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INCREASING THE EFFICIENCY OF SOME PHOSPHATIC FERTILIZERS UNDER NEWELY RECLAIMED EGYPTIAN SOILS

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ABSTRACT

Two pot experiments were carried out at the Soils Dep., Faculty of Agriculture, Mansoura Univeristy,Dakahlya Governorate, Egypt , during the wintery growing seasons of (2003& 2004) . The goals of this study are : 1- expose the pollutant wastes (sludge) and optimizing its role in the soil (especially it is a rich organic waste) . 2- Increasing the efficiency of some phosphatic fertilizers (super phosphate and rock phosphate) in the newly reclaimed soil (sandy and calcareous) using the sludge , elemental sulphur and bio-fertilizers (phosphoren or mycorhiza) . These examend materials were added to the used crop soybean (Glycine max) as a single or in combinations . This study was ended to that : it can decrease the phosphorus fixation and increase the phosphorus use efficiency using these materials and the best treatment is that received all those substrates together .

INTRODUCTION

Phosphorus fertilizer use efficiency indices in soil are very low, due to a large portion of the P added as fertilizers is lost rapidly by either chemical or physical removal from the media. The amount of absorbed P by plants is much very low and less than the amounts added as fertilizers.

Plants can only absorb P when it presents in phosphate ion form, and also organic forms can be absorbed to some extent. In solution, these ions undergo several physicochemical transformations, that in most cases, turn them into forms that are less available to plants. These transformations are referring as immobilization or fixation reactions and they are dependent on soil pH value.

Phosphorus ions can react with different elements, forming various insoluble products in the soil. In low soils pH, aluminum and iron are the most important elements responsible for the immobilization of P. Under neutral and alkaline conditions, different calcium compounds are responsible for these reactions. Soil organic matter, also plays an important role. Some organic compounds can function as adsorption sites where phosphate ions are held with different strengths, others can compete with phosphate ions on adsorption sites, resulting in less mobilization of phosphate ions.

Under Egyptian soil conditions, highly soluble (available) phosphorus in soil and applied P fertilizer decreases rapidly in availability due to the high pH and the dominant of soluble and exchangeable Ca in all soils, as well as, the dominance of $CaCO_3$ in calcareous soils. So, it decreasing the use efficiency of P by plants. Rock phosphate is insoluble source of P under Egyptian soil conditions due to the previous reasons.

There are many studies (Illarionova ,1978 ; Allen *et al.*,1993 and Zhang *et al.*, 2000) resulted in several means to increase availability (efficiency use) of P sources in different soil types (clayey , silty , sandy and calcareous) or P uptake by different plants . The mycorrhizal associations or phosphate solubilizing bacteria with plants increase P absorption of these plants {Bi *et al.* (2003 a), Koreish (2003), Mohamed (2003), Pattinson and McGee (2003), Song *et al.* (2003), Al-Karaki *et al.* (2004), Gamalero *et al.* (2004), Schroeder and Janos (2004)}.

Lowering soil pH (acidification) is benefit in increasing solubility of insoluble P forms (increasing P use efficiency). This means , increasing both available P in soil media and P uptake by plants, as well as, enhancing plant growth and yield. Lowering soil pH is caused by increasing organic or mineral acids in rhizosphere zone. This is by increasing microbiological activity in soils throughout the use 1- of phosphate solubilizing bacteria 2- organic matter { Mohammed (2003), Lee *et al.* (2004), Zhang *et al.* (2004), and Zinati *et al.* (2004)} and 3- sulphur {Chouliaras and Tsadilas (1996), Randhawa and Arora (2000), Omer (2003).

The aim of the present study is to study the effect of adding biofertilyzers, sludge and sulphure on increasing the efficiency use of P fertilizer such as super-phosphate (SP) and rock phosphate (RP) under newly reclaimed soil in Egypt (sandy & calcareous) using soybean as an indicator plant.

MATERIALS AND METHODS

Two pot experiments were conducted at soils Dept., Fac., Agric., Mansoura Univ., during seasons of 2003 and 2004 to evaluate increasing the efficiency of some phosphatic fertilizers under Egyptian soils conditions (calcareous and sandy). As described by Elshaboury-Hayam (2000), plastic pots (3 kg soils capacity) were used, each pot was filled with 3 kg soil. Two soil types were employed which collected from the surface layer (0-30 cm) to represent newly reclaimed soils as:

- sandy soil collected from Kalabshou area, Dakahlia governorate.
-calcareous soil collected from Janaklies area, Alexandria governorate.

The main characters of the 1st used soil are sandy in texture (95.47 % sand) - non calcareous (0.35 % $CaCO_3$). The 2nd is sandy loam in texture (68.7% sand, 20.9 % silt and 10.4 % clay) and a calcareous in type (29.57 % $CaCO_3$). Both soils are moderately alkaline in soil reaction (pH less than 8.5) which increases P fixation, non saline (EC less than 4 dS/m) and poor in organic matter content where the values were : 7.8 and 8.0 of pH, 0.5 and 0.6 dS/m of EC and 0.18 and 0.40 % of OM for sandy and calcareous soils, respectively. The fertility of both soils as compared with the critèria which reported by Hamissa *et al.* (1993) is poor in sandy soil and moderately in calcareous one, where available- N was 32 ppm (less than 40) and available- K was 192 ppm (less than 200) for sandy soil. In calcareous soil, available- N was 45 ppm (between 40-80) and available- K was271 ppm (between 200-400). Hence, N and K fertilizers must be added to plants to meet their demands ,so, P became the limiting nutrient under the present study, where both soils are poor in available P (5.3 and 7.1 ppm i.e.. less than 10 ppm, respectively).

