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Microbial activity and nutrient availability during phospho composting with *Parthenium* and cassia

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Abstract
The present experiment was conducted at research farm of Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dhule. Phosphocompost was prepared by using *Parthenium* and cassia weed along with low grade rock phosphate by pit method. Treatment composed of *Parthenium* and cassia weed incorporated with three levels of rock phosphate i.e. 4, 8 and 12 per cent of weed residues. Organic carbon content was continuously decreased with increase in period of composting as well as slight decrease was also noticed with increased rock phosphate levels. The maximum total N (1.87 %) and total P (1.48 %) contents were recorded in the phosphocompost prepared from cassia weed + 12 % rock phosphate. The C:N ratio was found to be gradually declined with period and rock phosphate levels. The lowest C:N ratio (16.33) was noticed under cassia weed + 12 % rock phosphate compost. The highest humic acid and fulvic acid contents (1.12 and 10.42 g 100 g^{-1}) were noted in cassia weed + 12 % rock phosphate compost. Also, the significant decrease in E4/E6 ratio of both humic acid and fulvic acid was noticed. The lowest E4/E6 ratio of humic and fulvic acid (1.25 and 4.55) recorded with cassia weed + 12 % rock phosphate compost. The significantly maximum fungal, bacterial, actinomycetes and PSB population were recorded in compost prepared from cassia weed. The dehydrogenase activity and alkaline phosphatase activity significantly increased with increased level of rock phosphate.

Keywords: Phosphocompost, rock phosphate, parthenium, cassia, biological properties

Introduction
Soil organic matter associated with microbial activity plays a major role in the nutrient cycling process in soil leading to enhanced nutrient availability. Increasing biomass production and return per unit cropped area and decreasing soil organic matter loss have been identified as the major considerations to control soil organic matter balance. Thus, low input sustainable agriculture and the reduced chemical input concept focus on the reconsideration of agricultural practices such as burying crop residues and organic matter recycling into soil, in order to maintain and preserve soil organic matter at an adequate level and to sustain arable land. Soil enzymes release nutrients into the soil by means of organic matter degradation, helps in the identification of microbial activity, they are sensitive indicators of ecological change. These enzymes may include amylase, arylsulphatases, β-glucosidase, cellulose, chitinase, dehydrogenase, phosphatase, protease, and urease released from plants. (Miwa *et al*. 1973) [11].
Most of the Indian soils are low in phosphorus. Also, yearly removal of P is more than its addition through P fertilizers during continuous and intensive cropping. Biosolids produced in cities, agro industries and at farms normally have low nutrient value, particularly of P content. Compost production from these biodegradable wastes is presently not an economically viable proposition. The traditional technology of composting, if improved in terms of nutrients content, may help in arresting trends of nutrient depletion to a greater extent. Further, the use of mineral additives such as rock phosphate along with microbial inoculants during composting has been found beneficial. On the other hand, many waste plants are growing menacingly threatening agriculture and environment and they are having abundant biomass which can be exploited for soil improvement and economic crop production. Among these, *Parthenium hysterophorus* and *Cassia tora* are fast growing which come up in abundance in fallow lands, road sides and gomal (range) lands. Besides having high content of N and P, they have succulent biomass and could be used to substantially in N and P economy of crops if incorporated in the soil (Pazhanivelan *et al*., 2006) [14].
The present study therefore, conducted to prepare phosphocompost with the use of weeds and to determine the microbial activity and nutrient availability during composting.

Materials and Methods
The experiment was carried out at College of Agriculture, Dhule (Maharashtra) during *kharif* 2017 to study the enhancement of phosphorous solubility from rock phosphate through composting with weeds.

