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# Effect of Phosphorus Levels with or without PSB Seed Treatment on Dynamics of P in Soil under Groundnut (*Arachis hypogaea* L.)

**Anjali M. C., Dhananjaya B. C.**

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**Abstract** A field experiment was conducted on a sandy loam soil during *kharif* of 2013 in order to investigate the effect of phosphorus levels with or without PSB seed treatment on dynamics of P in soil under groundnut. Eight treatments with the four levels of phosphorus @ 0, 25, 37.5 and 50 kg $P_2O_5$ / ha as DAP with or without PSB seed treatment were tried in a RCBD design with three replications. The result indicated higher values of saloid–P, Ca–P fractions, available P status, other nutrients and chemical properties of soil like pH, EC and OC in soil were recorded in treatment 50 kg $P_2O_5$ / ha as DAP with PSB seed treatment and similarly higher values of Al–P, Fe–P, red – P, occl–P, organic–P and total - P fractions were recorded in treatments involving P levels without PSB seed treatment compared to application of P levels with PSB seed treatment. The treatment which receives 50 kg $P_2O_5$ / ha as DAP recorded higher Al-P, Fe–P, red–P, occl–P, organic–P and total–P values.

**Keywords** Phosphate solubilizing bacteria (PSB), Groundnut, Phosphorus, P fractions.

Anjali M. C.*
Department of Soil Science and Agricultural Chemistry, Krishi Vigyan Kendra, College of Agriculture, UAHS, Shimoga 577204, Karnataka, India

Dhananjaya B. C.
Subject Matter Specialist, Department of Soil Science and Agricultural Chemistry, Krishi Vigyan Kendra, College of Agriculture, UAHS, Shimoga 577204, Karnataka, India
e-mail: anjumoni663@gmail.com
*Correspondence

## Introduction

Groundnut is often grown by poor farmers under rainfed conditions on marginal lands, which are poor in nutrients and suffer from moisture stress. In these lands, P deficiency is a wide spread nutrient constraint limiting crop productivity. Build up of soil P is anticipated at many places where intensive agriculture is practiced due to its regular application, quicker fixation and relatively slower movement in the soil. In soils, phosphates of fertilizer origin when applied to soils enter into complex reactions (transformation) with the various constituents of soils such as Fe, Al, Mg, Ca clay minerals and get quickly converted to less soluble or insoluble forms. Twenty to twenty five percent of the applied phosphatic fertilizer is utilized by the crop and the remaining is converted into insoluble forms of phosphorus and fixed in the soil. Crops cannot absorb insoluble forms of phosphorus and has to be converted into soluble forms by phosphatase enzyme. Several soil microorganisms particularly phosphate solubilizing bacteria (phosphobacteria), posses the ability to solubilize insoluble inorganic phosphate and make it available to plants. Seed or soil inoculation with phosphate solubilizing microorganisms is known to improve solubilization of fixed soil phosphorus and applied phosphates resulting in higher crop yields. These efforts were always made on such soils which are usually low in available soil P with a view to provide guidelines that even in P deficient soils, one can reduce the recommended dose of P to soil with the help of PSB. In view of the above facts, a field experiment entitled

**Table 1.** Effect of P levels with or without PSB seed treatment on available $P_2O_5$ in soil at different growth stages of groundnut. *DAS = Days after sowing.