Sludge (Slu.) was used as a source of organic matter, it was taken from Mansoura Sanitary Drainage Station, El-Mansoura, Dakahlia Governorate. The analysis of sludge sample revealed that total carbon percentage was 22.0 % and total nitrogen percentage equal 1.10 %, C/N ratio equal 23.33:1.

Three different soil amendments were used which were represented in sludge, sulphur and biofertilizer (phosphrien & mycorrhiza).

The selected combinations for each soil were :

1- Control (without application), (Cont.)
2- Soil + super phosphate, (S Ph.)
3- Soil + rock phosphate, (R Ph.)
4- Soil + super phosphate + sludge + sulphur, (S Ph. + Slu. + S.)
5- Soil + super phosphate + sludge + bio-fertilizers, (S Ph. + Slu. + Bio)
6- Soil + super phosphate + sludge + sulphur + bio-fertilizers, (S Ph. + Slu. + S. + Bio)
7- Soil + rock phosphate + sludge + sulphur, (R Ph. + Slu. +S.)
8- Soil + rock phosphate + sludge + bio-fertilizers, (R Ph. + Slu. + Bio)
9- Soil + rock phosphate + sludge + sulphur + bio-fertilizers, (R Ph. + Slu. + S. + Bio)

Each treatment was replicated 3 times in a complete randomized block design. The mean values of both seasons were analyzed in a combined analysis.

The soil was mixed with (0. 2% , soil – base) sludge, then irrigated to saturation limit and left for a month before sowing to elevate its damage on seedlings and their roots resulted from heat of sludge decomposion .

Sulphur was added at the rate of 1.2 g/pot, and mixed with the soil at the same time of sludge mixing (a month before sowing).

Rhizobium inoculant specified for soybean was used to inoculation of the plants. the source was General Organization Equalization Fund (GOAEF), Ministry of Agriculture, Egypt. Inoculant activity was tested in Laboratory of Microbiology Department, Faculty of Agriculture, Mansoura University.

Mycorrhiza inoculant was taken by growing host plant as onion in pure specified nursery, where plant roots which carry mycorrhizal spores with surrounding soil was considered the mycorrhizal inoculant. Mycorrhizal inoculant was added immediately before sowing into 3 hills in tested soil surface at rate of about 1.5 g/pot (0.5 g / hill).

After applying mycorrhiza and before sowing phosphate solubilizing bacteria was used as a suspension form which was injected by syringe in the same mycorrhizal hills at rate of 15 ml suspension / pot (5 ml / hill).

To achieve the purpose of the present study, soybean seeds (Glycine max L. Merr.), Giza 35 variety was used as an indicator plants.

The phosphorous was added according to the recommended dose, where, the two sources of the used phosphatic fertilizers were ordinary super phosphate 15.5% P_2O_5 (water soluble) and rock phosphate(12.47% P (acid soluble). The source of rock phosphate was from Abo-Tartor, Suze Governorate.

Rock phosphate was added at 2.25 g/pot, and mixed with the soil at the same time of sludge mixing (a month before sowing).

Calcium superphosphate was added before sowing immediately at the rate of 4.2 g/pot, and incorporated with soil at 5 cm depth.

Nitrogen was added according to the recommended dose (40 kg-N /fed), where ,ammonium sulphate (20 .6 % N) was applied at the rate of 0.6 g/pot as a constant background for all treatments. The rate was divided into 3 doses which added surround the hills as: 1^{st} dose immediately after sowing , 2^{nd} dose after thining, 3^{rd} dose after a week from flowering.

Potassium was added according to the recommended dose ,where , potassium sulphate (41.5 % K) was applied at the rate of 0.9 g/pot as a constant background for all treatments. The rate was divided into 2 doses which added in hills as:1^{st} dose after2 weeks from thining and 2^{nd} dose at the beginning of flowering.

Setrein is a liquid solution for spraying chelated micronutrients (Fe, Mn, and Zn). The source was General Organization Equalization Fund (GOAEF), Ministry of Agriculture, Egypt. It was sprayed for calcareous soil at 2 stages. 1^{st} was at the beginning of deficiency and 2^{nd} one was after 2 weeks from the 1^{st}.

Pots were irrigated after each application with tap water to the SP, then were irrigated every 3 days to reach FC .

Total nitrogen, Available phosphorus were determined according to Jackson, 1967.

Saturation percentage (SP) was determined according to Dewis and Freitas (1970).