The *Parthenium hysterophorus* and *Cassia tora* were collected from research farms of College. The phosphocompost was prepared by pit method with size 1m × 1m × 0.5 m. The *Parthenium* and cassia was chopped of 2 mm size. The shredded weeds were spread in layers of about 30 cm thick. Sprinkled slurry prepared by mixing cow dung and rock phosphate over weed. Prepared a second layer in the same manner. Added urea solution and microbial inoculants. Maintain moisture up to 60% by addition of water. Covered the pits with polythene. Turning were given at 15, 30, and 60 days after filling of pits. The experiment was laid in Randomized Block Design with six treatments each replicated four times. The treatment comprised T_1: *Parthenium* weed + 4 % rock phosphate, T_2: *Parthenium* weed + 8 % rock phosphate, T_3: *Parthenium* weed + 12 % rock phosphate, T_4: Cassia weed + 4 % rock phosphate, T_5: Cassia weed + 8 % rock phosphate, T_6: Cassia weed + 12 % rock phosphate. Organic carbon was estimated by combustion method (Black 1982) [3], total N by Microkjeldahl (Digestion distillation) method (Parkinson and Allen 1975) [13] and total P estimated by Vanadomolybdophosphoric yellow color method as suggested by Jackson (1973) [7]. Humic and fulvic acid was estimated by 0.5 N NaOH extraction method and E_4/E_6 ratio by Spectrophotometric (Stevenson 1982) [18]. Microbial population was enumerated by Serial dilution plate method (Dhingra and Sinclair 1993) [8]. Dehydrogenase (Casida *et al.* 1964) [4] and alkaline phosphatase activity (Tabatabai and Bremner 1969) [19] estimated by Spectrophotometric.

Results and Discussion

Nutrient composition of rock phosphate, weeds and cow dung

Results (Table 1) indicates that rock phosphate used for study contains 21.05 per cent total phosphorous, 1.12 per cent citrate soluble P and 0.004 per cent water soluble P. The calcium and magnesium contents in this rock phosphate were recorded 8.9 and 3.52 per cent, respectively and calcium carbonate is 7.16per cent. Among the weeds used for study, the Cassia contain higher organic carbon (49.36 %), total N (1.25 %), total P (0.70 %) and total K (0.94 %) over *Parthenium hysterophorus*. The higher C: N ratio (43.88) was recorded for *Parthenium hysterophorus* as compared to *Cassia tora* (39.49). The cow dung used for phosphocomposting contains 36.92, 1.90, 0.25, and 0.51 per cent organic C, total N, total P and total K, respectively having C: N ratio 19.43. Similar nutrient pattern was reported by Manna *et al.* (2003) [10] for cow dung and Biswas and Narayanasamy (2006) [2] for rock phosphate.

Table 1: Nutrient composition of rock phosphate, weeds and cow dung

x	***Total P (%)***	**Citrate soluble P (%)**	**Water soluble P (%)**	**Calcium (%)**	**Magnesium (%)**	**$CaCO_3$ (%)**
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	
Parthenium hysterophorus	42.12	0.96	0.65	0.72	43.88	
Cassia tora	49.36	1.25	0.70	0.94	39.49	
Cow dung	36.92	1.90	0.25	0.51	19.43	

Organic C, total N, total P and C, N ratio

The organic carbon content gradually declined from 30 to 90 days of phosphocomposting in all treatments.. 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 all periodical stages. At the end of phosphocomposting, the lower organic C content (28.46 %) was noted in *Parthenium* weed + 12 % rock phosphate and the higher organic C content (34.00 %) was observed with cassia weed + 4 % rock phosphate. Continuous decrease in organic carbon content during phosphocomposting was also noticed by Khan and Sharif (2012) [9], 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.

At all periodical stages Cassia incorporated with rock phosphate showed the higher total N contents over *Parthenium* (Table 2). At the end, the maximum total nitrogen content (1.87 %) was noted in cassia weed + 12 % rock phosphate treatment followed by cassia weed + 8 % rock phosphate (1.73 %). The minimum total nitrogen content (1.22 %) was recorded with *Parthenium* weed + 4 % rock phosphate. Appraisal of the results point out that at 90 days, the per cent increase of total nitrogen content in treatments T_1, T_2, T_3, T_4, T_5 and T_6 were 19.60, 18.18, 23.27, 19.71, 17.68 and 24.66 per cent, respectively over their 30 days contents. The total N content of compost treatments showed an increasing trend with increase in decomposition period was reported by Banta and Dev (2009) [1]. They stated that 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. Similarly, Sibi (2011) [15] concluded that apparent increase in total nitrogen content in compost is not only due to enrichment but also due to the reduction in weight because of decomposition.

