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EFFECT OF PHOSPHORUS SOURCES AND LEVELS WITH PARTICULAR EMPHASIS ON SELECTIVELY MINED EPPAWELA ROCK PHOSPHATE ON VEGETABLE PRODUCTION

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Abstract: A field experiment was conducted over a period of four cropping seasons to study the effect of Selectively mined Eppawela rock phosphate (SERP) as a P source for potato and vegetables on a Red Yellow Podzolic soil at Bandarawela. Selectively mined Eppawela rock phosphate was compared with Triple Superphosphate (TSP), Imported Rock Phosphate(IRP) and Eppawela Rock Phosphate(ERP). These were applied at the rates of 25, 50, 100 kg P/ha per crop. Crop sequence was potato, cabbage, pole bean, and tomato. The highest crop yields were obtained with TSP followed by IRP, SERP and ERP. Although addition of rock phosphates increased yields of these crops, the increases were very small compared to those obtained from the addition of TSP. Though P is high in SERP compared to ERP the availability of P from SERP was not superior to ERP. The available phosphorus content at the end of each crop showed highest values in TSP- treated plots, followed by IRP, SERP and ERP. These results suggest that rock phosphate sources such as SERP, IRP and ERP were inferior to TSP and not suitable for direct application as sources of P fertilizer for potato and vegetables.

Key words: Cabbage, Eppawela rock phosphate, fertilizers, phosphates, pole bean, potato, rock phosphate, tomato, triple superphosphate, vegetables.

INTRODUCTION

Rock phosphate, mined in several areas of the world, is a major source of phosphate fertilizer[1,2] and has been used for more than 150 years.[3] Significant differences in chemical characteristics exist between different rock phosphate materials.[4,5] Due to low P availability in rock phosphate compared with that in soluble phosphates, rock phosphates are only recommended for direct application as P fertilizers on a small scale.[2,6]

Considerable research has been conducted in recent years in search of alternative sources of P for crop production. The primary aim of the research was the use of low-cost indigenous material such as locally available rock phosphate deposits. Interest in these low-cost indigenous deposits was intensified in the early 1970s when the price of phosphate fertilizers increased sharply in the world market. Many rock phosphate sources were not developed because they

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were considered " problem ores " as their chemical properties were not suitable for production of commercially used fertilizer products using conventional processes. Alternative methods for their use were: direct application of finely ground forms to soil, development of granulation techniques to improve physical properties, mixing with organic materials and soluble P fertilizers and partial acidulation to increase water and citric acid solubility.[2]

Direct application of rock phosphate may be an agronomically and economically attractive alternative to the use of the expensive soluble P fertilizers such as single superphosphate and triple superphosphate.[2,7,8] Although it is well known that rock phosphate is often applied to slow growing crops such as perennials,[9] experiments with annuals suggest that Eppawela rock phosphate is not as effective as a direct application fertilizer.[10] This is particularly relevant for vegetables which have a short growing period of about 2 to 3 months, during which they generate a high quantity of biomass and remove large amounts of P from the soil. Therefore, it was concluded[10] that the Eppawela rock phosphate is inferior to TSP and not suitable for direct application as a source of P fertilizer for vegetables.

During the present mining operations at Eppawela, the primary apatite crystals are mixed with secondary phosphate matrix and due to this, wide range of variations has been observed in the commercial product. Therefore, several workers have suggested selective mining to obtain upgraded rock phosphate from Eppawela deposits.[11,12] This selected material has shown high value of phosphate and also high citric acid solubility.[12,13]

However, information is not available on the effect of direct application of selectively mined Eppawela rock phosphate on the yield of vegetable crops. This paper reports the findings of investigations carried out to study the effectiveness of selectively mined Eppawela rock phosphate compared with Eppawela rock phosphate (commercial), imported rock phosphate and triple superphosphate as P sources for potato and vegetable cultivation.

METHODS AND MATERIALS

A field experiment was conducted in a Red Yellow Podzolic soil with pH (1:2.5H_2O) 5.2, total N 0.12%, organic matter 2.5%, Olsen's P 9.3 ppm and exchangeable K 113 ppm at the Regional Agricultural Research & Development Centre, Bandarawela. The treatments consisted of three P levels (viz. 25, 50 and 100 kg P/ha) and four sources of phosphate (viz. triple superphosphate -TSP , imported rock phosphate - IRP , Eppawela rock phosphate - ERP and selectively mined Eppawela rock phosphate - SERP) which were factorially combined. A control plot with zero P was also included in the trial design. The experiment was laid out in a randomized complete block design and replicated three times. The plot size was 3 m x 2.5 m. The plan of randomization was kept unchanged for all crops in the cropping sequence potato, cabbage, pole bean, tomato so that the same pot received the same treatment combination during the entire period of the experiment. The chemical characteristics of fertilizers used are given in Table 1.

