

Original Research Article

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## Phosphorus Solubility from Rock Phosphate and Nutrient Availability through Composting with Crop Residues

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### ABSTRACT

The present experiment was conducted at research farm of Department of Soil Science and Agricultural Chemistry, Collage of Agriculture, Dhule (M.S.) with an objective to evaluate the phosphorus solubility and nutrient availability during phosphocomposting. Phosphocompost was prepared by using bajra straw and cotton stalks along with low grade rock phosphate (Jhabua rock phosphate, Madhya Pradesh) by pit method. The experiment was laid out in Randomized Block Design with six treatments replicated four times. Treatment composed of bajra straw and cotton stalks incorporated with three levels of rock phosphate i.e 4, 8 and 12 per cent of crop residues. The composting was carried out up to 120 days. Periodical chemical analysis of phosphocompost was carried out at 30, 60, 90 and 120 days and micronutrients (Zn, Mn, Cu and Fe) were estimated at 120 days of composting. The pH during phosphocomposting was gradually declined with time span, while, it significantly increases with increased levels of rock phosphate. The electrical conductivity was found to be increased with period and levels of rock phosphate. The maximum organic carbon content (27.34 %) was noted in cotton stalks with 4 % of rock phosphate level compost and the minimum organic C (24.13 %) was noticed in bajra straw with 12 % rock phosphate level. The maximum total N (1.36 %), total P (1.95 %), citrate soluble P (0.96 %) and water soluble P (0.082 %) contents were recorded in the phosphocompost prepared from cotton stalks + rock phosphate @ 12 % of crop residue. However, the highest total K (0.92 %) and total Ca and Mg (9.72 and 4.02, % respectively) contents were noted in bajra straw + rock phosphate @ 12 % of crop residue compost. The significantly highest Zn (2.75 mg kg<sup>-1</sup>), Mn (3.82 mg kg<sup>-1</sup>) and Fe (7.26 mg kg<sup>-1</sup>) contents were recorded in compost prepared from cotton stalks + rock phosphate @ 12 % of crop residue while, the maximum Cu content (0.32 mg kg<sup>-1</sup>) was noted in bajra straw with 12 % rock phosphate compost.

#### Keywords

Phosphocompost, Crop residues, Rock phosphate, Nutrient availability

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### Introduction

Biodegradable waste such as leaves, crop residues, straw, weeds, bagasse, kitchen waste etc. are some of the important sources of

improving the organic matter in the soil, which ultimately improves the physico-chemical and biological properties of the soil. Compost as fertilizer or soil conditioner improves the soil quality by enhancing

aeration, water status, macro and micro nutrients and aggregate stability which perk up plant growth (Amlinger *et al.*, 2007). The efficacy of inorganic additives (rock phosphate 5%, FeSO<sub>4</sub> 1% and lime 0.63%) meant to perk up the municipal solid waste composting process and to examine the physio-chemical parameter during composting in mechanical composter (Iqbal *et al.*, 2010).

In alkaline soils the solubility of most nutrient elements decreases many folds. At this condition most phosphorous fertilizer will be precipitated in soil and became unavailable for plants. Organic fertilizers are able to increase the phosphorous solubility in soil by different manner. Some of them may be covering soil surface of aggregates, buffering soil pH by different acidic functional group in organic matter. When soluble phosphorous is added to a soil it will be un-soluble after few hours (Pierzynski, 2005).

Phosphorous (P) is an element that is widely distributed in nature and occurs together with nitrogen and potassium as a primary constituent of plant and animal life. P plays a series of functions in the plant metabolism and is one of the essential nutrients required for plant growth and development, it has functions of a structural nature in macromolecules such as nucleic acids and of energy transfer in metabolic pathways of biosynthesis and degradation. Unlike nitrate and sulphate, phosphate is not reduced in plants but remains in its highest oxidized form (Marschner, 1993).

