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EFFICIENCY OF PRIMED ROCK PHOSPHATE FOR GRAIN PRODUCTION IN RICE*

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In India rock phosphates have been applied to acid and other soils in different agroclimatic regions during the last two or three decades with varying efficiency. Due to low phosphorus content, the phosphate deposits in India, estimated to be 130 million tonnes, are unsuitable for commercial exploitation in the manufacture of fertilizers. Therefore it is highly essential to device ways and means to improve phosphate availability from this indigenous source and make it as efficient as water soluble phosphatic fertilizers for direct application to field crops. The study was carried out with this objective.

Materials and Methods

Potted plant experiments with the rice variety (Triveni) were undertaken in five different soils representing the major rice growing tracts of Kerala, viz., karappadom, laterite, kayal, coastal sandy and kole soils with the following treatments.

- T_1 Control (No P)
- T_2 Superphosphate at flooding @ 45 kg P_2O_5/ha
- T_3 Rock phosphate ,, ,,
- T_4 Rock phosphate one week before flooding in moist aerobic soil @ 45 kg P_2O_5/ha
- T_5 Rock phosphate two weeks ,, ,, ,,
- T_6 Rock phosphate at flooding @ 67.5 kg P_2O_5/ha
- T_7 Rock phosphate one week before flooding @ 67.5 kg P_2O_5/ha
- T_8 Rock phosphate two weeks ,, ,, ,,
- T_9 67.5 kg P_2O_5/ha half as superphosphate and the other half as rock phosphate at flooding.

Rock phosphate used was Mussorie phosphate containing 20 per cent total P_2O_5. Soil fractionation study was conducted in treatments 1, 2, 4 and 5, following the method of Chang and Jackson (1957) and modified by Peterson and Corey (1966).

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Results and Discussion

Soil samples were analysed for their physical and chemical properties. Organic carbon content was found to range from 0.48 per cent in coastal sandy soil to 3.03 per cent in kayal soil, pH of the soiis under study ranged from 5.5 to 5.7. Total phosphorus content of soils showed wide variation from 111 ppm in coastal sandy soil to 1066 ppm in kole soil. But the lowest available phosphorus content of 1.81 ppm was recorded by kole soil and the highest of 13.2 ppm by coastal sandy soil.

Results of observations on plant growth characters, yield and uptake of nutrients indicated that phosphorus application is highly essential in all soils for good crop growth and grain yield. Statistical analysis of the grain and straw yieid and phosphorus uptake data revealed that application of rock phosphate in moisture aerobic soil, one or two weeks before flooding at the rate of 45 kg P_2O_5 per hectare resulted in maximum realization of applied phosphorus for grain production at that rate. At 67.5 kg P_2O_5/ha ($1\frac{1}{2}$ times of the recommended dose) T_9 with half the rate as superphosphate and other half as rock phosphate gave the highest grain yield and phosphorus uptake in most of the soils under study (Table 1 and 2).

When Mussorie phosphate was primed in most soil before flooding its efficiency approached or even exceeded that of superphosphate in grain yield and phosphorus uptake by rice in most of the soils under study. Shinde (1974) obtained similar results with acid rice soils of Orissa. Increased yield obtained with rock phosphate applied at flooding for kayal soil can be attributed to its high organic matter content.

The enhanced utilization of primed rock phosphate is due to conversion of apatite form of phosphorus to iron phosphate under moist aerobic condition and subsequent release of phosphorus to the soil solution as a result of reductive condition brougnt about by water-logging. Fractionation studies clearly indicated that applied phosphates in general increased iron phosphate in soils. Iron phosphate content was comparatively lower in treatment where superphosphate was applied at flooding.

Since rock phosphate contains mostly tricalcic form of phosphorus, when applied under most aerobic conditions in acid soiis, H^+ ions of the acid soil system might have brought about conversion of PO_4^{3-} to $H_2PO_4^-$. Orhophosphate ion is immediately converted to Fe-P and Al-P. Shinde (1974) and Mandal and Khan (1975) observed that transformation to Fe-P faction was higher in treatments when rock phosphate was primed in moist soil before flooding. The decrease in Al-P fraction observed in the present study by prolonging the incubation period of rock phosphate in moist aerobic soil can be attributed to the change from Al-P to Fe-P.

A soil system containing Fe-P and Al-P when submerged is known to release P into the soil solution by hydrolytic dissolution of Al-P, reductive solubilization of Fe-P, reduction in fixation and increased diffusibility of ions (Patrick and Mahapatra, 1968).