Total P content gradually increased from 30 to 90 days of composting. Significantly highest total P content (1.48 %) was recorded in treatment cassia weed + 12 % rock phosphate followed by treatment *Parthenium* weed + 12 % rock phosphate (1.43 %) 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_1, T_2, T_3, T_4, T_5, and T_6 were 65.33, 73.08, 76.54, 71.62, 71.95, and 72.09 per cent, respectively over their 30 days values. The lower content of total P (1.24 %) was noticed under *Parthenium* weed + 4% rock phosphate treatment. Higher phosphorous content during composting is due to greater mobilization of P from rock phosphate. Periodical increase in total phosphorous content during phosphocomposting was noted by Hellal *et al.* (2012) [6]. Sharif *et al.* (2013) [17] concluded that the availability of P from rock phosphate can be enhanced by the organic acids released during composting which might be due to the biological treatments.

At 30 days of phosphocomposting, the C:N ratio ranged between 29.61 to 39.23 which was gradually decreased to 16.33 to 25.48 at 90 days (Table 2). At the end of phosphocompost, the compost prepared from cassia weed + 12 % rock phosphate recorded the lowest C:N ratio (16.33) followed by compost obtaining from cassia weed + 8 % rock phosphate (18.87) treatment. While, the highest C:N ratio (25.48) was recorded with *Parthenium* weed + 4 % rock phosphate treatment. The decrease in C:N ratio with time span might be due to decrease in carbon due to loss of organic carbon through oxidation and increase in the total N of crop residues. The results of the present investigation are in congruence with those of Banta and Dev (2009) [1]. They noticed the C:N ratio at the initiation of composting was varied from 22.23 – 52.78, which was narrowed down to 13.31-24.30 at the maturity of compost. This reduction may be due to carbon degrading activity of microbial inoculants. However, Khan and Sharif (2012) [9] concluded that the narrowed down of C:N ratio with the time span might be due to the escape of CO_2 after decomposition while mostly N remained in the system.

Table 2: Organic C, total N, total P and C:N ratio during phosphocomposting

Treatment	Organic C (%)			Total N (%)			Total P (%)			C:N ratio		
	30	60	90	30	60	90	30	60	90	30	60	90
T_1 *Parthenium* weed + 4 % rock phosphate	40.02	38.60	31.09	1.02	1.12	1.22	0.75	0.94	1.24	39.23	34.46	25.48
T_2 *Parthenium* weed + 8 % rock phosphate	38.88	35.82	29.97	1.10	1.23	1.30	0.78	1.21	1.35	35.35	29.12	23.05
T_3 *Parthenium* weed + 12 % rock phosphate	38.01	33.74	28.46	1.16	1.32	1.43	0.81	1.27	1.43	32.77	25.56	19.90
T_4 Cassia weed + 4 % rock phosphate	48.21	43.67	34.00	1.42	1.63	1.70	0.74	0.97	1.27	33.95	26.79	20.60
T_5 Cassia weed + 8 % rock phosphate	47.17	40.92	32.64	1.47	1.69	1.73	0.82	1.25	1.41	32.09	24.21	18.87
T_6 Cassia weed + 12 % rock phosphate	44.42	38.12	30.53	1.50	1.80	1.87	0.86	1.33	1.48	29.61	21.18	16.33
SE ±	0.013	0.017	0.013	0.0249	0.0240	0.0227	0.004	0.008	0.006	0.0716	0.0243	0.0409
CD at 5%	0.038	0.051	0.040	0.0752	0.0725	0.0684	0.014	0.024	0.020	0.2159	0.0732	0.1232

