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Efficiency of Rock Phosphate Sources on Ginger and Turmeric in an Ustic Humitropept

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Abstract: Field experiment was conducted for three years (1995-98) to study the efficacy of different sources of rock phosphates in an Ustic Humitropept on nutrient availability, yield, agronomic efficiency and quality of ginger and turmeric. Bray's available P increased with the application of rock phosphates mixed with FYM and among the sources Raj phos was superior. Rhizome P concentration was higher when superphosphate and FYM incubated rock phosphates were applied. Significantly higher dry yield in turmeric was registered in Gafsa phos followed by Raj phos when incubated with FYM. Similar trend was observed in ginger with Raj phos and Gafsa phos application with FYM, and it was significantly higher than other sources of P applied. Not much variation was observed in oleoresin and curcumin contents of ginger and turmeric due to application of different sources of P. Among all the sources, apparent phosphate recovery, agronomic efficiency of the applied P and per cent yield response were higher for Gafsa phos followed by Raj phos incubated with FYM in both ginger and turmeric. (*Key words: Agronomic use efficiency, phosphate recovery, rock phosphate, ginger and turmeric*)

India is world's largest producer, consumer and exporter of spices. During 1996-97, India cultivated 71 and 134 thousand hectares and produced 233 and 543 thousand tonnes of ginger and turmeric respectively. Out of this 29,737 tonnes of ginger valued at 5924.41 lakhs rupees and 23,091 tonnes of turmeric valued at 5,844.61 lakhs rupees were exported. Hence, ginger and turmeric play major role in spices export and India's economy. About two-third of ginger and turmeric in India is grown on acidic soils that are deficient in P. Up to 80 per cent of added soluble phosphate gets fixed within 15 days of its application in acid soils. Under such conditions direct application of rock phosphate may be agronomically and economically more attractive than the use of expensive water soluble P fertilizers (Hammond *et al.* 1986). India has rock phosphate deposits of 145 Mt. Direct application of phosphate rock is favourable especially for plantation crops (Pushparaj *et al.* 1976; Sadanandan & Hamza 1995). Rock phosphates which contain phosphorus in the insoluble form, are generally preferred in acid soils where they become gradually soluble and available to plants without being fixed in large quantities (Punnoose *et al.* 1995). Hence an experiment was conducted with the objective of increasing the use efficiency of rock phosphate and to assess the agronomic efficacy of rock phosphate sources for augmenting production and quality of ginger and turmeric.

Materials and Methods

A field experiment was laid out at Indian Institute of Spices Research experimental farm Peruvannamuzhi (Ustic Humitropept) during three consecutive years (1995-98) using ginger cv. Maran and turmeric cv Alleppey as test crops. The soil was clayey with pH 5.3 (1:2, soil:water), CEC 7.5 cmol(p$^+$)kg^{-1}, 31g kg^{-1} organic carbon, 4.6 ppm Bray's P, 161, 281 and 105 ppm exchangeable K, Ca and Mg, respectively. The DTPA extractable Fe, Zn and Cu were 28, 0.56 and 1.0 ppm, respectively. There were 9 treatments *viz.*, check, recommended P (50 kg) to ginger and turmeric (Sadanandan & Hamza 1996, 1998) as single superphosphate (SSP), P as combination of SSP (1/3 recommended) with rock phosphate (2/3 recommended) either as Mussorie phos (MRP), Raj phos (RP) or Gafsa phos (GP) and combination of FYM with 1/2 recommended P either as superphosphate, Mussorie phos, Raj phos and Gafsa phos. In FYM combinations, the P sources were incubated with FYM for one week. Ginger and turmeric were planted in 3x1 m^2 beds having 40 plants. Each bed was taken as one treatment. There were three replications. Nitrogen and K were applied in common @ 75 and 50 kg ha^{-1} for ginger and 60 and 120 kg ha^{-1} for turmeric, respectively. Full dose of P and K was applied as basal and N was applied in two splits, one at 45 days after planting (DAP) and another at 90 DAP. Soil and leaf samples were taken during critical stage of crop growth (120 DAP) and analyzed for various nutrients as per standard procedures (Jackson 1967 ; Hesse 1971). In ginger fifth pair of leaf from top to bottom (Johnson 1978) and turmeric third leaf from top to bottom (Sadanandan and Hamza 1996) were taken as index leaves for nutrients analysis. Rhizome samples were taken during harvest (approximately 8-9 months after planting) and analysed for P uptake. Curcumin content of turmeric and oleoresin content of ginger were also analyzed as per standard procedures (ASTA 1968). Number of tillers produced and yield were also recorded. Agronomic efficiency (AE) and apparent phosphate recovery (APR) (Subba Rao *et al.* 1998) were calculated. The pooled data of three years are presented and discussed below.

