ROLE OF MACRO- AND MICRONUTRIENTS IN ROCK POWDER FERTILIZED SOILS: CONSTRAINTS.

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The objective of this special study under the Rock Powder Fertilizer Project was to compare rice response to phosphorus addition under varying macro- and micronutrient environments in nutrient depleted Sri Lankan soils. Conventional NPK fertilizers lack many of the vital micronutrients and their continued application may deplete the natural nutrient supply in intensely cultivated soils. The marginal micronutrient status of the rice soils may also contribute to the lack of P-response to phosphorus (P) addition in P-deficient soils. The local micronutrient source was prepared by acidulating phlogopite mica. Acidulated mica contains 3% K_2O, 8% MgO, 16% SiO_2, 9% Al_2O_3, 2% Fe_2O_3, 100 ppm MnO, 56 ppm Zn and 11 ppm Cu.

The overall objective of this one-year project, is to investigate whether the profitability of cultivating annual crops on nutrient depleted soils can be increased by replacing the imported P (phosphorus) fertilizers with locally manufactured phosphate fertilizer based on Eppawala rock phosphate (ERP) in combination with and without micronutrients (local as well as imported). The phosphate fertilizer was prepared by 50% acidulation of Eppawala rock phosphate (ERP) to give PAPR - Partilally Acidulated Phosphate Rock.

In the first stage, 14 farmers' fields were selected from 4 different agro-ecological regions based on the low availability of soil P and soil type; Reddish Brown Latosolic soils in Kandy-Kegalle (fields nos. - KK1, KK2 and KK3), Low Humic Gley soils in Anuradhapura (fields nos. - A1, A2, A3 and A4), Red Yellow Podsolic soils from Kalutara (field nos. - K1, K2, K3, K4 and K5) and Red Yellow Podsolic soils with plinthite from Homogama (field nos. - H1 and H2). To investigate the effectiveness of PAPR as a phosphorus fertilizer and of mica as a source of micronutrients the following treatments were used:

* 2 sources of P [TSP and PAPR]. In 2 of the 5 Kalutara sites, 3 sources of P were applied - ERP (not acidulated), PAPR and TSP.
* 3 levels of P [0, 40 and 80 kg P_2O_5/ha]
* 3 sources/levels of micronutrients

M_0 - no micronutrients ; M_1 - a mixture of $MgSO_4$ (25 kg/ha), $ZnSO_4$ (10 kg/ha) and $CuSO_4$(5kg/ha); M_2 - phlogopite mica at 100 kg/ha.

Each field site had three replicate blocks conforming to a randomised complete block design. Individual treatment plots (experimental units) were analysed before planting, and at harvest for available P, macro- and micronutrients, pH and Eh. Before planting, C.E.C, texture, C and N contents of selected composit samples were determined. Rice varieties BG 94-1 for the Kandy-Kegalle series (KK1-3) , BW 267/3 for the Kalutara and Homagama series (K1-5 and H1-2) and BG 11-11 for the Anuradhapura series (A1-4) were selected. Plants were analysed at maximum tillering stage and at harvest for P and macro- and micronutrients. Plant height, number of tillers, and yield were recorded at the appropriate times.

The Anuradhapura fields (A1 and A4) from the dry zone gave higher average yields (5-6 tons/ha) with BG 11-11 (Figs. 1 and 2), than the wet zone fields

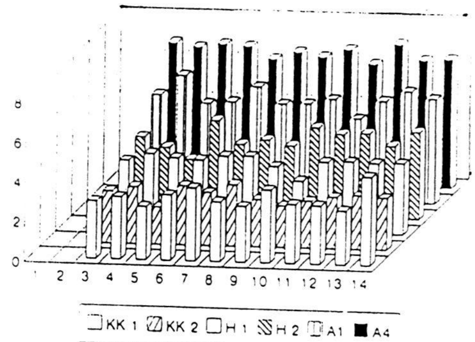

Fig. 1 Rice response in Anuradhapura, Homagama and Kandy-Kegalle fields

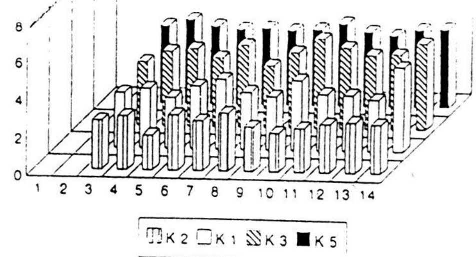

Fig.2 Rice response in the Kalutara fields

from Kandy-Kegalle, Homagama and Kalutara fields (KK, H and K series) with BG 94-1 and BW 267/3, where the yield averaged 2-4 tons/ha.

Out of the 14 fields a significant response to addition of micronutrients was obtained in 4 fields KK1, K3, K4 and A1 (Table 1). A response to addition of micronutrients was not always consistent with a response to (i)added P, (ii) P-source (TSP vs. PAPR), or (iii)P level (Table 1).