Humic acid, fulvic acid and E4/E6 ratio

The highest humic and fulvic acid content (1.12 and 10.42 g 100 g^{-1}, respectively) was observed in phosphocompost prepared from cassia weed + 12 % rock phosphate followed by cassia weed + 8 % rock phosphate (1.01 and 9.82 g 100 g^{-1}, respectively). Although, the lowest humic and fulvic acid content (0.87 and 8.16 g 100 g^{-1}, respectively) was noted with *Parthenium* weed + 4 % rock phosphate. Also noticed that increasing levels of rock phosphate from 4 to 12 per cent along with *Parthenium* and cassia, significantly increased the humic and fluvic acid content (Table 3). Further, it may be conceived that the wider C: N ratio of *Parthenium* responsible for the less humic acid content as compared to cassia. The present findings are accordance with Singh *et al.* (1995), who reported that wider C: N ratio of wheat straw contributed less per cent of humic acid as compared to rice straw.

E4/E6 ratio is related to the molecular weight and degree of condensation of the aromatic carbon network (or humification or aging). Low ratio indicates relatively high degree of condensation of aromatic humic constituents. While, high ratio indicates low degree of aromatic condensation and infers the presence of relatively large proportion of aliphatic structures, smaller size organic molecules and higher content of functional groups. Humic acid is more mature and therefore shows low ratio and the less mature fulvic acid possess high ratio. In present experiment, the E4/E6 ratio of fulvic acid was gradually declined upto the end of phosphocomposting. At the end of phosphocompost, the compost prepared from cassia weed + 12 % rock phosphate recorded the lowest humic and fulvic acid E4/E6 ratio (1.25 and 4.55, respectively) followed by compost obtaining from cassia weed + 8 % rock phosphate (1.45 and 4.63, respectively) treatment. While, the highest humic and fulvic acid E4/E6 ratio (2.35 and 5.42, respectively) was recorded with *Parthenium* weed + 4 % rock phosphate treatment. Kaddali *et al*. (2000) studied the characterization of humic substances and reported that the E4/E6 ratio of fulvic acid was found higher (5.0 to 8.15) than humic acid (4.02 to 5.46). They further observed that when organic residues were used, the resultant humic acid was more aliphatic in nature and more labile. Thakare and Adhav (2017) [20] observed the gradual declined in E4/E6 ratio during vermicomposting.

Table 3: Humic and fulvic acid contents and E4/E6 ratio during phosphocomposting

Treatment	Humic acid (g 100 g^{-1})			Fulvic acid (g 100 g^{-1})			E4/E6 ratio of humic acid			E4/E6 ratio of fulvic acid		
	30	60	90	30	60	90	30	60	90	30	60	90
T_1 *Parthenium* weed + 4 % rock phosphate	0.72	0.79	0.87	7.30	7.71	8.16	4.02	3.56	2.35	7.31	6.79	5.42
T_2 *Parthenium* weed + 8 % rock phosphate	0.75	0.82	0.91	7.85	8.35	8.81	3.83	3.42	2.22	7.08	6.63	5.40
T_3 *Parthenium* weed + 12 % rock phosphate	0.77	0.85	0.94	8.12	8.75	9.12	3.44	3.03	2.06	6.64	6.22	5.11
T_4 Cassia weed + 4 % rock phosphate	0.79	0.86	0.96	7.97	8.10	8.72	3.28	2.79	2.31	6.30	5.86	4.68
T_5 Cassia weed + 8 % rock phosphate	0.82	0.91	1.01	8.42	9.17	9.82	3.08	2.63	1.45	6.13	5.82	4.63
T_6 Cassia weed + 12 % rock phosphate	0.85	0.95	1.12	8.82	9.75	10.42	2.72	2.37	1.25	5.99	5.62	4.55
SE ±	0.002	0.008	0.008	0.0123	0.0194	0.0161	0.0092	0.0070	0.0100	0.046	0.009	0.103
CD at 5%	0.007	0.024	0.025	0.0372	0.0584	0.0485	0.0277	0.0210	0.0302	0.138	0.027	0.310

