SOLUBILITY ENHANCEMENT OF PHOSPHORUS FROM ROCK PHOSPHATE THROUGH COMPOSTING WITH POULTRY LITTER

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ABSTRACT

Improving solubility of rock phosphate is critical for phosphorus (P) management in cropping. This experiment was conducted during 2010 to determine the P solubilized from rock phosphate (RP) through composting with fresh poultry litter (PL). The RP used in the experiment was collected from Hazara area of Khyber Pakhtunkhwa (KP) province, Pakistan. The treatments comprised of PL alone, PL+RP, and PL+RP+ Effective Microorganism (EM). Each treatment had 3 replicates. The compost was prepared in excavated pits of 3.13 m^3 size in anopen field for 120 days. The results showed that Mehlic-3 extractable P was significantly higher in the treatments PL+RP+EM, and PL+RP both at day45 and day120 of the incubation, compared to PL only. The increase in available P in treatment PL+RP+ EM was 55.2% and 928.6% over PL+RP and Control, on day120 compared to day0, respectively. Likewise, the increasing trend with time was higher in the treatments where RP was added to PL, irrespective of the treatments, compared to the control where no RP was added. The P availability enhancement in treatment PL+RP+EM with time could be due to the enhanced microbial activities of EM which have solubilize phosphate rock. Contrary to the available P, the nutrient content of nitrogen (N), Total Organic Carbon (TOC) and C:N decreased with the time in all the treatments. There was a significant decrease in pH values in the treatment of PL+RP+EM. The results of the study suggest that composting of PL with RP has the potential to enhance available P content of the compost or RPR.

Key Word: **Rock phosphate (RP), available phosphorus, composting, P enriched compost, Effective Microorganisms (EM)**

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INTRODUCTION

Composting is an efficient way for recycling organic waste and preparing manures for crop production and improving soil health. Composts are valuable resource of plant nutrients especially N, P and organic substrates and may therefore affect physical, chemical and biological properties of a soil (Hussain *et al.* 2001; Zaman *et al.,* 2002 a, b). Composting and the use of composts offer several potential benefits including killing pathogens such as *Salmonella,* stabilize the soil organic matter with a high degree of humification and improve its quality as soil amendment (Ciavatta *et al.,* 1988; collins *et al.,* 1993; Mondini *et al.,* 1996). With the expanding poultry businesses, a lot of poultry litter are produced causing handling and environmental problems in the country. The poultry litter has high N content (Brake *et al.,* 1992). Manures/composts are not only low cost as compared with chemical fertilizers, but also their produce is healthier and fetches extra benefit. However, most of the organic materials and their manures are deficient in macronutrients content, therefore, a large quantity is required to be applied to satisfy crops nutritional demand.

Rock phosphate is basically tri-calcium phosphate with non available P (Brady, 1980; Das, 2005) to plant and is the main raw material for preparing chemical phosphatic fertilizers by treating mostly with sulphuric acid (H_2SO_4). In this reaction, mainly two calcium ions are removed by acid and monocalcium phosphate (single super phosphate) is prepared (fertilizer Manual 1979). Enrichment of manures with P by composting RP with organic materials therefore, seemed to be a viable option, because various organic acids are produced during the process of decomposition, either by soil microorganisms or from chemical reactions. The organic acids produced during the process are gluconic acid, fumaric acid, succinic acid, acetic acid, and some unknown organic acids in smaller concentrations, while oxalic acid and citric acid in larger concentration (Rashid *et al*., 2004). Citric acid showed maximum P solubilizing efficiency followed by oxalic acid maleic acid and formic acid (Kumari *et al.,* 2008).

The other acids produced during the process are carbonic acid (H_2CO_3) produced from evolution of carbon dioxide (CO_2) dissolved in water, nitric acid (HNO_3) produced by dissolution of nitrogen (N) in moisture of the compost. The overall reaction of P availability due to acidulation in the compost is as follow:

$$[Ca_3(PO_4)_2]_3CaCO_3 + 6H_2CO_3 \longrightarrow \underline{Ca(H_2PO_4)_2} + 7CaCO_3$$ [Monocalcium Phosphate](Das, 2005)