| | Treatments | 30 DAS | Available $P_2O_5$ (kg $ha^{-1}$) 60 DAS | 90 DAS | Harvest |
|---|---|---|---|---|---|
| $T_1$ : | Recommended NK | 155.83 | 155.49 | 150.05 | 147.54 |
| $T_2$ : | $T_1$ + PSB | 164.91 | 159.70 | 153.60 | 148.70 |
| $T_3$ : | $T_1$ + 25 kg $P_2O_5$ $ha^{-1}$ as DAP | 169.73 | 164.80 | 160.40 | 156.15 |
| $T_4$ : | $T_3$ + PSB seed treatment | 174.52 | 170.49 | 164.82 | 159.86 |
| $T_5$ : | $T_1$ + 37.5 kg $P_2O_5$ $ha^{-1}$ as DAP | 178.57 | 173.81 | 169.46 | 163.91 |
| $T_6$ : | $T_5$ + PSB seed treatment | 185.83 | 178.16 | 180.25 | 166.66 |
| $T_7$ : | $T_1$ + 50 kg $P_2O_5$ $ha^{-1}$ as DAP | 186.79 | 180.82 | 183.66 | 169.82 |
| $T_8$ : | $T_7$ + PSB seed treatment | 189.34 | 182.38 | 184.12 | 172.48 |
| | SEm± | 5.11 | 5.44 | 4.87 | 5.24 |
| | CD at 5% | 15.51 | 16.50 | 14.77 | 15.89 |

effect of phophorus levels with or without PSB seed treatment on dynamics of P in soil under groundnut (*Arachis hypogaea* L.) was conducted.

## Materials and Methods

A field experiment was conducted at Krishi Vignana Kendra (KVK), UAHS campus, Shimoga, during *kharif*, 2013. The soil was sandy loam with pH 5.28, organic carbon 5.30 g/kg, low available nitrogen (210.03 kg/ha), high available phosphorus (164.48 kg/ha), and medium available potassium (180.46 kg/ha). The different levels of phosphorus @ 0,25, 37.5 and 50 kg $P_2O_5$ as DAP/ha with or without PSB seed treatment with eight treatment combinations along with recommended dose of FYM, N and K fertilizers and gypsum used in a RCBD with three replications. Groundnut variety GPBD–4 was sowed on 22nd June with spacing of 30 cm×15 cm. Seed treatment with PSB (*Bacillus megatherium*) (375 g/ha) was done for seeds which were used in $T_2$, $T_4$, $T_6$ and $T_8$ treatments, shade dried and sown. Soil samples were collected from Ap horizon (0—15 depth) at different growth stages of crop growth like 30, 60, 90 days after sowing and at harvest of the crop. The soil samples are air dried at room temperature. Available phosphorus in soil at all stages of crop growth was extracted by using Brays No.1 extractant. Total phosphorus in the harvest soils was estimated by digesting one gram of finely powdered soil with perchloric acid as outlined by Jackson [1] and inorganic phosphate fractions viz. Saloid–P, Aluminum–P (Al–P), Iron–P (Fe–P), Reductant soluble–P (Red–P), Occluded–P (occl–P) and Calcium–P (Ca–P) of harvested soil by the fractionation procedure of Peterson and Corey [2]. Organic phosphorus content in soil was calculated as the difference between the total P content and the total mineral P content of soil. The chemical properties like pH, EC, organic carbon, available nutrient status like N, K, S and exchangeable Ca and Mg were analyzed in the harvested soil sample by using standard methods.

## Results and Discussion

### Available phosphorus status

The available P in soil at all the stages of crop growth varied significantly due to various levels of P with and without PSB treatment (Table 1). Among the treatments, treatment $T_8$ recorded highest available P values (189.34, 182.38, 184.12 and 172.48 kg/ha, at 30, 60, 90 DAS and at harvest, respectively) followed by $T_7$ compared to other treatments. Lowest available P was observed at all the stages in $T_1$ treatment. This might be due to increased availability of P in soil due to higher application of P, enhanced P availability by the mineralization of organic P in soil by soil microorganisms and also due to the solubilization of precipitated phosphate [3]. Application of PSB helps in realizing P from native P as well as protecting it from fixation of added P and rendering more available P. The results are in accordance with the earlier findings [4, 5].