Table 1: Some chemical characteristics of fertilizers.

Fertilizer	pH	Total P (%)	Citric acid soluble P(%)
ERP	6.9	10.9	1.2
TSP	2.8	20.1	-
IRP	7.4	14.1	3.2
SERP	7.3	15.9	1.7

The spacing and rates of application of N and K for each crop are shown in Table 2. Nitrogen was applied as urea and K as muriate of potash. Phosphorus was added basally while N and K were added according to the recommended times of application for each crop.[14]

Table 2: Recommended spacing and level of N and K applied for different crops by the Department of Agriculture (1990).

Crop	Spacing (cm)	N level (kg N/ha)	K level (kg K_2O/ha)
Potato	60 x 25	150	150
Cabbage	50 x 50	150	90
Pole bean	50 x 50	100	90
Tomato	50 x 50	90	80

The crops were grown under rainfed conditions with supplementary irrigation whenever necessary. The plots were maintained in a weed-free condition throughout the experiment. Three composite soil samples were collected from each replicate of each crop for analysis before and after commencing the experiment.

RESULTS AND DISCUSSION

Effect of P sources on yield

In maha 94/95, potato crop showed lowest yield with ERP (Table 3). However, IRP and SERP gave almost similar yields. Triple superphosphate gave significantly high yields compared to IRP, SERP and ERP. The application of IRP, SERP and ERP did not show any significant yield differences in potato.

Table 3: Effect of P sources on crop yield.

P Source	Crop yield (t/ha)			
	Potato (maha 94/95)	Cabbage (yala 95)	Pole bean (maha 95/96)	Tomato (yala 96)
TSP	10.9	22.5	16.3	13.3
IRP	8.7	10.4	13.1	7.7
SERP	8.9	6.8	12.5	5.5
ERP	7.8	2.2	10.7	5.3
LSD(p=0.05)	1.4	2.1	2.1	1.6
CV(%)	15.4	22.1	15.9	21.2

In yala 1995, application of TSP, IRP and SERP gave significantly higher cabbage yield than that from ERP application. However, TSP application gave the highest yield followed by IRP and SERP. Selectively mined Eppawela rock phosphate application gave a significantly higher yield for cabbage than ERP. In addition, IRP gave significantly high yield over SERP.

In maha 95/96, pole bean crop showed lowest yield with ERP . However, application of IRP, SERP and ERP did not show any significant yield differences in pole bean. Triple superphosphate application gave significant yield increase over the rock phosphate sources.

The application of TSP and IRP showed significant yield increase of tomato in yala 1996 over SERP and ERP. However, TSP application gave significantly high yield over IRP. During this season, the application of SERP and ERP gave almost similar yield of tomato.

The performance of vegetable crops to the application of rock phosphates was very poor. These results are in agreement with previous findings.[10] Throughout the experiment, the application of TSP resulted in significant yield increases of crops compared to rock phosphates. Eppawela rock phosphate was also found to be relatively ineffective even in flooded rice culture.[15] On the contrary, the rock phosphate has been as effective as TSP for annual crops grown in many parts of the world.[16]

The soil analysis after each crop showed that the available P (Olsen's) content of all the P treated plots was higher than that of the control plot. However, the increases with IRP, SERP and ERP were very small compared to that with TSP (Fig.1). This showed the low solubility of rock phosphates compared to TSP. Similar results have been previously reported.[10,17] All the crops showed a similar trend during the entire period of the experiment. Results suggests that P from TSP is more available than from other sources of rock phosphate. In addition, SERP was not superior to ERP as a source of P for vegetables. This suggests that though P is high in SERP, its direct application is not suitable as a source of P for potato and vegetable cultivation because of its low solubility (Table 1).