Addition of acid creating microbes can further enhance the process of P availability in composting. The mechanism behind the solubilization of P from RP by microorganisms in the soil is also mostly related to the production of organic acids and chelating substances (Datta *et al., 1982*). Solubilizing of inorganic phosphate involves a wide range of processes involving the secretion of organic acids, lowering of pH as a result of acid production, ion chelation and exchange reaction (Molla and Chowdhury, 1984). Effective Microorganisms is a mixed culture of photosynthetic and lactic bacteria, actinomycetes, yeasts and fermenting fungi and may improve composting process (Higa and Parr 1994) Composting with EM is encouraged in organic farming due to its significant benefits (Anon., 1996). The EM solution is acidic having pH 3.5 and enhance the composting process and nutrients availability (Ahmad *et al.,* 1997). Keeping in view the deficiency of P in Pakistani soil, (Rashid *et al.,* 2005) high prices of phosphatic fertilizers, huge reserves of RP (PMDC, 2006) in the country and beneficial effects of compost on crops, this study was designed to determine the extent of P solubilized form RP through composting with PL and EM.

MATERIALS AND METHODS

An experiment was conducted at Water Resources Research Institute, National Agricultural Research Center (NARC), Islamabad, during, 2010. Geographically it is situated at eastern latitude 73° 70′ and northern longitude 33° 39′ with an altitude of 457 to 610 meters above the sea level. The objective of the study was to determine the extent of P solubility from RP through adding with fresh PL and composting. The RP used in the experiment was collected from Hazara area of Khyber Pakhtunkhwa province, Pakistan and ground at 85 micron (mesh size 160) level. The PL was collected from nearby poultry farms for the experiment. The inputs (RP and PL) were analyzed for total and available P_2O_5, N, P, K and TOC content (Table I). Pits size 2.5×1.25×1 meters ($3.125m^3$) were excavated for decomposition of PL added RP. The pits were fully lined and covered with the polythene sheet to avoid nutrients leaching losses during the composting process. The PL was spread in the sun light for four days to make it air dry. The moisture content of the sun dried PL was determined by gravimetric method as prescribed by (Gardner, 1986), which was 8% before mixing with the RP. The RP was mixed with sun-dried PL at 1:6 (w/w), on dry weight basis (subtracting 8% moisture content from PL) in the respective treatments. The mixing was done on a polythene sheet out of the pits. Detail of the treatments is as: 1) Control or only PL, 2) PL+RP and 3) PL+RP+EM.

The experiment was laid out according to Complete Randomized Design with 3 repeats. The analysis of nutrients was done on day 0, day 45 and day 120. The extended EM solution at the rate of 1:1:50 (EM: Molasses: Water) was prepared 24 hours before application to activate the microbes. The EM was sprayed at the rate of 50 liter ton^{-1} of PL on the respective treatments. Five kg of already composted manure was mixed in 10 liter water and applied to all the treatments uniformly to enhance decomposition process. The material in every treatment was moisted with water up to the desired level ±40% for expediting the composting process (Guar, 1997). After mixing of all the additives, the measured amount of mixed material were put into the respective pits treatment-wise and covered with the black polythene sheet to enhance the microbial activities through enhancing heat. The moisture content of the composting material was monitored regularly to maintain desired level for proper composting.

The material in every pit was turned into the nearby empty pit for reshuffling after every 25 days. Samples for the determination of N, P, TOC and pH were collected from the composting pits. The analysis of total N was determined following Kjeldahal and wet digestion methods, respectively (Rayan e*t al*., 2001). Available or extractable P was analyzed through Mehlic-3 method, (Mehlic, 1984). TOC was determined by the procedure as given by Nelson and Somers (1982). The total P content (%) of in RP and the composting material in pit with RP was determined by the procedure of Olsen and Sommers, (1982).

Table I ***Analysis of inputs used in compost***

Inputs	Analysis						
	Total N (%)	P_2O_5 (%)		K (%)	pH	TOC (%)	C:N
		Total	Available				
RP	-	22.00	0.001	-	7.92	-	-
PL	1.62	2.82	0.16	1.23	7.64	34.11	21.06

RESULTS AND DISCUSSION

Phosphorus

The total P of control/only PL was 2.82% on day0 (Table I). The analysis of total P in the treatments with RP showed 5.92% content with ±0.15 variation on day0 while, by calculation it gave 6.49%. The difference between the analyzed and calculated value might be due to some non-homogenous mixing of RP with PL due to adhesive nature of well meshed RP and moisture application. Available or extractable P is mostly a friction of the total P (Rashid and Memon 2005) in composts/manures which is readily available to the plants.