Phosphorous inputs are required for sustainable agricultural production in most soils of the tropics and subtropics. Rock phosphate (RP) and organic materials have been suggested as alternative P source in these soils. It is estimated that about 260 million tons of RP deposits are available in

India (FAI, 2002) and only a fraction of it (about 5.27 million tons) meets the specification of the fertilizer industry because of low grade. In India crop residue like wheat straw, cotton stalk, bajra straw, soybean straw, sorghum stubbles and farm wastes are available in huge quantity. Similarly, with the increasing demand of food grain for ever increasing population of world, increased the demand of manure particularly, FYM for crop production. The livestock population of India is decreasing day by day; hence, the FYM stock may also narrow down in the context of demand of organic manures particularly FYM. Use of crop residues, industrial wastes, city and farm wastes need to utilize for preparation of phosphocompost.

In this context several procedure for testing the stability or maturity of phosphocompost have been proposed. 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 reaction. This approach provides an opportunity to recycle the nutrient waste and bridge the gap between demand and supply of both macro and micronutrients in agriculture. Therefore, the present study was undertaken with objectives to prepare phosphocompost using crop residues and rock phosphate and evaluate the nutrients availability during composting.

## **Materials and Methods**

The present study was conducted at research farm of Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dhule (M.S.) during *kharif* 2016. The bajra straw and cotton stalks were collected from research farms of College of Agriculture, Dhule. The experiment was laid in Randomized Block Design with six

treatments each replicated four times. The treatments composed of two crop residues, Bajra straw and Cotton stalks and the rock phosphate were mixed in both the residues @ 4, 8 and 12 % of crop residue. The phosphocompost was prepared by pit method with size 1m × 1m × 0.5m. The straw of bajra and cotton was chopped of 2 mm size. The shredded crop residues were spread in layers of about 30 cm thick. Sprinkled slurry prepared by mixing cow dung and rock phosphate over crop residues. Second layer was prepared in the same manner. Urea solution and microbial inoculants were added. The pits were covered with polythene. Turning was given at 15, 30, and 60, days after filling of pits. After 90 days of decomposing, heap of phosphocompost was collected at one place and allow to cure for another 30 days to obtained C:N ratio near about 20:1. Throughout study, the moisture was maintained at 60-70 per cent. The samples were collected at 30, 60, 90, and 120 days during phosphocomposting.

The proximate analysis of rock phosphate cow dung and crop residues was done at start of experiment. The pH during composting was estimated by potentiometry, electrical conductivity by conductometry, total P estimated by Vanadomolybdophosphoric yellow color, citrate soluble P and water soluble P by colorimetric methods as suggested by Jackson (1973). Organic carbon was estimated by using combustion method (Black 1982), total N by Microkjeldahl (Digestion distillation) method (Parkinson and Allen 1975), total K by flame photometry (Chapman and Pratt 1961), calcium and magnesium was estimated by EDTA method as suggested by Piper (1966). Micronutrients (Zn, Mn, Cu and Fe) were estimated by adopting Atomic Absorption Spectrophotometer method (Zoroski and Bureau 1977).

## Results and Discussion

### Proximate analysis of rock phosphate, crop residues and cow dung

The data presented in Table 1 indicated that the rock phosphate used for the preparation of phosphocompost contains total phosphorous 21.05 per cent, citrate soluble P 1.12 per cent and water soluble P 0.004 per cent. The calcium and magnesium contents in this rock phosphate were recorded 8.9 and 3.52 per cent, respectively and calcium carbonate is 7.16 per cent. Among the crop residues used for study, the cotton stalks contain higher organic carbon (50.12 %), total N (0.76 %) and total P (0.36 %) as compared to bajra straw. However, higher total K (0.70 %) was noted for bajra straw. The higher C: N ratio (74.54) was recorded for bajra straw as compared to cotton stalks (65.94).