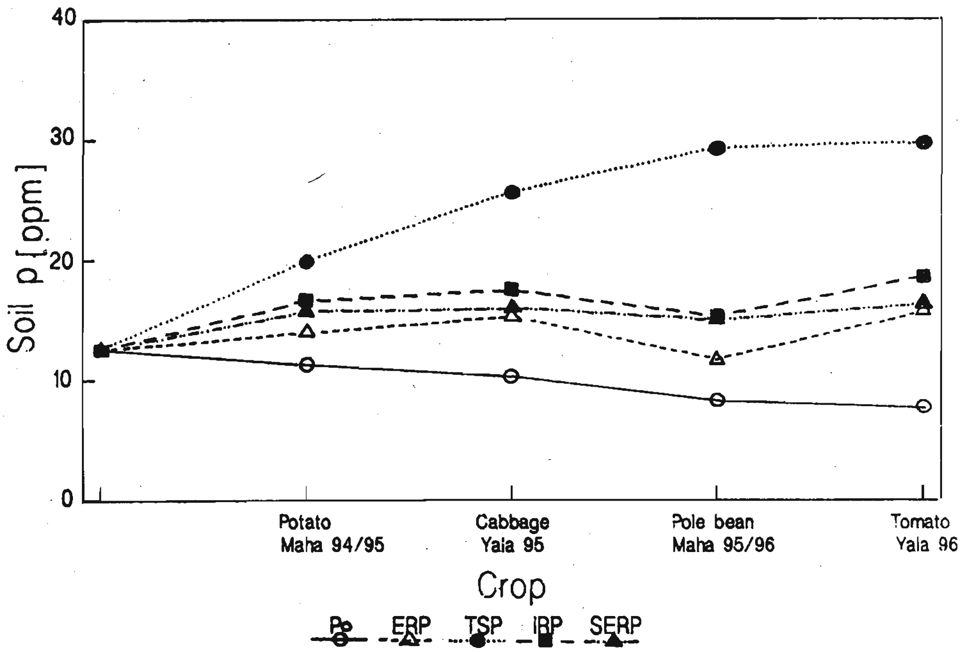

Figure 1: Available P content in soil after each crop with application of 100 kg P/ha.

Effect of P level on yield

The effect of different levels of P on yield of potato and vegetable crops is shown in Table 4. During the entire period of the experiment, potato in maha 94/95, cabbage in yala 1995, pole bean in maha 95/96 and tomato in yala 1996 showed significant yield response to the addition of 25 kg P/ha. Increased yields of potato in maha 94/95 and pole bean in maha 95/96 were not observed with the application of 50 kg P/ha over the application of 25 kg P/ha. During yala 95, cabbage yields were significantly increased by the application of 50 kg P/ha and even up to 100 kg P/ha. The same trend was also observed during yala 1996 with tomato. This may be due to high removal of P by cabbage and tomato compared to potato and pole bean. The tomato and cabbage have been categorized as high K removal crops while potato and pole bean as low K removal crops.[18] The cabbage heads and tomato fruits also remove more P and K than potato tubers and bean pods from cultivated fields.[19]

Table 4: Effect of P levels on crop yields.

	Crop yield (t/ha)			
P level (kg/ha)	Potato (maha 94/95)	Cabbage (yala 95)	Pole bean (maha 95/96)	Tomato (yala 96)
0	6.5	0.7	6.9	2.9
25	8.3	8.0	11.5	5.9
50	9.0	10.3	13.1	7.4
100	10.0	13.2	14.9	10.6
LSD P_0 vs levels ($p=0.05$)	1.7	2.9	2.7	2.2
LSD between levels ($p=0.05$)	1.2	2.1	1.8	1.4
CV(%)	15.4	22.1	15.9	21.2

Potato, cabbage, pole bean and tomato had shown significant response to P application levels 25, 100, 25 and 100 kg/ha, respectively. However, yield increment in potato and pole bean beyond P application levels of 25 kg/ha had plateaued indicating 25 kg/ha level as near optimum. But yield increment in cabbage and tomato had shown significant positive response up to the maximum P level of 100 kg/ha used in this study. Hence, their response beyond 100 kg P/ha level need to be studied to ascertain the optimum level of P. The continuous P application to Red Yellow Podzolic soils had resulted in slight P accumulation in soil when P was applied at 100 kg P/ha per season.[10] Hence results suggest that the application of P at 25 kg/ha is needed to obtain high yields from potato and pole beans while application of P at 100 kg/ha and above may be needed to obtain high yields from cabbage and tomato without appreciable build-up of P in the soil.

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