- Total carbon (C %) content was determined by walkly & Black method described by Hesse (1971).
- C / N ratio was calculated molecularly by dividing each determination on its molecular weight e.g. C/12 and N/14, then the obtained values of both C and N were divided (C / N).
- pH value , total soluble salts (dS/m) were determined according to (Richards, 1954).
- Mechanical analysis was carried out according to(Black, 1965) .
- Three forms of soil P (available, total inorganic, total organic) as well as phosphorus fixation capacity were determined in soil before sowing immediately and after harvesting soybean according to Hesse (1971).
- Available potassium in the soil was determined by extracting it with 1.0 N ammonium acetate at pH 7 (Page, 1982).

Soybean plants which were harvested after 4 months from sowing were separated into roots, vegetative organs(straw) and seeds. the separated organs were oven dried at 70 °C and dry matter (g/pot) were recorded.

Plant Analysis and N, P, K percentages:

The dry matter was digested by H_2SO_4 – $HClO_3$ mixture as described by peterburgski (1968). N, P and K nutrients were determined according to Jackson, (1967 and Page, (1982).

- Phosphorus use efficiency:

Phosphorus use efficiency (PUE, %) was calculated from P uptake by the following formula : PUE={(treatment P uptake - control P uptake) / applied p to a pot } x 100

Statistical Analysis:

The statistical analysis of the obtained data was done at the averages of both seasons as a combined analysis according to the methods described by Snedicor and Cochran (1967) using LSD (0.05)

RESULTS AND DISCUSSION

Whole soybean dry weight

As shown in Table (1), applying phosphatic fertilizers as Sph. or Rph. individually or in combination with different soil amendments gave different increases for dry weight. The differences between these means reached to the level of significancy for all treatments compared to control in both seasons. It is clear that whole dry weight of soybean plants of sandy soil was higher than that of calcareous soil, the difference reached to the level of significancy.

Data in Table (1) indicated that the interactions among all factors had a high significant effect on dry weight. The maximum values of whole dry weight of soybean plants were obtained from adding Sph. with (Slu.+S.+Bio.) under sandy soil condition (79.28 g/pot). The same treatment with Rph.(64.28 g/pot) is less than with Sph. but still higher than control and many other treatments in both seasons.

The positive effects of soil amendments used in present study (solubilizing P bacteria , mycorrhyza, sludge and sulphur) are in agreement with those of Jia *et al.* (2004) for the effect of arbuscular mycorrhizal fungi (AMF) on broad bean (Vicia faba) - Katiyar and Goel (2003) for the effect of Pseudomonas on mung bean - Bar-Tal et al (2004) for the effect of sewage sludge compost (SSC) and cattle manure compost (CMC) on wheat - Singh and Karion (2001) for the effect of sulphur on cotton .

Increasing growth and yield of crop due to elemental sulphur application to calcareous soils was reported by several investigators (Ali *et al.*, 1993; Mehana, 1994 and Matloub, 1996).

According to the previous results on dry weight of whole soybean plants it can be attributed to the following:

1)Increasing dry weights of whole soybean plants due to applying soil amendments (Slu., S., and Bio.) with Sph. or Rph. may attributed to increasing phosphorus use efficiency of Sph. or Rph. , where , these amendments may increase available P.

2)Applying soil amendments (Slu., S., and Bio.) may increase the native available P of soil.

3)Applying soil amendments (Slu., S., and Bio.) may increase the availability of the other nutrients in soil

4)Increasing available P and other nutrients in soil may increase dry weight of soybean roots and their area which reflected on increasing P uptake and other nutrients (Tables 1), hence increasing dry weights of whole soybean plants.

Jia *et al.* (2004) showed that Rhizobium and arbuscular mycorrhizal fungi (AMF) had positive effect on N and P accumulation by broad bean (Vicia faba) and reported that increasing N and P content influenced biomass production, leaf area and net photosynthetic rate .

Table (1): Effect of bio-fertilizers (Bio.), sludge (Slu.) and sulphur (S) added to super-phosphate (S Ph.) or rock-phosphate (R. Ph.) fertilizers and their interactions under sandy and calcareous soil conditions on whole soybean plant dry weight and its NPK uptake. (Average of two seasons as a combined analysis).