### pH, EC and organic C

The results pertaining to the periodical changes in pH during phosphocomposting prepared from bajra straw and cotton stalks are presented in Table 2. During composting period, the pH values remained declining irrespective of the treatments and the time span. Significantly increased in pH values with increase in rock phosphate level from 4 to 12 per cent in bajra straw and cotton stalks treatments was observed at all periodical stages. However, slight higher pH was recorded for cotton stalks as compared to bajra straw. At the end of phosphor-composting, the lowest pH (7.36) was observed in treatment T<sub>1</sub> i.e. bajra straw + rock phosphate @ 4 % of crop residues and the highest pH (7.45) was noted in treatment T<sub>6</sub> (cotton stalks + rock phosphate @ 12 % of crop residues). Similar declining trend was noticed by Khan and Sharif (2012). Hellal *et al.*, (2012) prepared rice straw phosphocompost and they stated that decrease in pH

may be caused by increased production of organic acids or increased nitrification.

The data in respect of electrical conductivity revealed that it continuously increased upto the 120 days of phosphocomposting and at this stage it ranged between 0.35 and 0.74 dSm<sup>-1</sup>. Further, it was noticed that increase in levels of rock phosphate from 4 to 12 per cent also significantly increases the electrical conductivity in bajra straw and cotton stalks during all periodical stages. Phosphocompost prepared from bajra straw recorded slightly higher electrical conductivity over cotton stalks. However, the lowest EC (0.35 dSm<sup>-1</sup>) was recorded with cotton stalks + rock phosphate @ 4 % crop residue treatment and the highest EC (0.74 dSm<sup>-1</sup>) was noticed under bajra straw + rock phosphate @ 12 % of crop residue treatment.

The increased in electrical conductivity during phosphocomposting with the addition of rock phosphate was also observed by HELLAL *et al.*, (2012).

Perusal of the data presented in Table 2 indicated the significant changes in organic carbon contents during phosphocomposting at all periodical stages. The organic carbon content gradually declined from 30 to 120 days of phosphocomposting in all treatments. However, the higher values were recorded for cotton stalks compared to bajra straw phosphocomposting.

At the end of phosphocomposting (120 days), it ranged between 24.13 to 27.34 per cent. However, it was noticed that the increased levels of rock phosphate from 4 to 12 per cent, significantly and slightly decreased the organic C content during phosphocomposting. At the end of phosphocomposting, the lower organic C content (24.13 %) was noted in treatment with bajra straw + rock phosphate @ 12 % of crop residues and the higher

organic C content (27.34 %) was observed with cotton stalks + rock phosphate @ 4 % of crop residues. The organic carbon content decreased as the decomposition proceeds from 0 to 90 days was noted by Banta and Dev (2009), which may be due to the carbon degrading activity by microbes or due to the stimulating effect of added N on microbial activity during decomposition.

### **N, P and K content**

Throughout phosphocomposting, the total nitrogen content was significantly and gradually increasing upto 120 days (Table 2). At 30 day, the total N was ranged in 0.59 to 0.85 per cent which was increased upto 1.12 to 1.36 per cent at 120 days of phosphocomposting. Further, it was noticed that increasing levels of rock phosphate slightly increased the total nitrogen content. At all periodical stages cotton stalks incorporated with rock phosphate showed the higher total N contents over bajra straw. At the end, the maximum total nitrogen content (1.36 %) was noted in cotton stalks + rock phosphate @ 12 % of crop residues treatment (T<sub>6</sub>) followed by treatment T<sub>5</sub> i.e. cotton stalks + rock phosphate @ 8 % of crop residues (1.32 %).

The minimum total nitrogen content (1.12 %) was recorded with bajra straw + rock phosphate @ 4 % of crop residues treatment (T<sub>1</sub>). Appraisal of the results point out that at 120 days, the per cent increase of total nitrogen content in treatments T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub> and T<sub>6</sub> were 89.83, 84.13, 90.48, 56.79, 57.14 and 60.00 per cent, respectively over their 30 days contents. Addition of microbial inoculants in rock phosphate lead to increase in N content of mature compost and addition of rock phosphate accelerates the mineralization of N. The results of the present investigation are in congruence with those of Khan and Sharif (2012).