In this study, the available P increased significantly with the time span in all the three treatment as compared with the initial day0. The magnitude of increase ranged from 0.15 to 1.60% amng the treatments with time span. The significantly highest available P (1.60%) was recorded on day120 in the treatment where RP, PL and EM were applied in combination, followed by PL + RP (1.02 %) as compared with control (0.30%). The increase in available P in this treatment was 55.17 and 928.6 % over PL+ RP and only PL (control) on day120 showing the effectiveness of EM and RP in the process of composting, respectively. It can be hypothised that the extra P availability in the treatment PL+RP and PL+RP+EM over control (only PL) might be released from added RP. The increasing trend with time span was sharper in the treatments where RP was added to the PL irrespective of the treatments, as compared with the control where no RP was added (Table 2). The availability enhancement in PL+RP+EM might be due to the enhanced microbial activities with the application of EM as mentioned by Taiwo and Ogundiya (2008). Ahmad *et al.,* (1997) have reported enhanced nutrient availability in composts with the application of EM. Akande *et al*., (2005) found that effectiveness of RP as P source for crop production was remarkably enhanced by addition in PL.

Total Nitrogen

The data recorded on total N revealed that the overall trend of concentration in the composting material decreased significantly with time span in all the treatments. The significantly least N losses of 7.4% were recorded in the treatment RP+PL+EM where concentration decreased from 1.48 to 1.37% followed by control (only PL), from 1.62% to 1.47% with 9.2% losses on day120 over day0. The maximum losses of N were recorded in the treatment PL+RP where concentration decreased from 1.45% to 1.30% showing 10.3% losses on day120 over day0. The results revealed that N decreasing trend in the treatment with EM was comparatively less than rest of the treatments (Table II). The decrease in N content with the time span might be due to the volatilization of NH_4-N at initial stages of composting. Mondini *et al.,* (1996) has reported similar losses of N in PL after composting. Atkinson *et al.,* (1996) suggest that N losses can be reduced by adding plant materials. The analysis of initial sample showed that N content in the treatments with RP was less than the control; this might be due to the addition of RP which does not contain any N.

Organic Carbon

In this study the TOC content decreased significantly with time span ranging from 34.11 to 15.82%, irrespective of the treatments. The highest TOC content on day0 was recorded in the treatment where only PL was used followed by PL+RP+EM with 30.8% and PL+RP with 30.46%. The difference among the TOC content in various treatments on the day0 might be due to the addition of RP in the respective treatments which does not contain any OC (Table-1). The maximum decomposition trend was recorded in the treatment PL+RP+EM where OC decreased from 30.46% to 21.26% and 15.22%, showing 29.0 and 49.8% decrease on day45 and day120 over day0, respectively. Since this treatment had microbe's population more than the others due to addition of EM might be the reason for enhanced decomposition. The only PL gave second higher decomposition rate where OC decreased from 34.11 to 24.17 and 18.15% on day45 and day120 over day0, respectively (Table 3). Our results are in accordance with the results of Jawson and Elliott (1986) and

Summerell and Burgess (1989) who reported continuous decrease in TOC during composting of organic material.

Carbon Nitrogen Ratio

The carbon nitrogen (C:N) ratio indicates the extent of decomposition rate and quality of compost of organic materials. It is calculated by dividing TOC by N content in the compost. Generally, 20 or <20 C: N ratio is considered as good indicator for decomposed manures and such manures are considered suitable for agricultural use. However, the quality of compost depends upon the constitution of the organic materials and their nutrient content and proportion. Some materials contain less N and high carbon content which are not fast in decomposition, as microbes need N for their own food to decompose organic materials (Alexander, 1976). Since, the PL contain higher total N content, therefore their C:N ratio is low and are decomposed rapidly. In this study the data indicate that after day45 the C:N ratio was lower than 20 and compost was fit for use, but as the objective was to determine the extent of P solubility from RP so the data was recorded up to day120. Irrespective of the treatments, the C:N ratio was decreased at the day45 and day120 as compared to day0. The C:N ratio narrowed down in all the treatments with the time span, might be due to the escape of CO_2 after decomposition while mostly N remained in the system (Sadasivam and Manickam 1993). Moreover, the C:N ratio indicate that the decomposition trend was more faster in the treatment PL+RP+EM as compared with the rest of the treatments might be due to the enhanced microbial activities in the compost of this treatment.