Maximum requirement of P by rice plant was observed during the active tillering stage and P absorbed at that stage is efficiently utilized for grain production (Patnaik and Gaikward, 1969). The increased solubility of P from soils containing primed rock phosphate at flooding falls within the active tillering stage of the transplanted crop. Moreover, Fe-P contains a form of phosphorus that is easily absorbed by the rice plant and which necessitates least energy for absorption by the rice plant when compared with other forms. It is therefore valid to assume that substantive conversion of rock phosphate applied in moist aerobic soil to Fe-P resulted in maximum utilization of P absorbed by rice plant towards grain production. This will also explain the difference in yield obtained by application of rock phosphate at flooding and priming in moist aerobic soil before flooding though the former treatment resulted in comparatively higher total P uptake. At 45 kg P_2O_5/ha (the recommended dose for medium duration high yielding varieties of rice as per the package of

Table 1
Total grain yield of rice (g/pot)

Treatments	S_1	S_2	S_3	S_4	S_5
T_1	7.02	1.60	5.90	4.50	9.80
T_2	4.49	13.00	10.10	4.70	15.50
T,	8.33	17.10	14.10	1.40	18.20
T_4	8.81	19.64	10.30	3.40	16.60
T_5	9.60	22.41	11.20	5.40	18.40
T_6	16.25	17.65	8.00	6.80	14.50
T_7	16.59	15.60	13.80	6.10	16.70
T_8	10.96	13.10	15.80	5.00	13.60
T_9	19.12	20.40	23.10	4.40	17.60
C. D. (1%) for comparison	7.84	6.03	1.57	1.36	4.24
Mean of treatments T_4 and T_5	9.21	21.00	10.90	4.40	17.50
C. D. (1%) for comparison of mean of T_4 and T_5 with T_1 and T_2	6.79	5.22	1.32	1.18	3.68

Table 2

Total phosphorus uptake (g/pot)

Treatments	S_1	S_2	S_3	S_4	S_5
T_1	0.027	0.016	0.032	0.012	0.022
T_2	0,035	0,041	0.056	0.019	0·030
T_3	0.055	0.066	0.067	0.011	0.051
T_4	0.035	0,056	0.050	0·013	0.045
T_5	0.040	0.060	0.048	0.012	0.046
T_6	0.062	0.076	0.034	0.027	0.053
T_7	0.053	0.069	0.053	0.030	0.058
[illegible]	0.043	0.044	0.051	0.021	0.044
[illegible]	0.080	0.079	0.075	0.036	0.052
C. D. (1%) for comparison	0.015	0,019	0.017	...	0.017
Mean of treatments T. and T_5	0.037	0.062	0.049	...	0.046
C.D. (1%) for comparison of mean of T_3 and T_5 with T, and T,	0.013	0.017	0.017	...	0.015

practices of Kerala Agricultural University), primed rock phosphate was found to be more efficient than superphosphate in karappadom, kole and coastal sandy soils. But it was inferior to rock phosphate applied at flooding in kaya! soil probably due to its high organic matter content.

Application of rock phosphate and superphosphate on equal P basis at flooding at higher rate of application (67.5 kg P_2O_5/ha) also resulted in substantial increase in plant growth, grain yield and nutrient uptake. Superphosphate might have supplied phosphorus to meet the initial high requirement of P for rice and gradual release of P from rock phosphate took care of further requirements. Application at the rate of one and a half times of the recommended dose (half as superphosphate and the other half as rock phosphate at flooding) might have substantially increased the grain yield and P uptake in all soils under study.

Summary

Potted plant studies were conducted in five major rice soils of Kerala namely karappadom, laterite, kayal, coastal sandy and kole soils to evaluate the efficiency of primed rock phosphate in moist aerobic soil with superphospate applied at flooding. Fractionation studies on the fate of applied phosphate revealed that priming of rock phosphate in moist aerobic soil resulted in substantial conversion of phosphate to iron phosphate and aluminium phosphate and these products increased availability of phosphorus to rice on submergence. Primed rock phosphate was found to be as efficient as superphosphate in karappadom, kayal and coastal sandy soil in yield and uptake of phosphorus. But in laterite soil it was found to be significantly superior to superphosphate.

സംഗ്രഹം

നനവും വായു സഞ്ചാരവും ഉള്ള മണ്ണിൽ റോക്ക് ഫോസ്ഫേററ് ചേർത്ത്, ഒരാഴ്ചക്കുശേഷം വെള്ളം കയററിയാൽ റോക്ക് ഫോസ്ഫേററിലടങ്ങിയ അലേയമായ ഭാവഹം നെല്ലിന്, സൂപ്പർ ഫോസ്ഫേററിലടങ്ങിയ ലേയഭാവഹം പോലെ ഉപയോഗപ്പെടുത്താൻ പററുമെന്ന് കേരളത്തിലെ പ്രധാന fflgjq^eft>g"lraJ നടത്തിയ പരീക്ഷണം തെളിയിക്കുന്നു. ഈർപ്പമുള്ള മണ്ണിൽ റോക്ക് ഫോസ്ഫേററ്ചേർക്കുമ്പോൾ അതിലടങ്ങിയ ഭാവഹം പ്രധാനമായി ഇരുമ്പും ഭാവഹവും ചേർന്ന സംയുക്തങ്ങളായി ffIOCl^a,t3E)^Q വെള്ളം കയററുമ്പോൾ അതിലടങ്ങിയ ഭാവഹം നെല്ലിന് ലഭിയ്ക്കയും ചെയ്യുന്നു.

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