Treatment		Whole soybean dry eight (g/pot)	N uptake (mg/pot)	P uptake (mg/pot)	K uptake (mg/pot)
Sandy soil	1. (Cont.)	43.35 l	854.450 k	129.72 j	642.50 j
	2. (S Ph.)	54.48 h	1134.19 h	177.70 f	928.10 f
	3. (R Ph.)	47.33 k	932.420 j	145.55 i	741.40 i
	4. (S Ph. + Slu. + S.)	65.89 d	1529.06 d	231.70 c	1340.6 c
	5. (S Ph. + Slu. + Bio)	71.28 b	1852.51 b	259.44 b	1539.4 b
	6. (S Ph. + Slu. + S. + Bio)	79.28 a	2288.44 a	307.59 a	1822.0 a
	7. (R Ph. + Slu. +S.)	52.78 l	1072.25 i	167.53 g	865.79 g
	8. (R Ph. + Slu. + Bio)	61.29 f	1318.47 f	202.16 e	1101.6 e
	9. (R Ph. + Slu. + S. + Bio)	64.28 e	1424.87 e	221.26 d	1240.4 d
Mean		60.00	1378.52	204.74	1135.75
Calcareous soils	1. (Cont.)	32.87 n	574.860 n	44.180 q	371.94 n
	2. (S Ph.)	47.02 k	820.660 k	77.750 n	577.24 k
	3. (R Ph.)	36.26 m	628.4m	52.520 p	423.09 m
	4. (S Ph. + Slu. + S.)	57.20 g	1192.48 g	106.73 k	806.05 h
	5. (S Ph. + Slu. + Bio)	61.35 f	1419.01 e	128.16 j	922.30 f
	6. (S Ph. + Slu. + S. + Bio)	68.21 c	1760.64 c	159.48 h	1101.7 e
	7. (R Ph. + Slu. +S.)	42.71 l	769.710 l	66.490 o	510.98 l
	8. (R Ph. + Slu. + Bio)	49.56 j	930.150 j	84.000 m	665.73 j
	9. (R Ph. + Slu. + S. + Bio)	53.56 hi	1065.51 l	97.070 l	719.14 i
Mean		49.86	1017.94	90.71	667.57
LSD 5%	Soil Type	**0.43**	**12.00**	**0.95**	**19.75**
	Treatments	**0.66**	**25.46**	**2.651**	**21.86**
	Interaction	**0.94**	**36.00**	**3.75**	**30.92**

*** means with different letters, within column, differ significantly according to LSd (0.05)**

5)Although calcareous soil is more fertile than sandy , but dry weights of whole soybean plants under sandy soil were higher than that of calcareous soil . The less values of plant dry weights under calcareous soil conditions may attributed to high content of $CaCO_3$ in such soil (29.57 % for calcareous and 0.35 % for sandy soil). The high content of $CaCO_3$ in calcareous soil, may led to high fixation of soil P and added P (Table 6), as well as , decreasing the availability of other nutrients (macro and micro) through increasing soil pH.

6)The superiority of superphosphate alone or with other amendments than rock phosphate may be arisen from the high solubility of superphosphate.

N, P and K Uptake (mg/pot) by Whole Soybean Plants

As shown in the Table (1), applying phosphatic fertilizers as (Sph.) or (Rph.) individually or in combination with different soil amendments to sandy and calcareous soil increased N, P and K uptake (mg/pot) significantly by whole plants of soybean.

It is quite evident from data in Table (1) that N, P and K uptake by soybean plants increased significantly under the conditions of sandy soil than the calcareous one. The respective values of N, P and K uptake calculated as a mean of the averages of all treatments were 1378.52, 204.74 and 1135.75 mg/pot for sandy soil,, and 1017.94, 90.71 and 667.57 mg/pot for calcareous one

Data in Table (1) indicate that the interactions among all factors involved in this work had significant effect on N, P and K uptake by soybean plants. The highest and the superiority values of N, P and K uptake of soybean plants were obtained from adding (Sph.) with (Slu.+S.+Bio.) under sandy soil condition (2288.44, 307.59 and 1822.0 mg/pot). The mean values of N, P and K uptake by soybean plants under calcareous soil condition due to adding (Sph.) with (Slu.+S.+Bio.) were : 1760.64, 159.48 and 1101.7. The same treatment of (Slu.+S.+Bio.) but with (Rph.) is less than with (Sph.) but still higher than control and other treatments. The mean values of N, P and K uptake by soybean plants under sandy soil condition due to adding (Rph.) with (Slu.+S.+Bio.) were : 1424.87, 221.26 and 1240.4 mg/pot . The mean values for the same treatment under calcareous soil conditions were : 1065.51, 97.07 and 719.14 mg/pot . Vice versa, the lowest values of N, P and K uptake by soybean paints were recorded from control and applying (Rph.) only.

From the previous results it can be said that the addition of (Rph.) with soil amendments led to an increase of P uptake more than dry matter accumulation e.g. increasing P efficiency but the value was less than (Sph.).

• Phosphorus Use Efficiency (%) by Whole Soybean Plants

Data illustrated in Table (2) indicate that the phosphorus use efficiency (PUE, %) by soybean plants increased due to adding phosphatic fertilizers as (Sph.) or (Rph.) and in combination with different soil amendments of both studied soils than phosphatic fertilizers as (Sph.) or (Rph.) individually.

The lowest values of PUE by soybean plants were recorded from applying (Rph.) only. From the previous explanation it can be said that, addition (Rph.) to soil with amendments led to an increase in PUE by whole plants of soybean but the value was less than (Sph.).

With respect to effect of soil conditions on PUE by soybean plants, it is obvious that the sandy soil have values more than calcareous soil. The highest values of PUE by soybean plants were resulted in sandy soil, where its mean value was 26.79 % . While the lowest values of PUE by soybean plants were produced under calcareous soil conditions where its mean value was 16.62 %.

Table (2): Effect of bio-fertilizers (Bio.), sludge (Slu.) and sulphur (S) added with super-phosphate (S Ph.) and rock-phosphate (R Ph.) fertilizers and their interactions under sandy and calcareous soil conditions on Phosphorus Use Efficiency (%) by whole soybean plants (Average of two seasons as a combined analysis).