**Table.1** Proximate analysis of rock phosphate, crop residues and cow dung used for composting

Particular	Total P (%)	Citrate soluble P (%)	Water soluble P (%)	Calcium (%)	Magnesium (%)	CaCO <sub>3</sub> (%)
Rock phosphate	21.05	1.12	0.004	8.9	3.52	7.16
	Organic C (%)	Total N (%)	Total P (%)	Total K (%)	C:N Ratio	
Bajra straw	41.15	0.55	0.24	0.70	74.54	
Cotton stalks	50.12	0.76	0.36	0.66	65.94	
Cow dung	37.42	1.92	0.23	0.50	19.49	

**Table.2** pH, EC, organic C content and total N availability during phosphocomposting

Treatment	pH				EC (dSm <sup>-1</sup> )				Organic C (%)				Total N (%)			
	30	60	90	120	30	60	90	120	30	60	90	120	30	60	90	120
<b>T<sub>1</sub> Bajra straw + RP @ 4% of crop residue</b>	7.49	7.48	7.44	7.36	0.19	0.23	0.30	0.53	39.65	37.26	30.83	25.64	0.59	0.63	0.86	1.12
<b>T<sub>2</sub> Bajra straw + RP @ 8% of crop residue</b>	7.55	7.53	7.50	7.40	0.22	0.30	0.42	0.63	38.56	35.53	29.65	24.91	0.63	0.65	0.92	1.16
<b>T<sub>3</sub> Bajra straw + RP @ 12% of crop residue</b>	7.63	7.57	7.51	7.42	0.34	0.42	0.48	0.74	37.70	33.44	28.15	24.13	0.63	0.70	0.97	1.20
<b>T<sub>4</sub> Cotton stalks+ RP @ 4% of crop residue</b>	7.56	7.56	7.51	7.40	0.14	0.18	0.26	0.35	48.94	44.49	35.28	27.34	0.81	0.85	1.04	1.27
<b>T<sub>5</sub> Cotton stalks + RP @ 8% of crop residue</b>	7.73	7.64	7.61	7.43	0.18	0.24	0.31	0.43	47.86	41.68	32.45	26.65	0.84	0.88	1.11	1.32
<b>T<sub>6</sub> Cotton stalks + RP@ 12% of crop residue</b>	7.76	7.69	7.62	7.45	0.22	0.32	0.39	0.53	45.18	38.93	29.27	25.83	0.85	0.93	1.16	1.36
<b>SE ±</b>	0.008	0.009	0.009	0.006	0.007	0.005	0.006	0.011	0.018	0.016	0.020	0.017	0.010	0.008	0.009	0.009
<b>CD at 5%</b>	0.023	0.028	0.028	0.018	0.020	0.014	0.019	0.033	0.055	0.048	0.061	0.051	0.031	0.025	0.029	0.026

**Table.3** Phosphorus and potash availability during phosphocomposting

Treatment	Total P (%)				Citrate soluble P (%)				Water soluble P (%)				Total K (%)			
	30	60	90	120	30	60	90	120	30	60	90	120	30	60	90	120
<b>T<sub>1</sub> Bajra straw + RP @ 4% of crop residue</b>	0.74	0.94	1.23	1.52	0.33	0.57	0.70	0.74	0.037	0.043	0.053	0.065	0.55	0.64	0.71	0.81
<b>T<sub>2</sub> Bajra straw + RP @ 8% of crop residue</b>	0.76	1.20	1.37	1.59	0.41	0.65	0.76	0.80	0.046	0.050	0.062	0.068	0.59	0.67	0.75	0.84
<b>T<sub>3</sub> Bajra straw + RP @ 12% of crop residue</b>	0.80	1.26	1.43	1.94	0.47	0.73	0.81	0.90	0.048	0.056	0.065	0.072	0.63	0.76	0.84	0.92
<b>T<sub>4</sub> Cotton stalks+ RP @ 4% of crop residue</b>	0.73	0.97	1.28	1.74	0.35	0.61	0.71	0.80	0.038	0.047	0.057	0.071	0.50	0.61	0.67	0.72
<b>T<sub>5</sub> Cotton stalks + RP @ 8% of crop residue</b>	0.80	1.24	1.40	1.88	0.45	0.67	0.82	0.90	0.048	0.053	0.064	0.076	0.56	0.63	0.71	0.73
<b>T<sub>6</sub> Cotton stalks + RP@ 12% of crop residue</b>	0.84	1.31	1.47	1.95	0.55	0.82	0.86	0.96	0.052	0.059	0.067	0.082	0.60	0.67	0.78	0.80
<b>SE ±</b>	0.012	0.014	0.012	0.007	0.011	0.013	0.009	0.010	0.001	0.001	0.001	0.001	0.007	0.010	0.011	0.009
<b>CD at 5%</b>	0.037	0.043	0.036	0.022	0.034	0.041	0.027	0.029	0.003	0.003	0.003	0.003	0.022	0.031	0.032	0.027

