

Original Research Article

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Effect of Composted Rock Phosphate with Organic Materials on Yield, Nutrient Uptake and Soil Fertility after Harvest of Maize (*Zea mays* L.)

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ABSTRACT

Keywords

Phosphorus rich compost, DAP, SSP, PSB, Vermiculture and Maize.

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A field experiment was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur during Kharif 2013 to study the effect of phosphorus rich compost on yield, nutrient uptake and nutrient status in soil after harvest of maize. Results revealed that application of various sources and levels of phosphorus (DAP, SSP and PRC incubate with and without PSB and vermiculture) significantly increase grain, stover and biological yield of maize was recorded under treatment 25% RDP through PRC + Vermiculture + PSB + 75% RDP through DAP by 107.55, 82.56 and 91.96 per cent, respectively over control. Similarly, uptake of nitrogen, phosphorus and potassium by crop was significantly higher with the application of 25% RDP through PRC + Vermiculture + PSB + 75% RDP through DAP by 159.56, 177.58 and 141.51 per cent, respectively over control. However, maximum available nitrogen, phosphorus and potassium in soil were recorded under treatment 100% RDP through PRC + Vermiculture + PSB after harvest of maize crop as compared to all other treatments.

Introduction

Phosphorus (P) is the major plant nutrient and considered one of the primary factor limiting crop yields (Zaidi *et al.*, 2009). Therefore, application of phosphatic fertilizers is essentially required to maximize crop yields. The overall P use efficiency of applied phosphatic fertilizer such as SSP, DAP, TSP etc. is lower than optimal and only 15 to 20 per cent of applied phosphorus is recovered by the first crop, because of the formation of insoluble P compounds in soil (Vance, 2001). An important factor contributing to this low recovery is high Ca content in calcareous

soils, which are very much prevalent in India. So addition of sufficient P through P fertilizers is direly needed.

The cost of conventional fertilizers like DAP, SSP is so high. Moreover, in India, continuously increasing the prices of such phosphatic fertilizers, consequently, it restrict their use by sizable poor farming community and also their scarcity at the right time of application mostly accounts for low P fertilizers use by the farmers resulting in relatively low crop yields in India. This

situation warrants the formulation of a cheaper and locally developed P product for field use.

For the production of phosphatic fertilizers only about 35 to 40 per cent of the requirements of raw material are being met through indigenous sources and rest is met through import in the form of rock phosphate, phosphoric acid and direct fertilizers (Tisdale *et al.*, 1995). The total rock phosphate deposits in India are estimated to be about 300 MT (TIFAC, 2011) of which only a fraction of it (about 25%) meets the specification of the fertilizer industry because of low grade P content (low grade). In Rajasthan, major sources of rock phosphate are Jhamarkotra (Udaipur) rock phosphate which is locally available source of phosphorus in Rajasthan. RP has good P content (28–30%) but cannot be directly used as a fertilizer because of its poor release of P for the use of plant (Reddy *et al.*, 2002). Rock phosphate is effective when applied directly to acidic soils. It cannot be used with the same levels of efficiency on alkaline calcareous soils. In alkaline soils of India, direct use of RP is not feasible because of its poor solubility. However, if RP is allowed to react with organic acids produced during composting, a major part of RP-P could be solubilizes for plant uptake (Singh and Reddy, 2011). It is well documented that during composting process of organic waste a variety of organic acids are released. The interaction of organic acids released during composting results in P solubilization from RP for plant uptake. The use of organic fertilizers made up of various composted materials, is now established as a key strategy not only for improving soil organic matter contents and nutrients supply to plants but also for reducing the input cost of mineral fertilizers and promoting healthier environments (Ahmad *et al.*, 2006). Therefore, the availability of phosphorus from these rock

phosphate could be improved through composting technology using FYM, agricultural wastes, crop residues, phosphate solubilizing bacteria (PSB) and earthworm (Vermiculture) to make available 'P' in alkaline soil. This may imply that the low grade RP reserves of India could be used efficiently by preparing phosphate rich compost which not only economical but also environment friendly.

Maize (*Zea mays* L.) is an important cereal crop of India and plays a pivotal role in agricultural economy both as staple food for larger section of population, raw material for industries and feed for animals (mostly poultry). Currently, it is cultivated over an area of 9.40 million ha with 24.19 million tonnes production with an average yield of 25.40 q ha⁻¹ contributing nearly 9 per cent in the national food basket (Anonymous, 2014). Rajasthan ranks first in respect of area, where in this crop occupies 1.05 million ha area with production of 1.95 million tonnes and productivity of 18.60 q ha⁻¹ (Anonymous, 2014). The productivity is quite lower than other developed countries mainly due to sub-optimal application of fertilizers and its cultivation on marginal lands. The phosphorus rich compost (PRC) being cheaper and eco-friendly and could be the alternatives of chemical fertilizers for improving both crop productivity and sustainability of the systems. Therefore, the present study was carried out with objective to study the effect of phosphorus rich compost on yield, nutrient uptake and available nutrient status in soil after harvest of maize in southern Rajasthan.