Table 1 Yield response to addition of P, different P sources and micronutrients

Field	KK1	KK2	H1	H2	K1	K2	K3	K4	K5	A1	A2	A4
(i) added P (con.vs rest)	no	no	yes	yes	no	yes	no	no	yes	yes	yes	no
(ii) P source	no	no	no	no	no	yes	yes	yes	no	no	no	no
(iii) P level	no	no	no	no	no	yes	no	no	no	no	no	no
(iv) micro	yes	no	no	no	no	no	yes	yes	no	yes	no	no
CHEM	a						a	a		a		
MICA	ab						ab	**		b		
0	b						b	b		ab		

** - mica not incorporated.

The chemical micronutrient mixture resulted in significantly higher yields in 3 out of the 4 fields (except in the A1 field) where micronutrient effects were observed compared to the control without micronutrients. Mica effects could not be separated from either the control or from the chemical mixture all 3 fields where a response was obtained. These results indicate that mica is not very effective at the application rates (100-150 kg/ha) tested because of its lower concentration of Mg, Zn and Cu compared tothe chemical mixture.

Fields KK1 and K3 were subject to detailed analysis to study response patterns (Table 2).
The straw samples from all treatments in the Kandy-Kegalle (KK1) field had sufficient levels of K, Mg, Mn and Zn, excess Fe and near deficient Cu compared to critical levels established by the International Rice Research Institute, Phillipines.

The Kalutara (K3) field had sufficient K, Mn and Zn and a higher yield than KK1, inspite of toxic levels of Fe and deficiency of Mg and Cu (Table 2). It is noted that the rice variety BW 267/3 used in Kalutara though resistant to iron toxicity, has a lower yield potential than that used in field KK1. A significant correlation (r^2=0.5581) between soil Mg at harvest and yield was also obtained in field K3, where higher yields were obtained in treatments where Mg was added with the chemical mixture confirming the response to addition of Mg in this case.
In the K3 field, where a significant response to addition of micronutrients was obtained, a marked increase in height towards the center of replicate 1 (upto 150 cm) at maximum tillering was noticed and the initial exchangeable soil K and Ca of the center plots, were significantly correlated with the post-harvest exchangeable soil K and the content of K in straw in replicate 1. This anomaly had resulted from the placement of the threshing floor prior to commencement of the field trial in this central position of replicate 1 resulting in luxury uptake of K from burnt straw.

This point illustrates the constraints encountered in farmers' field based trials. Inconsistency in response patterns when fertilizers are tested in farmers' fields are likely to result from several such factors as uneven site irrigation (especially with Mahaweli water issues) and drainage, the past fertilizer application history of the site, differences in farmers' practices, observer errors, lack of concomitant establishment of sites and neighbouring fields and resulting pest attacks, in addition to soil heterogeneity and factors beyond control such as variation in weather and micro-climate.

Table 2 Selected micro and macro element contents in rice plant

	Range (ppm)	Treatment Mean (ppm)	Critical level (ppm)		Straw* (ppm)	Remarks
Zn			*Def.*	*Toxic*		
Harvest						
K_3	37 -113	78	n.a.	1500	30	K_3= 3KK_1
KK_1	16 - 53	28	n.a.	1500		
Till						
K_3	39 - 83	57	10	n.a.		Sufficient
KK_1	n.a.	n.a.	10	n.a.		
Mn						
Harvest						
K_3	224 - 690	415	n.a.	n.a.	560	K_3 < KK1
KK1	79 - 719	545	n.a.	n.a.		
Till						
K_3	146 - 512	317	20	2500		K_3= KK_1
KK_1	183 - 424	323	20	2500		Sufficient
Cu						
Harvest						
K_3	4 - 11	7	6	30	3	K_3= KK_1 Close to
KK_1	2.5 - 35	8	6	30		deficient level
Fe						
Harvest						
K_3	93 - 782	511	n.a.	n.a.	200	K_3 < KK_1
KK_1	141 -3381	617	n.a.	n.a.		3 times in excess
Till						
K_3	181 - 556	314	70	300	n.a.	Close to toxic level
KK_1	72 - 444	250	70	300		
K						
K_3	5617-22419	12534	10,000	n.a.	13,600	K_3 < KK_1
KK_1	8241-26238	17281	10,000	n.a.		Sufficient K
Mg						
Harvest						
K_3	428 -1362	916	1,000	n.a.	2,600	K_3 = half of KK1
KK_1	455-7772	2323	1,000	n.a.		K_3 deficient in Mg
Yield (tons/ha)			*Maximum Yield (tons/ha)*		*Farmers' Yield (tons/ha)*	
K_3 (BW 267/3)	*2.78-5.15*	*4.02*	*6.232*		*3.903*	
KK_1 (BG 94-1)	*3.16-4.34*	*3.53*	*8.578*		*6.056*	

* - Straw content from IRRI Rice Research station (variety IR8)
K_3 Kalutara (variety BW 267/3)
KK_1 Kegalle - Kandy (variety BG 94-1)

These results suggest that initial fertilizer tests to obtain statistically valid responses under field conditions should be carried out mainly at research stations conducted under strict surveillance at farm sites. Such trials will provide the maximum potential response. Farmers' field trials can provide information on the percentage of maximum yield that can be realised by the farmer.

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