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Relative efficiency of Jhabua rock phosphate with super phosphate, farmyard manure and phosphobacteria on available nutrients and heavy metals content in soil under rice

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Abstract : The investigation was carried out to study the effect of Jhabua rock phosphate (JRP) in combination with single superphosphate (SSP), farmyard manure (FYM) and phosphobacteria (PB) on available nitrogen, phosphorus and potassium and heavy metals content in soil at post harvest stage of rice crop (CO 43) in clayloam soil. Combined application of JRP and SSP in 1:1 ratio along with FYM (12.5 t ha^{-1}) and PB significantly increased the soil available nitrogen, phosphorus and potassium over application of 100 per cent JRP alone but comparable with application of 100 per cent SSP alone. The heavy metals content (Cr, Cd and Pb) in post harvest soil was recorded in traces and it was far below the tolerance limit.

Key words : Jhabua rock phosphate, Available nutrients, Heavy metals.

Introduction

Owing to the increase in the price of phosphatic fertilizers coupled with low recovery (10-30%) of phosphorus from applied fertilizers due to fixation characteristics, the developing tropical countries are attempting to utilize their indigenous reactive ground phosphate rock as a cheap alternative source for more expensive chemically processed water soluble phosphatic fertilizers. However, direct application of rock phosphate to non-acid soil is not considered as a suitable practice. Under this condition, the P use efficiency of rockphosphate (RP) can be increased by the combined application of water soluble P fertilizer, organic manures and biofertilizers. Increased concern about the entry of various heavy metals into human food chain is prevailing in recent years. Phosphate rock contained various metals as minor constituents in the ores such as As, Cd, Cr, Pb, Hg, Ni and Vd (Mortvedt, 1996). The present study was undertaken to investigate the effect of Jhabua Rock Phosphate (JRP) in combination with single superphosphate (SSP), farmyard manure (FYM) and phosphobacteria (PB) on soil available nutrient status and heavy metal content in post harvest soil of rice crop.

Materials and Methods

A field experiment was conducted in Vertic Ustochrept of wetland, Tamil Nadu Agricultural University, Coimbatore with rice var. CO 43 as test crop during late samba season of 2000-2001. The soil of the experimental site was clay loam in textue with pH-8.4, EC 0.4 dSm^{-1}, OC-0.82 per cent and CEC-29.8 c mol (p+) kg^{-1}, the available N, P and K content were 226.8, 16.0 and 368.0 kg ha^{-1} respectively. The experiment was laid out in a randomized block design with 14 treatments and three replications.

The treatments consist of T_1-Control; T_2-SSP recommended dose as per crop production guide (CPG) (50 kg P_2O_5 ha^{-1}); T_3-JRP (50 kg P_2O_5 ha^{-1}); T_4 - T_3 + Phosphobacteria (PB) (seed treatment (600 g ha^{-1} of seeds), seedling treatment (2 kg in 12 lit. of water and soil application (2 kg ha^{-1}); T_5 - T_3 + Farm yard manure (FYM) (12.5 t ha^{-1}); T_6 - T_5 + PB (seed treatment, seedling treatment and soil application as in T_4; T_7-75% JRP + 25% SSP; T_8-T_7 + PB (seed treatment, seedling treatment and soil application as in T_4; T_9-T_7 + FYM (12.5 t ha^{-1}); T_{10}-T_9 + PB (seed treatment, seedling able 1. Effect of treatments on soil available nitrogen and phosphorus at different stages of crop growth

Treatments	$KMnO_4$ - N (kg ha^{-1})					Olsen's - P (kg ha^{-1})				
	*T	PI	F	H	Mean	T	PI	F	H	Mean
$_1$ - Control	273.0	263.2	237.3	202.7	244.05	10.5	9.8	8.1	5.3	8.41
$_2$ - 100% SSP	333.2	313.8	282.4	242.4	292.95	28.5	24.3	20.7	10.3	20.95
$_3$ - 100% JRP	281.4	268.3	242.3	209.8	250.46	13.0	11.6	9.8	7.1	10.37
$_4$ - T_3 + PB	301.0	287.0	262.3	222.6	268.23	16.6	13.1	11.6	8.1	12.34
$_5$ - T_3 + FYM	296.8	275.8	255.8	218.5	261.73	15.6	13.3	10.6	8.3	11.97
$_6$ - T_5 + FYM	305.2	289.0	262.8	225.3	270.58	18.9	16.3	13.0	8.9	14.32
$_7$ - 75% JRP + 25% SSP	313.6	293.6	268.3	228.6	276.03	19.5	16.8	13.3	9.3	14.73
$_8$ - T_7 + PB	317.8	295.8	271.2	231.8	279.15	20.6	17.8	14.7	9.5	15.64
$_9$ - T_7 + FYM	309.4	289.3	275.4	233.7	276.95	22.4	20.1	16.1	9.9	17.14
$_{10}$ - T_9 + PB	324.8	317.6	276.8	234.8	288.50	24.8	21.3	16.7	9.9	18.19
$_{11}$ - 50% JRP + 50% SSP	316.4	301.2	268.7	231.7	279.50	24.3	21.7	17.7	9.9	18.41
$_{12}$ - T_{11} + PB	323.4	316.4	278.3	236.7	288.70	26.8	22.3	18.2	9.8	19.28
$_{13}$ - T_{11} + FYM	326.2	318.6	278.8	235.6	289.80	25.7	21.8	19.7	10.0	19.29
$_{14}$ - T_{13} + PB	350.0	323.4	285.4	245.6	301.10	30.0	26.8	23.4	11.8	23.0
ean	312.3	296.6	267.6	228.6	276.27	21.2	18.3	15.3	9.2	16.0
	T	S	T x S			T	S	T x S		
D (P=0.05)	5.25	2.81	10.49			0.33	0.17	0.65		