**Table.4** Calcium, magnesium and micronutrients availability during phosphocomposting

Treatment	Total Ca (%)				Total Mg (%)				Micronutrients content (mg kg <sup>-1</sup> ) at harvest			
	30	60	90	120	30	60	90	120	Zn	Mn	Cu	Fe
<b>T<sub>1</sub> Bajra straw + RP @ 4% of crop residue</b>	4.75	5.83	6.88	7.79	1.25	1.55	2.55	3.14	2.35	2.35	0.23	5.80
<b>T<sub>2</sub> Bajra straw + RP @ 8% of crop residue</b>	5.10	6.21	7.00	8.92	1.44	1.71	2.82	3.50	2.60	2.68	0.25	6.50
<b>T<sub>3</sub> Bajra straw + RP @ 12% of crop residue</b>	6.22	7.16	8.89	9.72	1.60	2.32	3.21	4.02	2.67	3.38	0.32	7.03
<b>T<sub>4</sub> Cotton stalks+ RP @ 4% of crop residue</b>	4.07	5.15	6.81	7.77	0.95	1.39	2.31	3.06	2.43	2.81	0.20	6.32
<b>T<sub>5</sub> Cotton stalks + RP @ 8% of crop residue</b>	4.82	6.24	7.38	8.65	1.26	1.61	2.50	3.46	2.66	3.64	0.21	7.02
<b>T<sub>6</sub> Cotton stalks + RP@ 12% of crop residue</b>	5.18	6.80	8.32	9.14	1.39	1.95	3.14	3.71	2.75	3.82	0.24	7.26
<b>SE ±</b>	0.066	0.045	0.191	0.060	0.017	0.024	0.057	0.071	0.023	0.063	0.003	0.018
<b>CD at 5%</b>	0.199	0.135	0.576	0.181	0.053	0.072	0.171	0.214	0.070	0.189	0.009	0.054

Results pertaining to the changes in total phosphorous content during phosphocomposting at various periodical stages are presented in Table 3. Total P content gradually increased from 30 to 120 days of composting. At 30 days, it ranged between 0.73 to 0.84 per cent and was increased and ranged between 1.52 to 1.95 per cent at 120 days of composting. Further, it was noticed that with the increase in level of rock phosphate from 4 to 12 per cent, total P increased significantly. Slight higher values were recorded with cotton stalks compared to bajra straw.

However, at the end of phosphocomposting, significantly highest total P content (1.95 %) was recorded in treatment T<sub>6</sub> i.e. cotton stalks + rock phosphate @ 12 % of crop residues followed by treatment T<sub>3</sub> i.e. bajra straw + rock phosphate @ 12 % of crop residues (1.94 %) treatment and both these were found at par with each other. The magnitude of increase in total P content at the end of phosphocomposting in treatments T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub> and T<sub>6</sub> were 105.41, 109.21, 142.50, 138.36, 135.00 and 132.14 per cent, respectively over their 30 days values. Odongo *et al.*, (2007) stated that higher phosphorous content during composting is due to greater mobilization of P from rock phosphate.