Results and Discussion

Effect of Different Sources on Soil Availability of Nutrients

There was no significant change in soil pH due to different sources and combination of rock phosphate either with FYM or SSP (Table 1). Available nitrogen significantly increased in FYM treated plot. Application of P, in general, increased Bray's available P in all treatments compared to check. The highest Bray's P was recorded for FYM + Raj phos treatment followed by Gafsa phos and Mussorie phos in combination with FYM. Availability of P was more when rock phosphate sources were used as compared to SSP. Inherent low soil pH favoured the dissolution of rock phosphates and increased its availability. The complimentary effect of FYM in improving the soil available P

Table 1. Effect of sources and combination of phosphates with FYM on soil nutrient availability in ginger and turmeric

Treatment	pH	Available N	Bray-P	Exchangeable K	Exchangeable Ca	Exchangeable Mg	DTPA Zn
		(mg kg^{-1})					
Check	5.3	104	14	98	305	110	0.57
SSP	5.3	126	23	137	384	104	0.62
MRP+SSP	5.4	127	25	144	367	104	0.68
RP+SSP	5.4	124	21	146	317	104	0.59
GP+SSP	5.4	126	18	138	345	103	0.59
FYM+ MRP	5.3	126	27	167	374	123	0.70
FYM+RP	5.5	150	29	181	381	125	0.58
FYM+GP	5.4	136	26	161	376	128	0.68
FYM+SSP	5.5	136	22	159	381	120	0.54
CD (P=0.05)	0.3	5.2	2.2	21	41	14	0.10

when applied with rock phosphate could possibly be due to beneficial role of manure in solubilizing P from rock phosphate sources and extending the available pool by reducing P fixation (Sharpley *et al.* 1984). Exchangeable K and Mg and available Zn contents were maximum in P applied plots either as rock or superphosphate with FYM.

Effect on Growth, P Uptake, Yield and Quality of Ginger

Maximum tiller number (476 nos. in 3 m^2) was recorded in Gafsa phos applied in combination with FYM followed by Raj phos applied in combination with superphosphate. Leaf P concentration was maximum in 2/3 MRP + 1/3 SSP treatment and was on par with FYM + 1/2 recommended P as RP or GP (Table 2). With regard to rhizome P, full P as SSP and FYM + 1/2 recommended P as SSP were superior and was on par to FYM + P applied as MRP, RP or GP. Phosphorus uptake was significantly higher in FYM + 1/2 recommended P as GP and RP treatments followed by FYM + MRP or SSP treatments. With regard to yield and oleoresin also, FYM + 1/2 recommended P as GP was superior (4.37 t ha^{-1} and 179 kg ha^{-1}, respectively) and was on par with FYM + 1/2 P as RP.

Effect on Growth, P Uptake, Yield and Quality of Turmeric

Maximum number of tillers was recorded for the treatment FYM + 1/2 recommended P as MRP and was on par with RP and GP and 2/3 P as SSP (Table 3). Leaf P was higher in FYM + 1/2 recommended P as GP and was on par with MRP or SSP applied with FYM. Rhizome P was maximum in FYM + 1/2 recommended as RP or SSP and was par with application of full dose P as SSP. Phosphorus uptake was maximum in FYM + 1/2 recommended P as GP and was on par with FYM + RP. Curcumin production was maximum in FYM+1/2 as GP (311 kg ha-1) which was on par with FYM + RP or MRP treatment. Significantly highest yield was recorded by the treatment FYM + 1/2 recommended P as GP followed by RP and MRP with FYM, which were on par.

Table 2. Effect of sources and combination of phosphates with FYM on growth, P uptake, yield and quality of ginger