Treatments	PUE%		Mean Treat.
	Sandy	Calcareous	
1. (Cont.)	0	0	0
2. (S Ph.)	17.14	11.99	14.57
3. (R Ph.)	5.65	2.98	4.32
4. (S Ph. + Slu. + S.)	36.42	22.34	29.38
5. (S Ph. + Slu. + Bio)	46.33	29.99	38.16
6. (S Ph. + Slu. + S. + Bio)	63.53	41.18	52.36
7. (R Ph. + Slu. +S.)	13.50	7.97	10.74
8. (R Ph. + Slu. + Bio)	25.87	14.22	20.05
9. (R Ph. + Slu. + S. + Bio)	32.69	18.89	25.79
Mean (soil type)	26.79	16.62	21.70

Data listed in Table (2) show that the interactions resulted form the main effects of adding soil amendments, and soil type led to high effects on PUE by soybean plants. Great and marked increase was observed in PUE by soybean plants due to the interactions of adding (Sph.) with (Slu.+S.+Bio.) under sandy soil conditions (63.53 %) . The same treatment with (Rph., 32.69 %) is less than those treatments with (Sph.) but still higher than the two other treatments of Rph. And both Sph. & Rph. individually.

It can be concluded that applying amendments in combinations of (Slu.+S.), (Slu.+Bio.) and (Slu.+S.+Bio.) with Sph. or Rph. increase the efficiency of both superphosphate and rock phosphate in both sandy and calcareous soils and the superiority is for the combination of (Slu.+S.+Bio.) in sandy soil .

The positive effect of aplplying different amendments with (Sph.) or (Rph.) can be attributed to the high increase in available P in soil (Table 3) and other nutrients .It is knwon that, increasing available P in soil lead to increasing phosphorus use efficiency by plants which reflected on increasing P uptake more than dry matter accumulation . Increasing available soil P due to applying different combinations from amendments (Slu.+S.+Bio.) with Sph. or Rph. may be resulted from the effect of these amendments in lowering soi pH which reflected on increasing P solubility in both soil and phosphatic fertilizers (Sph. & Rph.) .

The characters of sludge analyss as shown in materials and metods imphasize increasing the efficiency of phpsphatic fertilizers (Sph. & Rph.) where the low C/N ratio and pH as well as high SP of sludge may increase the activity of soil microbes to mineralize the high levels of total macro and micronutrients in sludge. Thus let to a vigorous growth for both aerial parts and roots of plants (plants of higher mobilization capacity). This increase in the capability of plants to absorb more available P from rhizosphere e.g.

increasing the use efficiency of phosphatic fertilizers to be the highest at the treatment of (Sph.+ Slu.+S.+Bio.) under sandy soil conditions (63.53 %) than usual values (20 – 30 %) .

The previous explanation and positive effects of amendments used on chemical composition of soybean plants are in agreement with the following researcher on different plant kinds.

Mehana (1994) found that the addition of elemental sulphur to calcareous soils decreased soil pH and increased the availability of P, Fe, Mn, Zn, and Cu.

El-Ghamry and EL-Naggar (2003) compared the role of inorganic soil amendment to change some soil characteristics and NPK uptake of wheat plant using three agriculture soils (sand, calcerous, and alluvial soils). They pointed out that application of sulphur at the rates of 0.5, 1.0 and 1.5% significantly increased P uptake in different used soils compared with the control.

The results of Cui *et al.* (2004) showed that with S application at 200 mmol S/ kg, soil pH decreased with about 0.3 unit and the solubility of the Zn was significantly increased .

components of barley plants, as well as chemical composition (NPK content) .

Available Phosphorus in Soil Before Sowing and After Harvesting soybean

As shown in Table (3), adding (Sph.) and (Rph.) individually into experimental soil which grown with soybean plants increases available P in soil significantly in comparison with control before seeds sowing and after harvesting of soybean plants.

As shown in Table (3), adding the different amendments of sludge, sulphur and bio-fertilizer with (Sph.) or (Rph.) to calcareous soil increases soil available P significantly before seeds sowing and after harvesting in comparison with adding the amendments to sandy soil. The mean values of soil available P for sandy and calcareous soils before seeds sowing were 5.18 and 7.38 ppm and after harvesting were 7.84 and 8.44 ppm, respectively.

As shown in the table (3), the effect of interactions between adding the soil amendments with (Sph.) and (Rph.) to soybean plants in sandy and calcareous soils on available P in soil before seeds sowing and after harvesting was significant. The best interaction and the superiority was for the treatment of (Sph.+Slu.+S.+Bio.) under sandy (10.8 ppm) and calcareous (10.3 ppm) soil than other treatments after harvesting and before seeds sowing. The same treatment with (Rph.) (7.56 ppm under sandy and 8.51 ppm under calcareous) is less that with (Sph.) but still higher than control, (Sph.) and (Rph.) individually and many other treatments.

Table (3): Effect of bio-fertilizers (Bio.), sludge (Slu.) and sulphur (S) added to super-phosphate (S Ph.) or rock-phosphate (R. Ph.) fertilizers and their interactions under sandy and calcareous soil conditions on available P (ppm) in experimental soil before seeds sowing and after harvesting of soybean plants (Average of two seasons as a combined analysis).