### Soil P fraction

The results reveal that higher values of saloid–P and

**Table 2.** Effect of P levels with or without PSB seed treatment on transformation of native and applied phosphorus in a soil under groundnut. *DAS = Days after sowing, *Figures in the parentheses indicate the percent contribution to the total P pool.

| Treatments | | Sal-P | Al-P | Fe-P | Red-P | Occlu-ded-P | Ca-P | Org-P | Total-P |
|---|---|---|---|---|---|---|---|---|---|
| $T_1$ : | Recomm-ended NK | 18.16 (3.70) | 56.74 (11.56) | 68.23 (13.90) | 55.60 (11.33) | 6.93 (1.41) | 6.12 (1.25) | 279.10 (56.86) | 490.88 |
| $T_2$ : | $T_1$ + PSB | 22.73 (4.75) | 55.52 (11.60) | 64.77 (13.54) | 52.77 (11.03) | 5.83 (1.22) | 8.79 (1.84) | 301.34 (62.99) | 478.43 |
| $T_3$ : | $T_1$+25kg $P_2O_5$ ha$^{-1}$ as DAP | 24.26 (4.15) | 72.77 (12.45) | 88.54 (15.15) | 79.88 (13.67) | 15.00 (2.57) | 16.99 (2.91) | 286.85 (49.09) | 584.28 |
| $T_4$ : | $T_3$+PSB seed treatment | 27.50 (4.88) | 70.20 (12.45) | 84.32 (14.96) | 75.82 (13.45) | 13.84 (2.45) | 18.95 (3.36) | 273.16 (48.45) | 563.79 |
| $T_5$ : | $T_1$+37.5kg $P_2O_5$ ha$^{-1}$ as DAP | 28.25 (4.58) | 76.50 (12.40) | 96.89 (15.70) | 84.92 (13.76) | 18.74 (3.04) | 20.91 (3.39) | 290.72 (47.12) | 616.94 |
| $T_6$ : | $T_5$+PSB seed treatment | 33.51 (5.63) | 70.37 (11.83) | 92.79 (15.60) | 79.91 (13.44) | 17.22 (2.90) | 22.94 (3.86) | 277.98 (46.74) | 594.72 |
| $T_7$ : | $T_1$+50 kg $P_2O_5$ ha$^{-1}$ as DAP | 34.20 (5.19) | 79.84 (12.10) | 116.70 (17.69) | 91.03 (13.80) | 20.96 (3.18) | 23.93 (3.63) | 292.93 (44.41) | 659.58 |
| $T_8$ : | $T_7$ +PSB seed treatment | 39.11 (6.10) | 77.04 (12.01) | 110.85 (17.28) | 86.88 (13.54) | 19.11 (2.98) | 24.88 (3.88) | 283.66 (44.22) | 641.53 |
| | SEm± | 0.99 | 2.32 | 2.73 | 2.36 | 0.48 | 0.63 | 3.26 | 20.44 |
| | CD at 5% | 3.00 | 7.02 | 8.27 | 7.15 | 1.45 | 1.90 | 9.89 | 62.01 |

Ca–P fractions were recorded in treatments involving P levels with PSB seed treatment compared to application of only P levels (Table 2). Treatment $T_8$ recorded significantly higher saloid-P and Ca-P fractions in soil (39.11 and 24.88 mg/kg, respectively) followed by treatment $T_7$ compared to other treatments. Its due to the application of P irrespective of the sources tended to increase the content of saloid–P. Incorporation of PSB with DAP and rock phosphate (RP) marginally increased saloid–P value compared to RP and DAP alone. They attributed it to complexing of P fixing metallic cations with organic acids released from P solubilizing micro organisms and preventing P to be adsorbed on soil particles.