Dehydrogenase activity, alkaline phosphatase activity and microbial population

The significant increase in the dehydrogenase and alkaline phosphatase activities were observed with increased level of rock phosphate from, 4 to 12 per cent (Table 4). Higher value of dehydrogenase and alkaline phosphatase activities was recorded in cassia weed + 12 % rock phosphate (44.55 µg TPF g^{-1}compost 24 h^{-1} and 59.05 µg P-Nitrophenol g^{-1}compost24 h^{-1}, respectively) and lower value recorded with *Parthenium* weed + 4 % rock phosphate (36.63 µg TPF g^{-1} compost 24 h^{-1} and 44.88 µg P-Nitrophenol g^{-1}compost 24 h^{-1}, respectively). The higher enzyme activity was noticed under cassia weed as compared to *Parthenium* because of the presence of higher microbial population and orgaic carbon during cassia phosphocomposting. Dehydrogenase enzyme is an index of microbial activity because it refers to a group of mostly intercellular enzymes which catalyzes the oxidation of organic matter. The results are in consonance with the findings of Murthy *et al*. (2010) [12].

Appraisal of the results (Table 4) point out that with increase in levels of rock phosphate there is decrease in fungal population in both *Parthenium* and cassia treatments. The maximum fungal count (31.25 × 10^4cfu g^{-1} soil) was recorded in phosphocompost prepared from cassia weed + 4 % rock phosphate followed by *Parthenium* weed + 4 % rock phosphate followed by *Parthenium* weed + 4 % rock phosphate (30.00 × 10^4cfu g^{-1} soil) treatment. While, the bacterial, actinomycetes and PSB populations were significantly increased with increased levels of rock phosphate. The highest bacterial and actinomycetes count (41.50×10^7 and 21.75×10^6cfu g^{-1} soil, respectively) were recorded in phosphocompost prepared from cassia weed + 12 % rock phosphocompost. However, the phosphocompost prepared from cassia weed + 12 % rock phosphate showed the highest PSB count (37.75×10^7cfu g^{-1} soil) followed by compost prepared from cassia weed +8 % of rock phosphate (34.00×10^7cfu g^{-1} soil). The present findings are in agreement with those of Zayed and Motaal (2005). They noticed that rice straw enriched with rock phosphate and microbial inoculants significantly enhanced the microbial population in compost.

Table 4: Dehydrogenase and alkaline phosphatase activities and microbial population during phosphocomposting

Treatment	Dehydrogenase activity (µg TPF g^{-1} compost 24 h^{-1})	Alkaline phosphatase activity (µg P-Nitrophenol g^{-1} compost 24 h^{-1})	Fungi (x 10^4 cfu g^{-1} soil)	Bacteria (x 10^7 cfu g^{-1} soil)	Actinomycetes (x 10^6 cfu g^{-1} soil)	PSB (x 10^7 cfu g^{-1} soil)
T_1 *Parthenium* weed + 4 % rock phosphate	36.63	44.88	30.00	25.75	13.25	22.75
T_2 *Parthenium* weed + 8 % rock phosphate	38.00	46.60	26.00	30.75	15.25	25.25
T_3 *Parthenium* weed + 12 % rock phosphate	39.63	48.50	24.00	32.35	19.75	29.50
T_4 Cassia weed + 4 % rock phosphate	38.00	52.33	31.25	34.75	15.00	31.50
T_5 Cassia weed + 8 % rock phosphate	40.38	55.18	27.25	38.25	17.50	34.00
T_6 Cassia weed + 12 % rock phosphate	44.55	59.05	21.75	41.50	21.75	37.75
SE ±	0.595	0.612	0.593	0.651	0.594	0.870
CD at 5%	1.793	1.843	1.789	1.965	1.790	2.624

Conclusion

Implicit with the foregone discussion, it is concluded tha tphosphocompost prepared by using *Parthenium* and cassia along with rock phosphate contains the appreciable amounts of N, P, organic C, favorable C: N ratio, humic acid, fulvic acid, E4/E6 ratio, dehydrogenase and alkaline phosphatase activity. These phosphocompost also possess the higher population of fungi, bacteria, actinomycetes and PSB. Therefore, it may be ascertained that weeds which are in abundance 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.

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