Treatment	Tiller no in 3 m^2	Leaf P (%)	Rhizome P (%)	P uptake (kg ha^{-1})	Oleoresin (kg ha^{-1})	Yield (t ha^{-1})
Check	309	0.14	0.20	5.9	120	2.92
SSP	430	0.16	0.30	10.7^b	147^b	3.67
MRP+SSP	425	0.18	0.27	10.6^b	159^a	3.89
RP+SSP	440	0.15	0.27	9.7	142^b	3.55
GP+SSP	429	0.15	0.27	9.8	151^b	3.59
FYM+ MRP	422	0.16	0.29	10.8^b	143^b	3.66
FYM+RP	402	0.17	0.29	12.7^a	168^a	4.21
FYM+GP	476	0.17	0.29	12.7^a	179^a	4.37
FYM+SSP	398	0.18	0.30	11.1^a	164^a	3.92
CD (P=0.05)	43	0.01	0.01	0.60	20	0.21

recommended P as GP with FYM in both ginger (49.7%) and turmeric (70%) followed by FYM + RP application. Whereas the application of SSP alone as a P source responded only by 25.6 and 36 per cent increase in yield of ginger and turmeric, respectively (Table 4). Higher AE and APR values were recorded for P sources incubated with FYM and applied, with the highest in 1/2 recommended P as GP or as RP together with FYM, in both ginger and turmeric. There was 24.9 and 17.6 per cent increased efficiency of applied P as GP and RP along with FYM in turmeric over full dose SSP application alone (Table 4). Similarly, in ginger AE increased by 19.2 and 14.7 per cent in FYM + GP and RP applications over SSP alone. Interestingly FYM + MRP application has yielded in higher AE (16.9 per cent higher than SSP. treatment) in turmeric whereas in ginger no such response was recorded. Increased relative agronomic

Table 3. Effect of sources and combination of phosphates with FYM on growth, P uptake, yield and quality of turmeric

Treatment	Tiller no in 3 m^2	Leaf P (%)	Rhizome P (%)	P uptake (kg ha^{-1})	Curcumin (kg ha^{-1})	Yield (t ha^{-1})
Check	125	0.13	0.18	7.0	154	3.66
SSP	149	0.16	0.29	13.6	254^b	4.98
MRP+SSP	142	0.17	0.27	13.5	227	5.04
RP+SSP	160	0.18	0.27	15.7^b	299^a	5.54
GP+SSP	142	0.16	0.27	13.4	256^b	5.11
FYM+ MRP	163	0.18	0.27	15.2^b	309^a	5.83^b
FYM+RP	159	0.17	0.29	16.5^a	287^a	5.86^b
FYM+GP	154	0.19	0.28	16.5^a	311^a	6.22^a
FYM+SSP	144	0.18	0.29	15.8^b	260^b	5.54
CD (P=0.05)	13	0.02	0.01	0.51	26	0.17

Agronomic Efficiency, Yield Response and Recovery of Phosphate in Ginger and Turmeric

A higher yield response to the applied fertilizers was noticed in the application of 1/2

Table 4. Agronomic efficiency, yield response and phosphate recovery in ginger and turmeric

Treatment	Yield response (%) Turmeric	Yield response (%) Ginger	AE Turmeric	AE Ginger	APR Turmeric	APR Ginger
Check	–	–	73.2	58.4	–	–
SSP	36.1	25.6	99.7(-)*	73.3(-)*	13.1	9.6
MRP+SSP	37.6	33.1	100.8(1.1)	77.7(6.0)	13.0	9.4
RP+SSP	51.2	21.7	110.7(11.0)	71.1(-3.0)	17.4	7.7
GP+SSP	39.5	22.8	102.2(2.5)	71.7(-2.2)	12.7	7.9
FYM+ MRP	59.1	25.3	116.5(16.9)	73.2(-0.1)	16.4	9.8
FYM+RP	60.0	44.1	117.2(17.6)	84.1(14.7)	18.9	12.9
FYM+GP	69.9	49.7	124.5(24.9)	87.4(19.2)	18.9	13.6
+SSP	51.2	34.3	110.8(11.1)	78.4(7.0)	17.5	12.1

* Figures in parentheses show the percentage increase in AE over SSP as base

effectiveness of phosphate rocks to an average of 107 and 79 per cent in different seasons over triple superphosphate in corn grown in a P-deficient acid soil was reported by Mutuo *et al*. (1999). The positive role of FYM in raising the available P status and its persistence over time in turn resulted in higher AE and APR of applied rock phosphate sources. Similar rise in available P and APR was reported by Subba Rao *et al*. (1998).

Rock phosphate either as Raj phos or Gafsa phos can be applied to ginger and turmeric in acid soils. Among the sources, Gafsa phos or Raj phos @ 25 kg P_2O_5 ha^{-1} were superior with regard to uptake, yield and quality for ginger and turmeric. The agronomic efficiency can be increased by incubating with FYM (10 t ha^{-1}) and thereby the dose of P can be reduced to half *viz*. 25 kg ha^{-1}.

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