Results on changes in Al–P and Fe–P fractions in soil after harvest of groundnut were given in Table 2. Higher values of Al–P and Fe–P fractions were observed in treatments involving only P levels without PSB seed treatment compared to application of P levels with PSB seed treatment. Application of 50 kg $P_2O_5$ /ha as DAP ($T_7$) recorded higher Al–P and Fe–P values (79.84 and 116.70 mg/kg, respectively) followed by treatment $T_8$. This may be due to application of P fertilizers which increased the Al–P and Fe–P content over control. This suggests that portion of added P was transformed into Al–P and Fe–P. Application of DAP resulted in the formation of more Fe–P and Al–P during different period of incubation in the soil as the soluble monocalcium phosphate of DAP would have been converted to Fe–P and Al–P and dissolution of aluminium of the clay in the acid produced as a result of hydrolysis of DAP in soil [6]. The reduction of Fe-P and Al-P with P-solubilizers compared to phosphate fertilizers alone is ascribed to dissolution of Al and iron oxide coatings with organic acids produced by P solubilizers.

Higher values of red soluble–P, occl–P, organic–P fractions and total–P were recorded in treatments involving application of only P levels compared to P levels with PSB seed treatment (Table 2). Treatment

**Table 3.** Effect of P levels with or without PSB seed treatment on selected soil properties after harvest of groundnut.

| Treatments | | pH | EC (dS $m^{-1}$) | OC (g $kg^{-1}$) | Available N | Available $K_2O$ | Available S (mg $kg^{-1}$) | Exch Ca | Exch Mg |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | kg $ha^{-1}$ | | | cmol ($p^+$) $kg^{-1}$ | |
| $T_1$ : | Recommended NK | 5.42 | 0.04 | 6.19 | 182.74 | 199.36 | 7.03 | 2.17 | 0.87 |
| $T_2$ : | $T_1$ + PSB | 5.52 | 0.04 | 6.47 | 209.26 | 206.21 | 7.19 | 2.23 | 1.17 |
| $T_3$ : | $T_1$ + 25 kg $P_2O_5$ $ha^{-1}$ as DAP | 5.58 | 0.04 | 6.17 | 210.34 | 232.55 | 7.39 | 2.33 | 1.23 |
| $T_4$ : | $T_3$ + PSB seed treatment | 5.63 | 0.05 | 6.52 | 222.85 | 249.31 | 7.63 | 2.50 | 1.40 |
| $T_5$ : | $T_1$ + 37.5 kg $P_2O_5$ $ha^{-1}$ as DAP | 5.74 | 0.05 | 6.67 | 225.79 | 268.44 | 8.41 | 2.63 | 1.57 |
| $T_6$ : | $T_5$ + PSB seed treatment | 5.95 | 0.05 | 7.14 | 248.49 | 278.57 | 9.29 | 2.93 | 1.67 |
| $T_7$ : | $T_1$ + 50 kg $P_2O_5$ $ha^{-1}$ as DAP | 6.11 | 0.05 | 6.67 | 258.20 | 307.96 | 9.42 | 3.17 | 1.70 |
| $T_8$ : | $T_7$ + PSB seed treatment | 6.18 | 0.05 | 7.48 | 286.16 | 354.10 | 9.52 | 3.20 | 1.83 |
| | SEm± | 0.17 | 0.002 | 0.19 | 7.48 | 9.84 | 0.44 | 0.18 | 0.08 |
| | CD at 5% | 0.51 | 0.01 | 0.60 | 22.71 | 29.86 | 1.34 | 0.54 | 0.24 |

$T_7$ observed higher red soluble–P, occl–P, organic–P and total – P values (91.03, 20.96, 292.93 and 659.58 mg/kg, respectively) followed by treatment $T_8$. Application of DAP resulted in higher build up of red soluble–P values. Since, DAP is water soluble, readily reacts with ferric hydroxides, leading to conversion of water soluble form to insoluble form and the fixation and transformation of native and added P to occl–P is generally low [7]. The reduction of red soluble–P and occl–P with P–solubilizers compared to P fertilizers alone is dissolution of Al–P and Fe–P present in the form of oxides of Fe and Al by the action of organic acids released by P solubilizers. Stimulated plant growth and accumulation of organic material in soil contributes to higher organic P in soil [7]. There was significant increase in total–P in the soil with application of P fertilizers. These results corroborates with the findings of Sheela [6] and Ranjit [8].