The C:N ratio of the compost ranged from 21 to 12 among the treatments with the time period of 120 days (Table III). There were differences of ± 0.66 in C:N ratio among the treatments on the day0, might be due to the addition of RP having no N and quick action of EM for decomposition in the respective treatments. The C:N ratio of the control treatment where only PL was kept for decomposition gave the lower ratio (17.51 and 12.35) than treatment of PL+RP (19.37 and 13.23) on the day45 and day120, respectively might be due to the addition of RP.

Table II ***Available P_2O_5 and total N content of compost with time span***

Treatments Detail	Available P_2O_5 (%)			Total N (%)		
	Day0	Day 45	Day 120	Day0	Day 45	Day 120
1.Control (P.L)	0.16 a	0.23 c (43.8)	0.30 c (87.5)	1.62 a	1.38 a (-14.8)	1.47 a (-9.2)
2.P.L+RP	0.15 a	0.80 b (433.3)	1.02 b (580)	1.45 b	1.20 b (-17.2)	1.30 b (-10.3)
3. P.L+RP+EM	0.16 a	0.90 a (462.5)	1.60 a (900)	1.48 ab	1.28 ab (-13.5)	1.37 b (-7.4)
CV	5.21	5.88	6.74	3.09	3.45	2.88
LSD	0.025	0.115	0.198	0.142	0.134	0.118

Table III ***Total organic Carbon (TOC), C:N and pH values of compost with time span***

Treatments Detail	TOC			C:N			pH		
	Day0	Day 45	Day 120	Day0	Day 45	Day 120	Day0	Day 45	Day 120
1.Control (P.L)	34.11a	24.17 a (-29.1)	18.15a (-46.8)	21.05 a	17.51 ab (-16.8)	12.35 b (-41.3)	7.64b	7.62a (-.26)	7.60a (-.52)
2. P.L+RP	30.8b	23.27b (-24.4)	17.20b (44.1)	21.24 a	19.39 a (-8.7)	13.23 a (-37.7)	7.74a	7.70a (-5.1)	7.69a (-.64)
3. P.L+RP+EM	30.46b	21.62 c (-29.0)	15.82c (-49.8)	20.58 a	16.98 b (-17.9)	11.55b (-43.9)	7.40c	7.37b (-.40)	7.36b (-.54)
CV	1.47	0.62	1.37	2.25	3.68	1.57	0.19	0.47	0.94
LSD	0.71	0.45	0.71	1.43	2.0	0.60	0.043	0.11	0.22

The figure in parentheses show the percent increase over control

Table IV ***ANOVA for available P, total N, TOC, C:N and pH of compost with time span as influenced by different treatments i.e. PM, PM+RP and PM+RP+EM***

Parameter	day0	Day45	Day120
Available P_2O_5	1.5 NS	273**	296**
Total N	11.2**	12.4**	22.4**
TOC %	55.8**	242**	74.9**
C:N	1.51NS	11.3**	20.0**
pH	458**	82.2**	17.2**

NS= non- significant
*** Significant at p≤ 0.01*

Treatment which had no N and also utilized organic acids for solubilization rather than to be used for decomposition of organic materials. Our data confirm findings of Genevini *et al.,* (1997) and Ahmed *et al*., (1997) who observed that during the process of decomposition C:N ratio decreased.

pH value

The pH value of any material shows the amount of hydrogen ion concentration in the medium. The acids play a very vital role in the composting of organic materials and solubility of RP to the soluble P in the composting process. The pH value of PL+RP and PL+RP+EM on day0 was 7.74 and 7.4 while only PL showed value of 7.64. The variation in values on day0 might be due to the addition of RP which had pH value 7.92 (Table I) and EM having pH 3.5 (Ahmed *et al*., 1997). During composting period the pH value remained declining irrespective of the treatments and time span (Table III). The organic and chemical acids production during the composting are the main factors to decrease the pH of compost (Michel and Reddy, 1998).The pH of treatment where EM was applied to RP+PL showed the lowest pH value than the rest of the treatments throughout the composting span. This might be due to the more population of acid creating microbes in the medium/compost by addition of EM. The pH value of the treatment RP+PL remained highest throughout the composting period might be due to the high pH of RP added to the treatment and created acid consumed in solubilizing P from RP. Our values are in the range of acceptable composts (Kiehl., 1985).

CONCLUSION AND RECOMMENDATION

It can be concluded from the study that addition of RP at the ratio of 1:6 in the fresh PL before composting may enhance the available P content of the compost/manure. The magnitude of available P can be further enhanced by 55% if EM solution is applied to the composting material well before start of the composting process.

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