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Rock phosphate enriched compost: An approach to improve low-grade Indian rock phosphate

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Abstract

In this study, rock phosphate enriched composts (RP-compost) were prepared by mixing four low-grade Indian rock phosphates with rice straw with and without *Aspergillus awamori*. RP-compost had higher total P, citrate soluble P (CSP), organic P (Org.P), acid and alkaline phosphatase activities, and lower water soluble P (WSP) and microbial biomass C (MBC) than normal compost. Inoculation with *A. awamori* increased total P, WSP, CSP, Org.P, MBC and acid phosphatase activity. RP-compost recorded lower Olsen P at the initial period of incubation study than diammonium phosphate (DAP), but improved significantly with the progress of time. RP-compost prepared at 4% charged rate resulted in higher Olsen P throughout the incubation period compared to 2% charged rate. Similar trend were obtained with those RP-composts prepared with *A. awamori*. Data on pot experiment revealed higher yield and P uptake by mungbean (*Vigna radiata*) due to addition of RP-composts over control. The effectiveness of RP-compost ranged from 61.4% (MussoorieRP-compost) to 94.1% (PuruliaRP-compost) as that of DAP on dry matter yield and 48.8% (JhabuaRP-compost) to 83.7% (PuruliaRP-compost) on total P uptake. Enriched compost prepared at 4% charged rate recorded 15.8% and 10.6% extra yield and P uptake, respectively by mungbean over 2% charged compost. Also RP-compost inoculated with *A. awamori* resulted in 13.0 and 21.5% extra yield and P uptake than without *A. awamori* treated group. Thus, RP enriched compost could be an alternative and viable technology to utilize both low-grade RPs and rice straw efficiently.

Keywords: Rock phosphate; Rice straw; Compost; *Aspergillus awamori*; Olsen P

1. Introduction

Phosphorus (P) is the second limiting nutrient after nitrogen in majority of soils for crop production. The cost of applying conventional water soluble P fertilizer is high in India because their manufacture requires importing high-grade rock phosphate (RP) and sulphur. Thus, alternative use of indigenously available low-grade RP is gaining importance in India. It is estimated that about 260 million tonnes (Mt) of RP deposits are available in India (FAI, 2002) and only a fraction of it (about 5.27 Mt) meets the specification of the fertilizer industry because of their low P content (low-grade). Most of the RPs are reasonably suitable for direct use in acid soils, but has not given satisfactory results in neutral to alkaline soils (Narayanasamy and Biswas, 1998). Some methods for improving the efficiencies of these materials are mixing with elemental sulphur (Basak et al., 1987), partial acidulation with nominal amount of acid (Hammond et al., 1986; Stephan and Condron, 1986; Biswas and Narayanasamy, 1998) and dry compaction with water soluble P fertilizers (Menon and Chien, 1996; Begum et al., 2004). However, the feasibility of commercial production for P fertilizers by partial acidulation and compaction are low due to the cost involved in those methods.

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The loss of soil organic matter due to intensive agriculture is responsible for a decrease in soil fertility. The most common practice to preserve and/or restore soil fertility is to add organic matter to these soils regularly. Therefore, in present day agriculture, the recycling of agricultural and industrial wastes is of prime importance not only because it adds much needed organic matter that improves physical and microbiological properties of soil but also supplements sufficient amount of nutrients to the soil. It is estimated that about 246 Mt of cereal straw is available annually in India (Ramaswamy, 1999). A substantial amount of which (mainly rice straw) is burnt in the field after the harvest of crop in order to clean the field for growing the next crop because of labour constraints with consequent losses of nutrients and CO_2 inputs to atmosphere.

Considering all these factors, there is a need to develop a cost effective, eco-friendly and sustainable system where the supply of P to plants can be ensured. In this respect preparation of rock phosphate enriched compost (RP-compost) using crop residue holds a lot of promise in developing countries like India. The present study was therefore, undertaken to explore the possibility of increasing the availability of P from low-grade RP incorporated during decomposition of rice straw along with and without phosphate solubilizing microorganism (PSM) viz. *Aspergillus awamori*, where potential biochemical transformations of P could be expected and to evaluate the products through a soil incubation study and a greenhouse experiment.

2. Methods

2.1. Rice straw

Rice straw (*Oriza sativa* L.) was collected after harvest at the experimental farm of Indian Agricultural Research Institute (IARI), New Delhi, India. It was air-dried and chopped into small pieces, about 5–6 cm in length. On dry matter basis, it contained (%) 43.1 total C, 0.50 N, 0.03 P, 0.95 K and the C/N ratio of 86.2.

2.2. Rock phosphate

Four Indian RPs, namely, Jhabua (JhabuaRP) from Madhya Pradesh State Mining Corporation Ltd., Meghnagar, Madhya Pradesh; Mussoorie (MussoorieRP) from Pyrites, Phosphate and Chemicals Ltd., Dehradun, Uttaranchal; Purulia (PuruliaRP) from West Bengal Mineral Development and Trading Corporation Ltd., Purulia, West Bengal and Udaipur (UdaipurRP) from Rajasthan State Mines and Minerals Ltd., Udaipur, Rajasthan were used for the preparation of RP-composts. All the rock phosphates were of sedimentary origin and categorised as low-grade because of their low P content. The chemical constituents of the RPs (100-mesh size particle) were determined as per the standard procedure and given in Table 1.

Table 1
Chemical composition of rock phosphates used for composting with rice straw

Rock phosphate	Total P (%)	WSP (%)	CSP (%)	CISP (%)	K (%)	Ca (%)	Mg (%)	S (%)	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})
JhabuaRP	7.25 ± 0.09	0.003 ± 001	1.10 ± 0.06	6.15 ± 0.09	0.13 ± 0.02	9.0 ± 1.20	3.48 ± 0.13	0.40 ± 0.05	5870 ± 25	904 ± 5	213 ± 8	40 ± 3
MussoorieRP	8.25 ± 0.05	0.001 ± 0.0	1.19 ± 0.04	7.06 ± 0.09	0.39 ± 0.01	12.0 ± 0.50	5.88 ± 0.23	0.52 ± 0.07	7020 ± 40	1200 ± 25	486 ± 11	70 ± 4
PuruliaRP	9.87 ± 0.18	0.004 ± 0.001	1.25 ± 0.05	8.62 ± 0.10	0.36 ± 0.01	7.8 ± 0.20	5.64 ± 0.14	0.31 ± 0.06	8720 ± 50	3680 ± 21	631 ± 12	120 ± 5
UdaipurRP	8.62 ± 0.08	0.002 ± 0.001	1.26 ± 0.06	7.36 ± 0.09	0.19 ± 0.02	6.4 ± 0.30	5.64 ± 0.14	0.39 ± 0.03	6850 ± 35	2764 ± 16	261 ± 5	70 ± 4

Note: (i) JhabuaRP = Jhabua rock phosphate; MussoorieRP = Mussoorie rock phosphate; PuruliaRP = Purulia rock phosphate; UdaipurRP = Udaipur rock phosphate. (ii) WSP = water soluble P; CSP = citrate soluble P; CISP = citrate insoluble P. (iii) Rice straw contained OC = 43.1%; N = 0.5%; P = 0.03%; K = 0.95% and C/N ratio = 86.2.