Treatments \ parameter		Available P			
		Before seeds sowing		After harvesting	
Sandy soil	1. (Cont.)	5.40	l*	6.36	n
	2. (S Ph.)	5.83	i	7.20	k
	3. (R Ph.)	5.50	k	6.72	m
	4. (S Ph. + Slu. + S.)	6.26	f	8.37	f
	5. (S Ph. + Slu. + Bio)	6.20	g	9.29	C
	6. (S Ph. + Slu. + S. + Bio)	6.30	f	10.8	a
	7. (R Ph. + Slu. +S.)	5.76	i	7.03	l
	8. (R Ph. + Slu. + Bio)	5.70	j	7.26	k
	9. (R Ph. + Slu. + S. + Bio)	5.91	h	7.56	j
Mean		5.18		7.84	
Calcareous soils	1. (Cont.)	7.11	e	7.49	j
	2. (S Ph.)	7.43	b	8.00	g
	3. (R Ph.)	7.17	de	7.66	i
	4. (S Ph. + Slu. + S.)	7.57	a	8.82	d
	5. (S Ph. + Slu. + Bio)	7.47	b	9.24	c
	6. (S Ph. + Slu. + S. + Bio)	7.63	a	10.3	b
	7. (R Ph. + Slu. +S.)	7.36	c	7.83	h
	8. (R Ph. + Slu. + Bio)	7.23	d	8.07	g
	9. (R Ph. + Slu. + S. + Bio)	7.46	b	8.51	e
Mean		7.38		8.44	
LSD (5%)	Soil Type	0.05		0.03	
	Treatments	0.04		0.06	
	Interaction	0.06		0.09	

means with different letters, within column, differ significantly according to LSD (0.05)

It is worthy to note that increasing available P in calcareous soil than sandy soil and this can be attributed to the high content of available P in calcareous than in sandy soil as mentioned in material and methods about soil characteristics .

It is noted that increasing available P in control soil after harvesting than control soil before seeds sowing . This may be attributed to :

1. As known, the nature of leguminous crops roots can bind divalent cations such as Ca more strongly than monovalent which lower P fixation e.g. increasing available soil P
2. The role of root inoculation with symbiotic bacteria in increasing AMF colonization on plant roots which help in increasing the solubility of soil P and other nutrients. In this respect, Catford *et al.* (2003) reported that nodulation systemically influences AMF root colonization and vice versa. Nodules on one half of the split-root system suppressed subsequent AMF colonization on the other half
3. The exudation of leguminous roots such as soybean to organic acids which lower pH of rhizosphere, hence increasing the solubility of soil P (as in

calcareous soil). This explanation is supported by the results of Kamh, *et al.*(1999 and 2002).

4. Increasing the extent of root hairs of soybean plants after sowing and with development root growth (Kamh 2004) may help in incresing P solubility and uptake.
5. Horst *et al.* (2001) mentioned that some leguminous crops were P-mobilizing plants.

*** Total Inorganic Phosphorus in Soil Before Sowing and After Harvesting soybean plants.**

As shown inTtable (4), adding (Sph.) or (Rph.) individually to experimental soil which grown with soybean plants increases soil total inorganic P significantly in comparison with control before seeds sowing and after harvesting of soybean plants.

Table (4): Effect of bio-fertilizers (Bio.), sludge (Slu.) and sulphur (S) added to super-phosphate (S Ph.) or rock-phosphate (R. Ph.) fertilizers and their interactions under sandy and calcareous soil conditions on total inorganic phosphorus (ppm) in experimental soil before seeds sowing and after harvesting of soybean plants (Average of two seasons as a combined analysis).

parameter / Treatments		Total Inorganic P (ppm)			
		Before seeds sowing		After harvesting	
Calcareous soil	1. (Cont.)	103.54	d*	106.28	h
	2. (S Ph.)	107.09	bc	116.16	e
	3. (R Ph.)	106.48	c	111.92	g
	4. (S Ph. + Slu. + S.)	107.08	bc	122.96	c
	5. (S Ph. + Slu. + Bio)	106.68	c	127.60	b
	6. (S Ph. + Slu. + S. + Bio)	107.28	bc	133.06	a
	7. (R Ph. + Slu. +S.)	108.16	ab	114.94	f
	8. (R Ph. + Slu. + Bio)	107.64	bc	118.13	d
	9. (R Ph. + Slu. + S. + Bio)	108.59	a	122.83	c
Mean		106.95		119.32	
Sandy soil	1. (Cont.)	93.800	h	94.170	m
	2. (S Ph.)	95.750	efg	97.700	k
	3. (R Ph.)	95.250	fg	96.560	l
	4. (S Ph. + Slu. + S.)	95.560	efg	99.550	j
	5. (S Ph. + Slu. + Bio)	94.630	g	100.37	j
	6. (S Ph. + Slu. + S. + Bio)	95.130	fg	102.99	i
	7. (R Ph. + Slu. +S.)	96.250	ef	97.420	kl
	8. (R Ph. + Slu. + Bio)	95.470	efg	97.790	k
	9. (R Ph. + Slu. + S. + Bio)	96.520	e	99.330	j
Mean		95.37		98.43	
LSD(5%)	Soil Type	**0.85**		**0.39**	
	Treatments	**0.55**		**0.64**	
	Interaction	**0.78**		**0.91**	

*** means with different letters, within column, differ significantly according to LSD (0.05)**

Data illustrated in the table exert that adding the different amendments of sludge, sulphur and biofrtilizers with (Sph.) or (Rph.) fertilizers into studied soil (sandy and calcareous) increases soil total inorganic P before seeds sowing and after harvesting in comparison with control and adding both Sph., and Rph. individually. The increases reach to the level of significancy.

