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PHOSPHORUS DISSOLUTION AND TRANSFORMATION IN DIFFERENT TYPE OF CALCAREOUS BLACK SOILS

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ABSTRACT

Laboratory incubation experiment was conducted in different type of calcareous soils for eight weeks under field capacity condition to study the phosphorus dissolution and transformation. The results of this experiment revealed that application of P in the form KH_2PO_4 (150 and 300 mg kg^{-1}soil) + PSB along with FYM under eight week of incubation showed that saloid-P fraction was very low of 8.71, 8.99 and 8.88 ppm in slightly, moderately and strongly calcareous soils respectively. The Ca-P was recorded maximum P fraction under strongly calcareous (283.75 ppm) followed by moderately and slightlycalcareous soils of 209.18ppm and 172 ppm respectively. In dissolution study Olsen's-P extractant recorded the available phosphors of 90.02 ppm, 95.75 ppm and 111.56 ppm under strong, moderate and slightly calcareous soils, respectively.

KEY WORDS
Calcareous soils
Dissolution
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INTRODUCTION

Phosphorus (P) is one of the major nutrient elements limiting agricultural production in the world. On an average, soil contains 0.02 to 0.5% total P availability of P further reduced under calcareous soils, due to the presence of the mineral calcium carbonate in the parent material and an accumulation of lime. Phosphorus is added to the soil in the form of phosphatic fertilizers, a part of which (1%) is utilized by plants and the rest is rapidly converted into insoluble complexes, *e.g.*, calcium phosphate, iron phosphate and aluminium phosphate in the soil (Gyaneshwar *et al.*, 2002). A holistic understanding of phosphorus transformation and dissolution in different types of calcareous soil to plants is necessary for optimizing phosphorus recommendation and reducing consumption of chemical phosphate fertilizer. The extent and rate of dissolution of dissolved P must be available for plant uptake. Phosphorus rich organic manure along with P fertilizer increased the available pools soil phosphorus after harvest of soybean under Olsen's extractant (Shanker *et al.,* 2014). Phosphorus behaviour in calcareous soils and the corresponding plant availability of native and applied phosphorus depend on cultivation techniques and several soil properties such as soil pH, total and free calcium carbonate distribution and occurrence of Fe oxides (Ryan *et al.,* 1985). Application of phosphate fertilizer along with FYM and PSB strain increase the P solubilzing bacterial population and Phosphorus availability in the soil (Suresh and Ghasolia, 2013).This study was conducted with an objective to assess the dissolution and transformation of phosphorous in different types of calcareous soils containing varying amount of calcium carbonate under laboratory conditionby incorporating microbial inoculants (phosphorus solubulizing bacteria) and organic matter (FYM).

MATERIALS AND METHODS

A laboratory incubation experiment has been conducted for eight weeks in the Department of Soil Science and Agricultural Chemistry, UAS Raichur to study the dissolution and transformation of phosphorus in slightly (0-5 % $CaCO_3$), moderately (5-10% $CaCO_3$) and strongly (>10 % $CaCO_3$) calcareous soils at field capacity condition by adding two phosphorus levels (150 mg $kg^{-1}$and 300 mg kg^{-1}) along with combined application of FYM and PSB (*Pseudomonas phosphaticum*) in duplicates. The experiment comprised of nine treatments *viz.*, T_1:Control; T_2:150 mg KH_2PO_4 kg^{-1} soil; T_3:300 mg KH_2PO_4 kg^{-1} soil; T_4:150 mg KH_2PO_4 kg^{-1} soil + 5 mg PSB kg^{-1} soil; T_5:300 mg KH_2PO_4 kg^{-1} soil + 5 mg PSB kg^{-1} soil; T_6:150 mg KH_2PO_4 kg^{-1} soil + 5 g FYM kg^{-1} soil; T_7:300 mg KH_2PO_4 kg^{-1} soil + 5 g FYM kg^{-1} soil; T_8:150 mg KH_2PO_4 kg^{-1} soil + 5 mg PSB kg^{-1} soil + 5 g FYM kg^{-1} soil; T_9:300 mg KH_2PO_4 kg^{-1} soil + 5 mg PSB kg^{-1} soil + 5 g FYM kg^{-1} soil. Analysis of different phosphorus fractions like Saloid-P (S-P), Aluminum-P (Al-P), Iron-P (Fe-P), Reductant soluble-P (R-P), Occluded-P (Occl-P), Calcium-P, Total-P, and Organic-P (Org-P) was determined by methods as outlined by (Hesse, 1971) and phosphorus

Dissolution was determined by different method of extractants like Bray's and $BaCl_2$-TEA method of extraction by (Konabo and Gilkes, 1988), Olsen's method of extraction by (Olsen *et al.*,1954) and 0.5 M NaOH method of extraction by (Wright *et al.*,1992).

