ROCK POWDER FERTILIZERS FOR NUTRIENT DEPLETED SOILS IN SRI LANKA

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Objectives

The major objective of this one-year Rock Powder Fertilizer Project was to investigate whether the profitability of rice cultivation on nutrient depleted soils of Sri Lanka can be increased by replacing the imported P fertilizers with locally available fertilizer products. The main emphasis is towards investigating if PAPR (Partially Acidulated Phosphate Rock) from Eppawala can outrank the imported TSP. PAPR has not been tested on an extensive basis for annual crops in Sri Lanka. Attention is also drawn to locally available mica, a possible micronutrient fertilizer: conventional NPK fertilizers lack many of the vital micronutrients and their continued application may deplete the natural nutrient supply in intensively cultivated soils. The marginal micronutrient status of the rice soils may also contribute to the lack of P-response upon P-addition to P-deficient soils. Therefore, an extended field programme in different agro-ecological regions of Sri Lanka was initiated with maximum collaboration of farmers with on-farm testing, monitoring and evaluating.

Field selection

14 fields were selected in different agro-ecological regions [Reddish Brown Latosolic from Kandy-Kegalle (3 fields, KK1-KK3), Reddish Brown Earth fron Anuradhapura (4 fields, A1-A4), Red Yellow Podsolic from Kalutara (5 fields, K1-K5) and Red Yellow Podsolic with Plinthite from Homagama (2 fields, H1-H2)] on the basis of a high probability of response to P: all selected sites had water soluble and available P levels (Olson P) that were considered deficient (<0.13 ppm and <10 ppm, respectively).

Treatments

To investigate the effectiveness of PAPR as a phosphorus fertilizer and of mica as a source of micronutrients, the following treatments were carried out: 2 control plots (no P added), one to which only NK was added (C1) and one to which NKS (C2) was added; 2 sources of P (TSP and PAPR], 2 levels of P [60 and 120 kg P_2O_5/ha in Anuradhapura and 40 and 80 kg P_2O_5/ha for the other fields] and 3 sources/levels of micronutrients [0, mica at 150 kg/ha or a mixture of technical grade micronutrients ($MgSO_4$, $ZnSO_4$ and $CuSO_4$)]. Only in 2 of the 5 Kalutara sites, 3 sources of P were applied: ERP (not acidulated), PAPR and TSP. The reasons for applying an extra P source on the Kalutara soils are the following: firstly, the rice yields in these regions are low, therefore, the farmers do not have the resources to spend much money on fertilizer and ERP, when effective, would be less costly than PAPR: secondly, because of the low pH of the Kalutara soils compared to the other soils, the changes of ERP effectiveness in former soils are greater. To all the plots, the Department of Agriculture recommended levels of N and K were added (In some instances, the levels of N and K or the time of application were adjusted to correct for visible deficiencies of the rice crop). S was imported with the PAPR and the chemical mixture of micronutrients and the S level of all the plots (except C1) was adjusted to the maximal amount of S imported with these fertilizers through addition of elemental S. The experiment is performed in triplicate. The experimental design is a RCBD.

Analyses

All the field plots (experimental units) were analysed before planting for water soluble and available P and available micro- and macronutrients; at maximum tillering for available P; and at harvest for available P and available micro- and macronutrients.

Plants are analysed at maximum tillering and at harvest for P and macro- and micronutrients. Plant height, number of tillers, panicle numbers and yield were recorded at the appropriate times.

This array of soil and plant analyses are being carried out 1) to try to find a suitable soil test for P for wetland rice to be able to make P-fertilizer recommendations 2) to relate yield response (or lack of response) with plant and soil nutrients other than P 3) to obtain an idea about how measured parameters are interrelated and 4) to be able to perform a covariance analysis with the initial soil data, given the known variability of paddy soils, in the hope of increasing significancy levels.