A glance at the data of that table, it can be seen that the trend of total inorganic P are in the direction of slight increase due to adding soil amendments with (Sph.) into the both studied soils before seeds sowing. However the differences do not reach the level of significancy for most treatments.

The recorded data emphasizes that total inorganic P increases under the conditions of calcareous soil than the sandy . The values of total inorganic P calculated as a mean on of all treatments for both calcareous and sandy soil before seeds sowing were : 106.95 and 95.37 ppm and after harvesting were : 119.32 and 98.43 ppm, respectively.

The combination between the treatments and soil type (interactions effect) resulted in significantly effects on total inorganic P .It is worthy to note that the highest values of total inorganic P due to adding of (Sph) with (Slu.+S.+Bio.) was 133.06 ppm under calcareous soil conditions after harvesting of soybean plants. The value at the same treatment with (Rph.) was less (122.83 ppm) but still higher than control and many other treatments in the two seasons.

Total Organic Phosphorus in Experimental Soil Before Sowing and After Harvesting of soybean

Adding (Sph.) or (Rph.) individually to experimental soil which grown with soybean plants did not affect total organic P in comparison with control before seeds sowing and after harvesting of soybean plants as cleared in Table (5).

Also from data in Table (5), it is obviously that adding the different amendments of sludge, sulphur and bio-fertilizers with (Sph.) or (Rph.) to studied soils (sandy and calcareous) did not have any effect on total organic P in soil before seeds sowing in comparison with control and adding both Sph., and Rph. individually. While, it was found that adding the different amendments with Sph., or Rph. in two types of soil decreased total organic P after harvesting of soybean plants than control and adding both Sph., and Rph. individually.

About effect of soil type, data in Table (5) reveal that calcareous soil has total organic P more than sandy soil and the differences reach to the level of significancy. The obtained mean values of all treatments were 6.91 and 5.37 ppm for calcareous and sandy soils, respectively before seeds sowing and 6.45 and 5.42 ppm after harvesting soybean plants.

This finding may be due to the high content of total organic P in soil as well as the low activity of this soil.

All interactions among the two factors (amendments and soil type) before seeds sowing had a significantly effect on total organic P and after harvesting soybean also.

Table (5): Effect of bio-fertilizers (Bio.), sludge (Slu.) and sulphur (S) added to super-phosphate (S Ph.) or rock-phosphate (R. Ph.) fertilizers and their interactions under sandy and calcareous soil conditions on total organic phosphorus (ppm).

Treatments		Total organic phosphorus (ppm)			
		Before seeds sowing		After harvesting	
Calcareous soil	1. (Cont.)	6.90	a*	7.14	a
	2. (S Ph.)	6.93	a	6.82	ab
	3. (R Ph.)	6.94	a	7.07	a
	4. (S Ph. + Slu. + S)	6.88	a	6.33	cde
	5. (S Ph. + Slu. + Bio)	6.89	a	5.96	ef
	6. (S Ph. + Slu. + S. + Bio)	6.87	a	5.01	j
	7. (R Ph. + Slu. +S.)	7.07	a	6.69	bc
	8. (R Ph. + Slu. + Bio)	6.78	a	6.68	bc
	9. (R Ph. + Slu. + S. + Bio)	6.92	a	6.39	cd
	Mean	6.91		6.45	
Sandy soils	1. (Cont.)	5.04	c	6.04	def
	2. (S Ph.)	5.06	c	5.85	f
	3. (R Ph.)	5.10	c	6.04	def
	4. (S Ph. + Slu. + S.)	5.07	c	5.47	gh
	5. (S Ph. + Slu. + Bio)	5.08	c	4.94	i
	6. (S Ph. + Slu. + S. + Bio)	5.09	c	3.94	j
	7 (R Ph. + Slu. +S.)	5.94	b	5.78	fg
	8. (R Ph. + Slu. + Bio)	6.04	b	5.46	gh
	9. (R Ph. + Slu. + S. + Bio)	5.94		5.23	hi
	Mean	5.37		5.42	
LSD(5%)	Soil Type	0.47		0.07	
	Treatments	0.30		0.20	
	Interaction	0.42		NS	

* means with different letters, within column, differ significantly according to LSD (0.05)

Fixation capacity of phosphorus in Experimental Soil Before and After Harvesting of soybean

Data of table (6) illustrate that P fixation capacity decreases significantly when the amendments were added with Sph or Rph before seeds sowing and after harvesting soybean plants

Results in the table reveal also that high differences of P fixation capacity between sandy and calcareous soils. Moreover, it can be stated that mean values of P fixation capacity under calcareous and sandy soils before seeds sowing were 143.85 and 108.95 ppm. While after harvesting soybean plants were 130.46 and 99.94 ppm

The combination between the amendments and soil type (interactions affect) resulted in significantly effects on fixation capacity of P before seeds sowing and after harvesting soybean as shown in Table (6). The better interaction is due to adding (Slu.+S.+Bio.) to (Sph) under sandy soil where had the lowest fixation capacity . The mean values were 106.37 ppm before seeds sowing and 84.51 ppm after harvesting soybean plants.