RESULTS AND DISCUSSION

Dissolution study

In different type of P the extratants 0.5 M NaOH followed by Olsen's, Bray's and $BaCl_2$-TEA-P extratants, recorded maximum plant available phosphorus with 300 mg KH_2PO_4 along with PSB and FYM under different types of calcareous soils from the results presented in Table 1. The combined application of phosphorus with FYM and PSB increased the available phosphorus due to the release of significant quantities of carbon dioxide during microbial organic matter decomposition and complexing of cations such as Ca^{2+} and hence reducing the fixation of phosphorus in calcareous soils similar result reported by (Tolanur and Badanur, 2003). $BaCl_2$-TEA extractable phosphorus was more in strongly and moderately calcareous soils followed by slightly calcareous soils. In slightly calcareous soil, 0.5 M NaOH extractant recorded available phosphorus is more reliable in comparison to moderately and strongly calcareous soil due to the availability of relatively higher Al-P and Fe-P than other two groups of calcareous soil.These results are in accordance with the findings of (Mishra, 1995). Olsen's extractant depicted the presence of higher available phosphorus in slightly calcareous soils followed by moderately and strongly calcareous soils. However Bray's extractant was not effective in extracting the available phosphorus from strongly calcareous soil. In general, Bray's extractable P is extremely low in the calcareous soil due to the presence of more $CaCO_3$ resulting in large quantity of CaF_2 crystals which will trap P in the solution and cause great underestimation of Bray's extractable phosphorus. These results are conformity with the work of (Smillie and Syers, 1972).

Transformation study

Phosphorus Transformation study results revealed that the maximum value of saloid-P fraction, in slight (8.71 ppm), moderate (8.99 ppm) and strongly (8.88 ppm) calcareous soils, was recorded at end of incubation period in T_9 treatment (300 mg KH_2PO_4 + PSB + FYM). In all the treatments saloid-P was gradually decreased with the increase in the incubation period (up to 8th week) in the treatments which were amended with FYM and PSB in comparison to other treatments and control due to the fact that the formation of metallo-organic complexes with organic ligands which decrease their susceptibility to absorption, fixation or precipitation reaction in soil and forming soluble complexes with native as well as added P. These results are in conformity with the findings of Das *et al.* (1991). In different type of calcareous soils, there was decrease in Aluminum-P, Iron-P, Reductant soluble P and Occluded-P fractions was noticed with the increase in the time of incubation. The value of maximum decrease of Aluminum-P

Table 1: Effect of P on dissolution of phosphorus at 8th week of incubation

Treatment	Bray's(ppm)	Olsen's(ppm)	0.5 M NaOH(ppm)	$BaCl_2$-TEA(%)
R-I Slightly Calcareous soils				
T_1: Control	27.20	14.00	24.91	15.00
T_2: 150 mg KH_2PO_4 kg^{-1} soil	111.25	83.12	138.55	22.50
T_3: 300 mg KH_2PO_4 kg^{-1} soil	138.77	88.56	147.61	30.10
T_4: 150 mg KH_2PO_4 kg^{-1} soil + PSB	116.00	81.94	140.73	22.80
T_5: 300 mg KH_2PO_4 kg^{-1} soil + PSB	136.00	87.75	193.25	30.50
T_6: 150 mg KH_2PO_4 kg^{-1} soil + FYM	111.31	100.65	148.00	20.50
T_7: 300 mg KH_2PO_4 kg^{-1} soil + FYM	136.75	108.07	179.21	30.00
T_8: 150 mg KH_2PO_4 kg^{-1} soil + PSB + FYM	109.80	102.87	183.35	23.50
T_9: 300 mg KH_2PO_4 kg^{-1} soil + PSB + FYM	146.05	111.56	205.71	31.00
R-II Moderately calcareous soils				
T_1: Control	20.00	10.00	17.03	22.70
T_2: 150 mg KH_2PO_4 kg^{-1} soil	41.25	58.35	120.49	31.00
T_3: 300 mg KH_2PO_4 kg^{-1} soil	56.00	81.70	186.63	37.10
T_4: 150 mg KH_2PO_4 kg^{-1} soil + PSB	38.75	62.47	118.31	30.00
T_5: 300 mg KH_2PO_4 kg^{-1} soil + PSB	79.00	83.81	175.91	37.60
T_6: 150 mg KH_2PO_4 kg^{-1} soil + FYM	58.75	70.58	120.31	29.60
T_7: 300 mg KH_2PO_4 kg^{-1} soil + FYM	78.50	93.99	178.05	39.00
T_8: 150 mg KH_2PO_4 kg^{-1} soil + PSB + FYM	60.00	73.00	125.25	33.50
T_9: 300 mg KH_2PO_4 kg^{-1} soil + PSB + FYM	86.25	95.75	190.26	39.50
R-III Strongly calcareous soils				
T_1: Control	ND	6.85	13.58	25.10
T_2: 150 mg KH_2PO_4 kg^{-1} soil	ND	60.48	116.31	34.80
T_3: 300 mg KH_2PO_4 kg^{-1} soil	ND	77.96	163.23	41.20
T_4: 150 mg KH_2PO_4 kg^{-1} soil + PSB	ND	61.57	125.01	35.50
T_5: 300 mg KH_2PO_4 kg^{-1} soil + PSB	ND	78.75	151.00	41.00
T_6: 150 mg KH_2PO_4 kg^{-1} soil + FYM	ND	67.25	138.03	34.60
T_7: 300 mg KH_2PO_4 kg^{-1} soil + FYM	ND	88.48	170.94	42.70
T_8: 150 mg KH_2PO_4 kg^{-1} soil + PSB + FYM	ND	70.48	151.36	36.00
T_9: 300 mg KH_2PO_4 kg^{-1} soil + PSB + FYM	ND	90.02	189.16	43.90