Materials and Methods

The experiment was conducted at the Instructional Farm, Rajasthan College of Agriculture, Udaipur during Kharif 2013. The site is situated at South-Eastern part of

Rajasthan at an altitude of 579.5 m above mean sea level, at 24°35' N latitude and 74°42' E longitude. The mean annual rainfall of the region is 610.2 mm, most of which is contributed by south west monsoon from July to September. Maximum and minimum temperatures ranged between 27.1 to 32.6°C and 14.2 to 24.8°C, respectively during kharif 2013. Before conducting the experiment, initial characteristics of the soil was determined by standards procedure as described by Jackson (1973). The soil of the experimental field was sandy clay loamy in texture, slightly alkaline (pH 7.78), medium in organic carbon (0.62%), nitrogen (262 kg ha⁻¹), P₂O₅ (20.5 kg ha⁻¹) and high in K₂O (432 kg ha⁻¹) and sufficient amount of DTPA extractable micronutrients.

For the preparation of P rich compost, four pits of six feet length, three feet width and two feet depth were made. Raw materials like farm wastes and fresh cow dung were collected and mixed in the ratio of 1:1 on dry weight basis. Low grade rock phosphate (16% P₂O₅) was procured from Rajasthan State Mines and Minerals Ltd., Udaipur, Rajasthan. The pits were filled with crop residue; FYM and Jhhamarkotra rock phosphate in the ratio of 10:1, respectively and mix them well. The mixed material was filled to all the four pits, and finally was add water for better composting. After twenty days of composting were release vermiculture in the two pits having treatment of worms and PSB. The organic material was composted and vermicomposted for three months and all pits was keep moist throughout the composting period.

The experiment was laid out in randomize block design having three replications with following 11 treatments T0 (Control), T1 (100% RDP through DAP), T2 (100% RDP through SSP), T3 (25% RDP through PRC + 75% RDP through DAP), T4 (25% RDP

through PRC + PSB + 75% PDP through DAP), T5 (25% RDP through PRC + Vermiculture + 75% PDP through DAP), T6 (25% RDP through PRC + Vermiculture + PSB + 75% RDP through DAP), T7 (100% RDP through PRC), T8 (100% RDP through PRC + PSB), T9 (100% RDP through PRC + Vermiculture) and T10 (100% RDP through PRC + Vermiculture + PSB). The field was prepared by cross cultivator followed by planking to obtain well pulverized soil tilth. During sowing 50% of total dose of N and full dose of P₂O₅ and K₂O were applied as basal and remaining 50% in 25-30 DAS.

The grain and stover yields were recorded after threshing the bundles of maize plants from each treatment. The plant samples were collected at harvest and analyzed for N, P and K content in grain and stover.

Soil samples (0-15 cm) were collected after harvest. Total nitrogen was determined by Micro-Kjeldhal method (Snell and Snell, 1955), Phosphorus by Vanadomolybdate phosphoric acid yellow colour method (Jackson, 1973) and Potassium by flame photometer (Jackson, 1973). The collected soil samples were analyzed for pH using pH meter (1:2 soil: water suspension), electrical conductivity by conductivity meter (Richards,1954) and organic carbon by rapid titration method (Piper,1960).

Available N was estimated by alkaline permanganate method (Subbiah and Asija, 1956), available P by Olsen's method (Olsen *et al.*,1954) and available K by ammonium acetate extraction method (Richards, 1954). The data collected was analyzed statistically by using Fisher's analysis of variance technique and individual treatment means were separated by using least significant difference (RBD) test at 5 percent probability level.

Results and Discussion

Grain and stover yield

The application of P sources significant influenced the grain and stover yields of maize (Table 1). Data shows that that application of 60 kg P₂O₅ ha⁻¹ through DAP, SSP and PRC with and without PSB and Vermiculture and PRC with integration of inorganic P fertilizer significantly increased grain and stover yields of maize over the control. The crop fertilized with 25% P through PRC + Vermiculture + PSB + 75% P through DAP produced significantly higher grain yield by 107.58, 19.07, 18.46 and 15.68 per cent, over T0 (Control), T3 (25% RDP through PRC + 75% RDP through DAP), T7 (100% RDP through PRC) and T9 (100% RDP through PRC + Vermiculture), respectively.