From these data, it is clear that adding soil amendments (Slu.+S.+Bio.) with Sph., or Rph. significantly decrease the fixation capacity of P if compared with other treatemtns after harvesting soybean plants where the superiority was to adding these amendments with Sph.

Table (6): Effect of bio-fertilizers (Bio.), sludge (Slu.) and sulphur (S) added to super-phosphate (S Ph.) or rock-phosphate (R. Ph.) fertilizers and their interactions under sandy and calcareous soil conditions on fixing phosphorus (ppm) in experimental soil before seeds sowing and after harvesting of soybean plants (Average of two seasons as a combined analysis).

Treatments	parameter	fixing phosphorus (ppm)			
		Before seeds sowing		After harvesting	
Calcareous soil	1. (Cont.)	146.18	a*	161.38	a
	2. (S Ph.)	145.30	ab	133.38	c
	3. (R Ph.)	144.81	abc	139.35	b
	4. (S Ph. + Slu. + S.)	142.02	de	122.15	f
	5. (S Ph. + Slu. + Bio)	143.22	cd	117.21	g
	6. (S Ph. + Slu. + S. + Bio)	141.55	e	109.31	h
	7. (R Ph. + Slu. +S.)	143.66	c	133.71	c
	8. (R Ph. + Slu. + Bio)	144.47	bc	131.24	d
	9. (R Ph. + Slu. + S. + Bio)	143.44	cd	126.45	e
	Mean	143.85		130.46	
Sandy soils	1. (Cont.)	112.71	f	117.84	g
	2. (S Ph.)	109.13	h	101.04	i
	3. (R Ph.)	110.96	g	109.24	h
	4. (S Ph. + Slu. + S.)	106.86	i	95.240	k
	5. (S Ph. + Slu. + Bio)	107.55	hi	90.710	l
	6. (S Ph. + Slu. + S. + Bio)	106.37	i	84.510	m
	7. (R Ph. + Slu. +S.)	108.94	h	102.67	i
	8. (R Ph. + Slu. + Bio)	108.86	h	100.87	l
	9. (R Ph. + Slu. + S. + Bio)	109.15	h	97.380	j
	Mean	108.95		99.94	
LSD(5%)	Soil Type	0.14		0.48	
	Treatments	0.84		1.36	
	Interaction	1.19		1.91	

* means with different letters, within column, differ significantly according to LSD (0.05)

The above mentioned findings emphasize that :

1. The high power fixation of P under calcareous soil than sandy.
2. Adding amendments with both superphosphate and rock phospate reduces the fixation capacity of P.
3. The superiority was to the combination between amendments of Slu.+S.+Bio.

Recommendations:

It is recommended that the addition of amendments such as sludge , biofertilizers (phosphate solubilizing bacteria and mycorrhiza) and elemental sulphur with phosphatic fertilizers such as super and rock phosphate into newly reclaimed soils of Egypt as sandy and calcareous soils is very important to increase p sufficiency use and decrease the soil fixation power for P . Also, more studies must be done under field conditions with different crops to be in more applied form .

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رفع كفاءة بعض الأسمدة الفوسفاتية بالأراضى المصرية الحديثة الإستصلاح

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- اقيمت تجربتا اصص بقسم علوم الاراضى- كلية الزراعة – جامعة المنصورة – خلال شتاء موسمى (٢٠٠٣ ، ٢٠٠٤)
- الهدف من الدراسة : ١- التخلص من النفايات (sludge) و تعظيم دوره كسماد عضوى غنى ٢- زيادة كفاءة استخدام سماد السوبر فوسفات و سماد صخر الفوسفات تحت ظروف لاراضى المصرية حديثة الاستصلاح (الرمليه – الجيرية)
- المحصول المستخدم هو فول الصويا و المواد المدروسة هى{ sludge ، الكبريت المعدنى ، الاسمدة الحيوية (الفوسفورين – الميكوريزا) }
- اضيفت تلك المواد لكل سما د سواء فرادى اوفى مجموعات تشمل المجموعة بعضهم او كلهم
- انتهت الدراسة الى انه يمكن تقليل تثبيت الفوسفور و زيادة كفاءة استخدام الفوسفات phosphate use efficiency باستخدام الخامات سالفة الذكر و كانت افضل النتائج مع المعاملة التى اضيف لها كل تلك المواد مجتمعة (sludge + الكبريت المعدنى + الاسمدة الحيوية)