NOTE: PSB @ 5 mg kg^{-1} soil; FYM @ 5 g kg^{-1} soil

Table 2: Effect of P on different forms of P (ppm) at 8th week of incubation

Treatment	S-P	Al-P	Fe-P	R-P	Occl-P	Ca-P	Org-P	Total-P
R-I Slightly Calcareous soils								
T_1: Control	3.01	34.39	59.00	65.02	95.27	110.05	444.61	811.35
T_2: 150 mg KH_2PO_4 kg^{-1} soil	3.73	41.40	68.95	78.17	97.32	134.12	537.37	961.06
T_3: 300 mg KH_2PO_4 kg^{-1} soil	6.99	48.25	80.36	89.11	105.43	171.51	611.26	1112.91
T_4: 150 mg KH_2PO_4 kg^{-1} soil + PSB	3.75	42.95	67.23	77.27	99.49	133.92	536.39	961.00
T_5: 300 mg KH_2PO_4 kg^{-1} soil + PSB	6.83	45.72	85.00	91.20	101.05	168.64	612.57	1111.01
T_6: 150 mg KH_2PO_4 kg^{-1} soil + FYM	6.17	45.52	65.19	80.15	96.27	136.55	540.60	970.45
T_7: 300 mg KH_2PO_4 kg^{-1} soil + FYM	8.50	49.32	83.50	89.34	106.17	171.72	650.82	1159.37
T_8: 150 mg KH_2PO_4 kg^{-1} soil + PSB + FYM	6.81	46.79	64.51	78.12	97.90	139.01	542.56	975.70
T_9: 300 mg KH_2PO_4 kg^{-1} soil + PSB + FYM	8.71	51.00	85.32	92.01	106.91	172.00	655.06	1171.01
R-II Moderately calcareous soils								
T_1: Control	2.25	31.36	51.96	62.57	93.00	157.77	455.44	854.35
T_2: 150 mg KH_2PO_4 kg^{-1} soil	3.95	39.40	65.91	73.60	95.02	187.18	539.90	1004.96
T_3: 300 mg KH_2PO_4 kg^{-1} soil	4.83	45.25	77.49	83.83	97.00	207.08	639.37	1154.85
T_4: 150 mg KH_2PO_4 kg^{-1} soil + PSB	3.02	38.00	62.49	72.09	93.61	188.32	540.46	997.99
T_5: 300 mg KH_2PO_4 kg^{-1} soil + PSB	5.51	42.50	80.25	87.26	96.52	205.99	647.52	1165.55
T_6: 150 mg KH_2PO_4 kg^{-1} soil + FYM	6.08	40.57	61.51	76.25	93.52	185.88	550.06	1013.87
T_7: 300 mg KH_2PO_4 kg^{-1} soil + FYM	8.84	45.01	80.31	85.61	98.57	207.91	652.41	1178.66
T_8: 150 mg KH_2PO_4 kg^{-1} soil + PSB + FYM	6.13	40.36	59.96	75.19	93.82	189.25	556.16	1020.87
T_9: 300 mg KH_2PO_4 kg^{-1} soil + PSB + FYM	8.99	47.51	82.32	89.49	101.65	209.18	659.66	1198.80
R-III Strongly calcareous soils								
T_1: Control	2.05	29.31	48.06	65.01	89.61	189.01	498.20	921.25
T_2: 150 mg KH_2PO_4 kg^{-1} soil	3.88	35.00	59.91	69.25	91.02	228.52	585.07	1072.65
T_3: 300 mg KH_2PO_4 kg^{-1} soil	6.50	40.55	71.65	78.00	95.50	277.37	653.67	1223.24
T_4: 150 mg KH_2PO_4 kg^{-1} soil + PSB	3.50	35.04	61.94	70.69	92.57	231.48	577.87	1073.09
T_5: 300 mg KH_2PO_4 kg^{-1} soil + PSB	7.61	40.17	77.31	83.52	94.25	278.18	640.51	1221.55
T_6: 150 mg KH_2PO_4 kg^{-1} soil + FYM	6.27	39.30	59.40	75.30	91.49	232.29	587.89	1091.94
T_7: 300 mg KH_2PO_4 kg^{-1} soil + FYM	8.82	41.00	78.21	81.51	93.38	281.04	684.49	1268.45
T_8: 150 mg KH_2PO_4 kg^{-1} soil + PSB + FYM	6.79	38.75	57.91	71.65	90.50	231.25	590.10	1086.95
T_9: 300 mg KH_2PO_4 kg^{-1} soil + PSB + FYM	8.88	42.25	79.00	83.08	96.83	283.75	689.66	1283.45