The citrate and water soluble P was significantly and gradually increased with time span and the incorporation of increasing levels of rock phosphate from 4 to 12 per cent also increases their contents (Table 3). However, at the end of composting, the maximum citrate (0.96 %) and water soluble P (0.082%) was recorded in cotton stalks + rock phosphate @ 12 % of crop residue (T<sub>6</sub>) followed by cotton stalks + rock phosphate @ 8 % of crop residues i.e. 0.90 and 0.076 per cent, respectively. While, their minimum contents (0.74 and 0.065 %, respectively)

were observed in bajra straw + rock phosphate @ 4 % of crop residue treatment. The proton excreted from decomposition of organic matter is able to increase the solubility of rock phosphate by 13-38 per cent and can be further enhanced by 55 per cent if microbial inoculants is applied before start of composting process. Biswas and Narayanasamy (2006) stated that increase in citrate soluble P was obvious because of production of organic acids like citric, oxalic, tartaric etc. during composting of organic matter, which in turn, enhanced the dissolution of P from RP.

The significant changes in total potassium content during phosphocomposting with bajra straw and cotton stalks incorporated with low grade rock phosphate levels was observed (Table 3). At 30 days, the total potassium content was ranged between 0.50 to 0.63 per cent which was found to be increased at 120 days and ranged in 0.72 to 0.92 per cent with different treatments.

Appraisal of the results point out that increased in rock phosphate levels from 4 to 12 per cent also significantly increases the total K contents. At the end, the phosphocompost prepared from bajra straw + rock phosphate @ 12 % of crop residues (T<sub>3</sub>) recorded the maximum total potassium content (0.92 %) followed by the treatment (T<sub>2</sub>) bajra straw + rock phosphate @ 8 % of crop residue (0.84 %) and their increase in total potassium content were 46.03 and 42.37 per cent, respectively over initial content.

The minimum total K content (0.72 %) was noticed under cotton stalks + rock phosphate @ 4 % crop residues treatment (T<sub>4</sub>). The result of present investigation are in congruence with those of Punde and Ganorkar (2012), they found the increase in total potassium content throughout the vermicomposting period.



### Calcium, magnesium and micronutrients

During various periodical stages of phosphocomposting the total calcium and magnesium content was significantly affected due to different treatments (Table 4). It was noticed that the calcium and magnesium contents were gradually increased from 30 to 120 days of composting and with increasing levels of rock phosphate from 4 to 12 per cent in both the crop residues. At the end of composting, the highest total calcium (9.72%) and magnesium content (4.02 %) was noted with bajra straw + rock phosphate @ 12 % of crop residue (T<sub>3</sub>) treatment followed by cotton stalks + rock phosphate @ 12 % of crop residue (9.14 and 3.71 %, respectively) treatment. Although, their lowest contents were observed under the treatment cotton stalks + rock phosphate @ 4 % of crop residue. Results tend support to earlier finding of Sibi (2011), who reported the considerable increase in calcium and magnesium contents during phosphocomposting than the ordinary compost, which may be due to the mineralization of nutrients by the microorganisms.

Total micronutrient contents were estimated from the final phosphocompost prepared from bajra straw and cotton stalks along with low grade rock phosphate. All four micronutrient content were increased with increase in levels of rock phosphate from 4 to 12 per cent of crop residues (Table 4). The total zinc, manganese, copper and iron contents were ranged between 2.35 to 2.75, 2.35 to 3.82, 0.20 to 0.32 and 5.80 to 7.26 mg kg<sup>-1</sup>, respectively. However, the highest content of Zn, Mn and Fe were recorded in cotton stalks + rock phosphate @ 12 % of crop residue treatment, while, the maximum content of Cu was noticed under treatment bajra straw incorporated with rock phosphate @ 12 % of crop residue. The results are in agreement with Rama Lakshmi *et al.*, (2013), they

opined that increased micronutrient concentration in matured compost might be due to loss of mass during composting and nature and composition of substrates.

Results concluded that phosphocompost could be an alternative and viable technology to utilize both crop residues and low grade rock phosphate efficiently and could be used successfully as a cheaper source of P – fertilizer in place of costly water soluble P in crop production. It may be ascertained that crop residues which are not fed to the animals or in excess in the farm, if utilized effectively by converting them in to compost may improve their quality in a shortest possible time, which in turn, provide balanced nutrition to plants, improve biological health of soil and ultimately sustained crop production. Thus, the results of the present study suggest that composting of crop residues with low grade rock phosphate has the potential to enhance the manurial value of compost in terms of nutrient availability.

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