However, it was observed at par with treatment T1 (100% RDP through DAP), T2 (100% RDP through SSP), T4 (25% RDP through PRC + PSB + 75% RDP through DAP), T5 (25% RDP through PRC + Vermiculture + 75% RDP through DAP), T8 (100% RDP through PRC + PSB) and T10 (100% RDP through PRC + Vermiculture + PSB). Similar trends were also observed under biological yield.

This may be attributed to the higher amount of total P present in composted rockphosphate with vermiculture and PSB had higher grain and stover yields than those without it. The effective utilization of different RPs in combination with vermiculture and PSB was obvious because these organisms secrete organic acids and enzymes which helped in bio-transformation of insoluble P to available form. Moreover, these increased the potentiality of more due to solubilization of both organic as well as inorganic P in soil.

The results corroborate the findings of Mishra *et al.*, (1982), attributing the effect of rock phosphate enriched compost to the release of P from rock phosphate during decomposition and partially the additive effect of organics. Also the organics enriched with inorganic P, when added to soil are subjected to biological mineralization and there is a production of organic-P fractions as phosphor-humus complexes which easily supply nutrients to plants.

Opala *et al.*, (2009) reported that integrated application of organic and inorganic phosphorus sources had significant positive role in the growth characteristics of maize.

These results are consistency with Hellal *et al.*, (2013), and Lal *et al.*, (2015) who found that yield was increased significantly by the application of RP composted with organic materials. Similar, results were also reported by Zafar *et al.*, (2011), Vyas *et al.*, (2012), Hellal *et al.*, (2013), and Sepat and Rai (2013).

Nutrient uptake

Data on nitrogen, phosphorus and potassium uptake by maize as affected by RP composted organic material are given in table 2. Total N, P and K uptake 91.86, 20.18 and 99.43 kg ha⁻¹ with 159.56%, 177.58% and 141.51% increase, respectively over control was found in treatment where combination of 25% RDP through PRC + Vermiculture + PSB + 75% RDP through DAP (T6) which was statistically at par with 25% RDP through PRC + PSB + 75% RDP through DAP (T4), 25% RDP through PRC + Vermiculture + 75% RDP through DAP (T5) and 100% RDP through PRC + Vermiculture + PSB (T10) in case of N and P uptake by maize. The minimum plant N uptake of 33.39 kg ha⁻¹ was noted in control.

Awaad *et al.*, (2009) reported that N uptake in plant increased by the combined application of phosphatic source such as RP composted fertilizers. Data regarding plant P uptake by maize revealed 177.58% significantly

increase over control plot with 20.18 kg ha⁻¹ P uptake, where 25% RDP through PRC + Vermiculture + PSB + 75% RDP through DAP (T6) was used.

Table.1 Effect of phosphorus rich compost on yield of maize

Treatments		Grain	Stover	Biological
		Yield (kg ha ⁻¹)	Yield (kg ha ⁻¹)	Yield (kg ha ⁻¹)
T ₀	Control	1895	3143	5038
T ₁	100% RDP through DAP	3510	5137	8647
T ₂	100% RDP through SSP	3440	5070	8510
T ₃	25% RDP through PRC + 75% RDP through DAP	3303	4953	8256
T ₄	25% RDP through PRC + PSB + 75% RDP through DAP	3708	5483	9191
T ₅	25% RDP through PRC + Vermiculture + 75% RDP through DAP	3590	5368	8958
T ₆	25% RDP through PRC + Vermiculture + PSB + 75% RDP through DAP	3933	5738	9671
T ₇	100% RDP through PRC	3320	4893	8213
T ₈	100% RDP through PRC + PSB	3490	5133	8623
T ₉	100% RDP through PRC + Vermiculture	3400	4965	8365
T ₁₀	100% RDP through PRC + Vermiculture + PSB	3605	5338	8943
SEm±		175.71	260.61	287
CD (5%)		518.33	768.81	846

Table.2 Effect of phosphorus rich compost on Nutrient uptake

Treatments	Nutrient uptake (kg ha ⁻¹)		
	N	P	K
T ₀ : Control	35.39	7.27	41.17
T ₁ : 100% RDP through DAP	77.73	17.10	86.01
T ₂ : 100% RDP through SSP	75.67	16.69	84.17
T ₃ : 25% RDP through PRC + 75% RDP through DAP	71.85	15.76	81.12
T ₄ : 25% RDP through PRC + PSB + 75% RDP through DAP	85.42	18.53	93.63
T ₅ : 25% RDP through PRC + Vermiculture + 75% RDP through DAP	81.97	17.62	90.76
T ₆ : 25% RDP through PRC + Vermiculture + PSB + 75% RDP through DAP	91.86	20.18	99.43
T ₇ : 100% RDP through PRC	71.58	15.26	78.13
T ₈ : 100% RDP through PRC + PSB	77.11	16.84	83.02
T ₉ : 100% RDP through PRC + Vermiculture	73.75	16.13	79.93
T ₁₀ :100% RDP through PRC + Vermiculture + PSB	81.59	17.62	86.38
SEm±	4.54	1.01	3.21
CD (5%)	13.40	2.99	9.48