*Note: T - Tillering stage; PI - Panicle initiation stage; F - Flowering stage; H - Harvest stage)

able 2. Effect of treatments on soil available potassium at different stages of crop growth and heavy metal content

Treatments	NH_4OAC - K (kg ha^{-1})					Heavy metals (mg kg^{-1})		
	*T	PI	F	H	Mean	Cr	Cd	Pb
T_1 - Control	446.9	318.7	298.7	180.6	311.23	0.70	0.08	2.54
T_2 - 100% SSP	489.8	428.3	380.4	256.7	388.79	0.74	0.10	2.68
T_3 - 100% JRP	461.3	336.8	306.2	196.3	325.15	2.42	0.22	6.23
T_4 - T_3 + PB	471.3	340.9	323.7	216.8	338.17	2.20	0.18	3.54
T_5 - T_3 + FYM	461.5	338.7	314.2	213.7	332.03	2.32	0.20	4.46
T_6 - T_5 + FYM	467.7	352.2	330.1	228.6	344.66	1.92	0.14	4.04
T_7 - 75% JRP + 25% SSP	469.3	363.8	338.8	223.5	348.85	1.98	0.16	3.54
T_8 - T_7 + PB	470.8	373.7	342.1	245.6	358.04	1.88	0.14	3.50
T_9 - T_7 + FYM	472.0	378.6	348.6	236.3	358.89	1.56	0.16	3.52
T_{10} - T_9 + PB	471.3	382.1	353.8	250.8	372.82	1.48	0.10	3.20
T_{11} - 50% JRP + 50% SSP	473.7	412.6	365.7	252.8	376.21	1.32	0.12	2.86
T_{12} - T_{11} + PB	475.5	400.1	358.3	251.6	371.38	1.32	0.1	2.72
T_{13} - T_{11} + FYM	477.3	414.3	370.8	253.0	378.86	1.30	0.14	2.78
T_{14} - T_{13} + PB	498.8	446.9	392.2	275.8	403.41	1.24	0.10	2.70
Mean	471.9	377.7	344.5	236.8	357.75	1.59	0.14	3.45
	T	S	T x S			T	S	T x S
CD (P=0.05)	9.06	4.84	18.11			0.056	0.006	0.146

*Note: T - Tillering stage; PI - Panicle initiation stage; F - Flowering stage; H - Harvest stage) treatment and soil application as in T_4; T_{11}-50% JRP + 50% SSP; T_{12}-T_{11} + PB (seed treatment, seedling treatment and soil application as in T_4; T_{13}-T_{11} + FYM (12.5 t ha^{-1}); T_{14}-T_{13} + PB (seed treatment, seedling treatment and soil application as in T_4. Phosphobacteria seed treatment was given by soaking the seeds (600 g ha^{-1} seeds) in water for overnight. The excess water was poured over the nursery area itself. Rice seedling roots were dipped and kept in PB slurry (2 kg PB dissolved in 12 lit. of water) for 30 minutes. Then, the seedlings treated with and without PB were transplanted in their respective plots with a spacing of 20 cm x 10 cm. PB @ 2 kg ha^{-1} was applied after mixing with sand to those plots as per the treatment. The FYM application was done at the beginning @ 12.5 t ha^{-1} for those plots as per the treatment schedule and incorporated in the soil.

Representative soil samples were collected during tillering, panicle initiation, flowering and harvest stages of crop growth and analyzed for available macro nutrient status. Post harvest soil samples were collected and analyzed for DTPA extractable heavy metals.