NOTE: PSB @ 5 mg kg^{-1} soil; FYM @ 5 g kg^{-1} soil

was in control (34.39, 31.36 and 29.31ppm) and minimum decrease was noticed under treatmentT_9 (300 mg KH_2PO_4 + PSB + FYM) the values were51.00, 47.51 and 42.25ppm in slightly, moderately and strongly calcareous soils, respectively. At the end of the incubation, slightly calcareous soils recorded maximum decrease of Iron-P was noticed in control (59.00 ppm) and minimum decreased was noticed in T_9 (85.32 ppm). In moderately calcareous soils, the maximum decrease of Iron-P was noticed in control (51.96 ppm) and minimum decrease was noticed in T_9 (82.32 ppm). The maximum and minimum decrease of Fe-P was noticed in control (48.06 ppm) and T_9 (79.00 ppm), respectively was observed in strongly calcareous soils. The maximum Fe-P fraction was recorded in slightly calcareous soils compared to moderately and strongly calcareous soils due to release of organic acids and carbon dioxide from organic manures facilitating the build up of iron phosphorus in soil (Patil*et al.,* 2011) similar results reported by (Shivakumar *et al.,* 2004). At 8th week of experiment, in slightly, moderately and strongly calcareous soils, the maximum decrease of reductant soluble-P was noticed in control (65.02, 62.57 and 65.01 ppm, respectively) and the minimum decrease was noticed in T_9 treatment (92.01, 89.49 and 83.08 ppm, respectively). The slightly calcareous soils showed that maximum decrease of reductant soluble P in control (95.27 ppm) and minimum decrease was in T_9 (106.91 ppm) at 8th week of incubation period was mainly due to organic manures contains organic acids by the activity of microorganisms, mean while PSB synthesized organic acids and the production of organic acids results in the acidification of the microbial cell and its surroundings.Similar results are reported by Muhammad *et al.* (2012). Maximum decrease of reductant soluble P was in control (93.00 ppm) and minimum decrease was 101.65 ppm in T_9 in moderately calcareous soils. In strongly calcareous soils, the maximum decrease of reductant soluble P was found in control (89.61 ppm) and minimum decrease was 96.83 ppm in T_9. The maximum occluded phosphorus was observed in slightly calcareous soils followed by moderately and strongly calcareous soils. The maximum and minimum of Ca-P was 172 ppm and 110.05 ppm (slight), 209.18 ppm and 157.77 ppm (moderate) and 283.75 ppm and 189.01 ppm (strongly) calcareous soils was found in control and T_9, respectively. The maximum organic phosphorus was observed in treatment T_9 (655.06 ppm) and minimum was in control (444.61 ppm) in slightly calcareous soils. In moderately and strongly calcareous soils, the maximum organic-P (659.66 and 689.66 ppm) was noticed in $T_9$and minimum in control (455.44 and 498.20 ppm), respectively. The application of KH_2PO_4 along with FYM and PSB improved the higher amount of saloid-P, Al-P, Fe-P, occluded-P and reductant soluble P due to release of organic acids and carbon dioxide from organic manures facilitating the build up of iron phosphorus in soil (Basavaraj, 2000).

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