Table.3 Effect of phosphorus rich compost on available nutrients status of soil after harvest of maize

Treatment	Available N (kg ha ⁻¹)	Available P ₂ O ₅ (kg ha ⁻¹)	Available K ₂ O (kg ha ⁻¹)
T ₀ : Control	252.38	19.50	390.98
T ₁ : 100% RDP through DAP	263.17	23.67	424.38
T ₂ : 100% RDP through SSP	262.08	22.52	420.41
T ₃ : 25% RDP through PRC + 75% RDP through DAP	265.17	23.10	421.36
T ₄ : 25% RDP through PRC + PSB + 75% RDP through DAP	270.46	24.71	429.35
T ₅ : 25% RDP through PRC + Vermiculture + 75% RDP through DAP	267.08	24.12	425.21
T ₆ : 25% RDP through PRC + Vermiculture + PSB + 75% RDP through DAP	274.58	24.89	431.36
T ₇ : 100% RDP through PRC	268.42	23.34	427.52
T ₈ : 100% RDP through PRC + PSB	278.92	25.66	447.50
T ₉ : 100% RDP through PRC + Vermiculture	274.58	24.61	442.35
T ₁₀ :100% RDP through PRC + Vermiculture + PSB	290.04	26.12	455.58
SEm±	6.44	0.58	10.55
CD (5%)	19.00	1.70	31.12

This increased P uptake was followed by the treatments where 25% RDP through PRC + PSB + 75% RDP through DAP was applied. Minimum plant P uptake of 7.27 kg ha⁻¹ was recorded in control where no fertilizer was applied. It is well documented that P uptake by crop largely depends on dry matter accumulation and concentration of P in plant parts at cellular level and increased availability of P in the soil due to solubilization of added phosphorus by P solubilizers through production of organic acids. These results are similar to findings of Ali *et al.*, (2014) who reported that nutrients accumulation in plant were enhanced by the use of RP composted and inorganic materials. Erdal *et al.*, (2000) also reported that accumulation increased in plant N and P when dung as organic material and chemical fertilizer was applied.

Available nutrients after harvest of maize crop

The available N, P and K after harvested as influenced via residual effects of RP composted organic material are show in table 3. Data on soil available nitrogen content revealed that maximum (290.04 kg ha⁻¹) was received within the treatment of 100% RDP through PRC+ Vermiculture + PSB (T10) followed by the 100% RDP through PRC+ PSB (T8). The lowest nitrogen content in soil after maize crop harvest as 252.38 kg ha⁻¹ was recorded by treatment of control which was not fertilized (Table 3). Esilaba *et al.*, (2000) investigated that the organic manure and NPK fertilizers improve the concentration of soil nitrogen. The highest available P content in soil was recorded as 26.12 kg ha⁻¹ by treatment 100% RDP through PRC + Vermiculture + PSB (T10) followed by the 100% RDP through PRC+ PSB (T8). Minimum P content 19.50 kg ha⁻¹ was observed in the treatment of control without fertilized. Laskar *et al.*, (1990) reported that rock phosphate alone and in combination with

organic manure significantly enhance the content of organic P in soil. Wang *et al.*, (1993) opined that in calcareous soil, addition of organic manures increased P availability and microbial activity while decreasing level of P-fixation. Available potassium ranged from 390.98 to 455.58 kg ha⁻¹ in soil after harvest of maize crop. The maximum available K was observed in the treatment 100% RDP through PRC + Vermiculture + PSB (T10). The results indicated that improvements in available potassium content came from K released from organic input of applied compost or from increased availability of native potassium following the addition of compost. Most of the simple cationic forms of nutrients present in the soil at any time are in exchangeable forms associated with clay minerals and the organic fractions of the soil, of which these can be rapidly exchanged with cations in the soil solution. These results are collaborated with findings of Ali *et al.*, (2014) who reported that composted rock phosphate with organic material significantly increased the content of nutrients in soil.

The study revealed that composted of low-grade rock phosphate along with organic material and phosphate solubilizing bacteria and earthworms helped to enhance the mobilization of unavailable P in rock phosphate to available forms of P. It has potential to improve crop production and nutrient uptake by crop. Post-harvest soil N, P and K concentrations were increased by the addition of composted rock phosphate with organic material. Thus, composted rock phosphate could be alternatives and viable technology to utilize low- grade rock phosphate and could be used successfully as cheaper and indigenous source of P fertilizer.

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