Results and Discussion

(i) Available nitrogen status

The trend of $KMnO_4$-N gradually decreased with the advancement of crop growth stages. This might be ascribed to the reduction of NH_4-N and absence of NO_3-N under submergence condition coupled with continuous uptake of N by rice till heading (Table 1). The mean $KMnO_4$-N ranged from 244.05 to 301.1 kg ha^{-1}. From the results of pooled analysis, it was found that the treatment T_{14} recorded the highest $KMnO_4$-N (301.1 kg ha^{-1}) followed by T_2 (292.95 kg ha^{-1}), T_{13} (289.8 kg ha^{-1}), T_{12} (288.7 kg ha^{-1}) and T_{10} (288.5 kg ha^{-1}), which were on par with each other. The control (T_1) recorded the lowest available N content (244.05 kg ha^{-1}). This is inline with the findings of Tisdale *et al.* (1997). The highest available N in T_{14} treatment might be attributed to the increased nitrogen fixation in the soil by the *Pseudomonas striata* zpresent in phosphobacteria together with the influence of trace quantities of Fe, Mo, Mg, Cu etc. which would have been released from rock phosphate.

(ii) Available phosphorus status

From the pooled analysis, it was observed that the treatments had significant effect on the soil Olsen's-P at all the stages of crop growth. The mean Olsen's-P content at tillering stage was 21.2 kg ha^{-1}, which was decreased to 18.3 kg ha^{-1} at panicle initiation, 15.3 kg ha^{-1} at flowering and 9.2 kg ha^{-1} at harvest stage (Table 1). The decreased P availability with advancement of crop growth might be due to continuous uptake of P by rice upto heading (Dhanasekaran, 2000). The mean value of Olsen's-P varied from 8.41 to 23.0 kg ha^{-1} (Table 1). Among the treatmetns, the treatment T_4 registered significanthy the highest (23.0 kg ha^{-1}) Olsen's-P followed by T_2 (20.95 kg ha^{-1}). The reason might be due to the fact that 50 per cent of P_2O_5 was readily water soluble P and in addition, the additive components of FYM and PB might have solubilized the rock phosphate. This is in accordance with findings of Malewar *et al.* (1995) and Dhanasekaran (2000). Further, the organics had the capacity to form complexes with inorganic components and these complexes were reported to be soluble (Bhujbal, 1989). Application of FYM increased the soil available P due to production of organic acids during decomposition which solubilized the insoluble form of P to soluble form. Similar findings were reported by Paulraj and Velayudham (1995).

(iii) Available potassium status

When comparing different stages of crop growth, the NH_4OAC-K status was significantly decreased from tillering (471.9 kg ha^{-1}) to harvest stage (236.8 kg ha^{-1}) (Table 2). It is obvious because of continuous uptake of K by rice till heading and also due to the retention of K in clay complexes. Addition of different forms of phosphatic fertilizers could not influence e available K content of soil significantly. mong the treatments, the treatment T_{14} recorded he highest NH_4OAC-K (403.41 kg ha^{-1}) followed by T_2 (388.79 kg ha^{-1}) (Table 2). The treatments T_{13} (378.86 kg ha^{-1}), T_{11} (376.21 kg ha^{-1}), T_{10} (372.82 kg ha^{-1}) and T_{12} (371.38 kg ha^{-1}) were comparable with each other. The ontrol (T_1) recorded the lowest NH_4OAC-K (311.23 kg ha^{-1}) when compared to all other eatments. It is quite obvious that P and K ad no interaction either with soil or in plant. The marginally more available K in the plots that received 50 per cent JRP+50 per cent SP with FYM and PB could be attributed the release of organic and mineral acids hich might have solubilized K from primary inerals of soil. Similar findings were reported Kanagabushani (1980).

, Heavy metal content

hromium, lead and cadmium

The data (Table 2) of Cr content revealed nat, among the treatments T_3 registered the ighest Cr (2.42 mg kg^{-1}), which is far below he tolerance limit of 150 mg kg^{-1} (Rovira *et al.* 1996). The Pb and Cd contents in the ost harvest soil ranged from 2.54 to 6.23 mg kg^{-1} and 0.08 to 0.22 mg kg^{-1} respectively. Among the treatments, T_3 recorded the highest Pb and Cd content (6.23 and 0.22 mg kg^{-1} espectively) (Table 2), which are also below he tolerance limit of 300 mg kg^{-1} and 3.0 mg kg^{-1} of soil (Rovira *et al.* 1996) respectively. Similar results were reported by Dhanasekaran 2000).

It could be concluded that the indigenously available JRP can be effectively and profitably utilized as a P source for improving soil available nutrient status in rice soil and there is no need to be panic over the heavy metal pollution owing to JRP application for the present.

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