fertilizer rates and inoculation with cyanobacteria and\or phosphate dissolving bacteria on total bacteria , Actinomycetes and fungi count in soil at different growth stages of peanut (cfu = Colony formed per unit/g soil)

Treatments		Total count bacteria (cfu g soil^{-1})			Total count Actinomycetes (cfu g soil^{-1})			Total count fungi (cfu g soil^{-1})		
Rock phosphate fertilizer rate	Inoculation	Initial time X10^5	Flowering stage X10^5	Harvest stage X10^5	Initial time X 10^3	Flowering stage X 10^3	Harvest stage X 10^3	Initial time X 10^4	Flowering stage X 10^4	Harvest stage X 10^4
Control	A	26.00	30,00	13.00	8.00	9.33	5.00	4.00	8.67	5.38
	B	26.00	36.67	16.00	8.33	18.67	6.00	5.00	22.33	8.67
	C	28.67	39.33	19.00	8.00	20.33	10.33	5.33	25.00	9.00
	D	28.67	54.00	21.60	8.00	32.00	17.33	5.33	27.67	12.33
200 kg fed^{-1}	A	27.00	39.00	15.00	9.33	12.67	5.12	4.12	10.12	6.00
	B	29.00	54.00	19.33	11.00	48.33	9.00	5.00	27.33	7.00
	C	31.67	60.67	24.00	12.00	59.67	14.33	5.67	30.31	7.33
	D	32.67	87.70	27.00	12.67	61.00	22.67	6.00	45.67	16.33
400 kg fed^{-1}	A	27.00	44.00	19.66	9.66	15.33	5.14	4.67	14.33	6.67
	B	30.67	61.00	26.00	11.33	47.33	10.33	5.00	40.67	8.33
	C	31.00	78.00	29.67	1233	65.67	19.67	6.00	50.33	15.00
	D	33.00	104.00	31.00	12.67	73.67	30.67	6.67	52.33	20.67
600 kg fed^{-1}	A	27.00	46.00	22.00	986	18.67	5.33	4.67	15.67	6.67
	B	28.00	71.67	23.33	12.00	49.00	20.00	6.67	42.67	9.00
	C	29.33	94.00	27.67	11.33	67.67	26.00	6.67	59.00	18.00
	D	31.0	127.67	43.00	12.67	86.00	38.33	7.00	65.67	21.67

***A= uninculated (control) B= Cyanobacteria C= Bacillucs megatherium D = B + C**