Results

For five of the twelve harvested fields, there was a difference in yield between the control plots and the P-treated plots (Table 1). From the initial deficient levels of P, [water soluble and available P (Pi-P)] however, a P-response for all fields would have been expected. Upon submergence, P is made available through reduction of iron oxides and hydroxydes to which P is bound. After submergence (and before transplanting), the water soluble P attained levels, 2 to 10 times the sufficiency level (Table 1). Thus, when considering the water soluble P level after submergence, none of the fields would be expected to show a response to P.

Table 1: Yield response and initial P levels of the dry soil (water soluble and Pi-P) and initial water soluble P level of the submerged soils

Field	K1	K2	K3	K4	K5
Yield	no effect	Cts-rest* L2>L1	P PAPR a TSP b M chem a mica ab 0 b	L 2>1 M chem a 0 b	Cts-rest
Pi-P, ppm, dry soil	4.88	-	4.34	2.31	2.32
Water-P, ppm, dry soil	0.088	0.072	0.062	0.078	0.066
Water-P, ppm submerged soil	0.369	0.739	0.315	1.217	2.51

Field	A1	A2	A4	KK1	KK2	H1	H2
Yield	Cts-rest M chem a 0 ab mica b	C1<C2	*No effect*	M chem a 0 ab mica b	P*L	Cts-rest	Cts-rest
Pi-P, ppm, dry soil	8.21	4.23	4.34	2.21	2.00	3.88	-
Water-P, ppm, dry soil	0.115	0.085	0.102	0.107	0.125	0.080	0.125
Water-P, ppm submerged soil	0.753	1.197	0.978	1.371	0.671	0.611	0.439

*: cts-rest: significant diffference in yield between the control treatments that have not received any P (these are C1 and C2) and the 12 treatments that received P

Covariance analysis with any of the initially measured soil parameters did not contribute to the significancy of the model. In the cases where rice is responsive to P addition, PAPR and TSP are equally effective. Since PAPR is a slow release fertilizer, applying PAPR may have an 'adding-up' residual effect over the years.

Treatment effects (effect of P source and level and of micronutrient addition) occurred but were not consistent within an agro-ecological area (Table 1). In general, rice was much more responsive in earlier growth stages (treatment effects on height and tillers, plant-P and available P at maximum tillering) than towards harvest (data not shown). Significant correlations between yield and available P and plant P at tillering (among others) exist, but again, these coefficients are not consistant.

Since none of the P-parameters so far analysed gave satisfactory results in terms of demarcating deficiency levels, an adsorption experiment together with a small pot experiment was started. Knowledge on the P-buffering capacity of the soil, the P quantity (·available P) and intensity (· concentration of P in the soil solution) together with growth and P-uptake of rice plants from soils (selected from 8 of the 14 fields) to which no P was added, might make it possible to determine the functional relationship between P uptake and the status of P in the soil.

Some economic considerations

In the cases were P-treatment resulted in a significantly higher yield compared to the control, PAPR can only be recommended as fertilizer if it is cheaper than TSP. Acids for the acidulation process have to be imported, which makes PAPR more expensive than TSP. For a 40 kg/ha P_2O_5 addition, the cost incurred with TSP is Rs 913/ha and with PAPR Rs 1456/ha. If it would be possible to produce PAPR in collaboration with the one sulphuric acid producing plant in Sri Lanka, applying PAPR as P-fertilizer would be less expensive (Rs 684/ha) than using TSP. Apart from that it, then, will be more economical for the farmer to apply PAPR, substituting TSP with locally produced PAPR will decrease the spending of foreign exchange on imported fertilizers and provide some extra local employment.

Overall (considering both the fields where P-addition resulted in a significant yield increase or where no effect of P-addition was found), applying P-fertilizer (TSP or would-be locally made PAPR) results in an income increase of about 7 %.

It is hoped that these results will encourage the Department of Agriculture to continue field testing on an islandwide scale so as to assess if the local fertilizer products are as effective and also cheaper than the imported P-fertilizers.