Soil chemical properties

Application of P levels with or without PSB significantly increased soil properties and nutrient status under groundnut crop (Table 3). However, treatment $T_8$ recorded significantly higher soil pH and OC under groundnut compared to other treatments and was on par with treatment $T_7$ and $T_6$. This might due to increased biomass production of above and below ground part due applied P levels which might have contributed to higher level of OC. The treatment $T_8$ recorded significantly higher available N, K, S, Ca and Mg in soil after harvest of crop compared to other treatments. Phosphorus fertilization helps in promoting root growth and efficient functions of nodule bacteria. Thus, expanded root system increased the number and dry weight of nodules. Nodule production of legumes associated with extensive root formation increases the symbiotic nitrogen fixation and improves N availability. Similar observations was recorded by Kumar [9]. The increased P levels causing increased above and below ground biomass production of which might have contributed to higher level of organic matter of soil. The available S is directly proportional to the soil organic matter. Therefore, available S increases with increasing P levels with PSB seed treatment. These observations are in accordance with the findings of Nagar and Meena [10]. The organic acids produced during crop growth act as effective chelating agents and form stable complexes with Ca and Mg and make them available to the plants.

Application of different P levels with PSB seed treatment perform better as compared to without seed treatment with respect to available phosphorus, soil chemical properties and soil P fraction. The higher P levels with PSB seed treatment compare to other levels which are significantly increases the available P, saloid–P, Ca–P, soil chemical properties and nutrient status. Available P, saloid–P, Ca–P, soil chemical properties and nutrient status were higher in the treatment $T_8$ compared to other treatments and was on par with $T_7$ and $T_6$. Treatment $T_7$ recorded higher Al–P, Fe–P, red soluble–P, occl–P, organic–P fractions and total-P values as compared to $T_8$ and other treatments. Therefore, application of P @ 75% RDP with PSB is beneficial over 100% RDP.

**References**

1. Jackson ML (1967) Soil chemical analysis. Prentice Hall Pvt Ltd, New Delhi.
2. Peterson GW, Corey RB (1966) A modified Chang and Jackson procedure for routine fraction of inorganic soil phosphates. Soil Sci Soc Am Proc 30 : 563—564.
3. Pradhan N, Sukla LB (2006) Solubilization of inorganic phosphates by fungi isolated from agricultural soil. Afr J Biotechnol 5 : 850—854.
4. Iman M, Azouni EL (2008) Effect of phosphate solubilizing fungi on growth and nutrient uptake of soybean plants. J Appl Sci Res 4 : 592—598.
5. Kuhad RC, Singh S, Lata, Singh A (2011) Phosphate solubilizing microorganisms, bio-augmentation, biostimulation and bio-control. Soil Biol 28 : 65—84.
6. Sheela BS (2006) Dynamics of phosphorus in acid soils of North Karnataka. MSc (Agric) thesis. Univ Agric Sci, Dharwad.
7. Park M, Singvilay O, Shin W, Kim E, Chung J, Sa T (2004) Effects of long-term compost and fertilizer application on soil phosphorus status under paddy cropping system. Commus Soil Sci Pl Anal 35 : 1635—1644.
8. Ranjit R (2005) Response of groundnut genotypes to lime and phosphorus levels in coastal alluvial soil of north Karnataka. MSc thesis. Univ Agric Sci Dharwad.
9. Kumar NBT (2012) Productivity of groundnut as influenced by different nutrient rations of N and P. MSc (Agric) thesis. Univ Agric Sci, Dharwad.
10. Nagar KC, Meena NL (2004) Effect of phosphorus, sulfur and phosphate solubilizing bacteria on yield component, yield and quality of cluster bean. Leg Res 27 : 27—31.