COMPARISON OF PHOSPHATE SOURCES ON GROWTH OF VEGETABLES ON AN ACID SOIL

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ABSTRACT

Three sources of phosphate fertilizers of differing solubilities were evaluated at Bandarawela on a Red Yellow Podzolic soil of pH 4.3 in a long term field experiment which began in 1987 yala season. The fertilizers were triple superphosphate (TSP), high citric acid soluble rock phosphate (HCRP) and Eppawala rock phosphate (ERP). They were added at rates of 25, 50 and 100 kg P/ha per crop. Potato, cabbage, tomato, pole bean, potato, cabbage and tomato were cultivated in this sequence. The highest crop yields were obtained with TSP and the lowest with ERP. Although addition of ERP increased yields of the above crops, the increases were very small compared to those obtained from the addition of TSP. The chemical analysis of soil for available phosphorus content (Olsen) at the end of each crop season and percent P in plants showed highest values in TSP-treated plots, followed by HCRP and ERP. These findings demonstrate that HCRP and ERP were inferior to TSP and not suitable for direct application as sources of P fertilizer for vegetables.

KEY WORDS : Acid soil, Eppawala rock phosphate, High citric acid soluble rock phosphate, Triple superphosphate, Upcountry, Vegetables

INTRODUCTION

The upcountry intermediate zone of Sri Lanka lies between 600-1400 m above mean sea level. The mean maximum and minimum temperatures are about 27°C and 15°C respectively. Average annual rainfall ranges between 1100-1400 mm. The soils are mainly Red Yellow Podzolic (Panabokke, 1967) with a pH range of 4.0–6.5.

Agriculture in upcountry areas of Sri Lanka is characterized by intensive cultivation of vegetables. Farming system in this region commonly consists of cultivating 2—3 crops a year.

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Unlike the general pattern of low fertilizer use in the low country of Sri Lanka, most farmers in the upcountry use high quantities of chemical and organic fertilizers and consequently the content of residual soil phosphorus is high in the vegetable growing lands in this region (J. D. H. Wijewardena and S. L. Amarasiri, 1988, unpublished).

The consumption of fertilizer in Sri Lanka has been increasing steadily during the last 25 years. For a developing country like Sri Lanka which imports almost all its requirements of chemical fertilizers, a rapid increase in the world market price of fertilizers causes heavy drain on the foreign exchange reserves. It is therefore necessary to use fertilizers judiciously and to find effective alternate sources of locally available materials. In this context the locally available. Eppawala rock phosphate has an important role to play.

Rock phosphates are expected to be more available to plants grown on acid soils than on neutral and alkaline soils. They are often recommended to be applied to slow growing crops such as perennials on neutral and acid soils. Under these conditions the rate at which P is supplied by the phosphate rock is usually sufficient to meet the crop requirements. On the other hand, almost all the vegetables are annuals and have a short growing period of about 2 to 3 months. They generate very high quantity of biomass rapidly and remove large quantities of P from the soil. They are shallow—rooted and have thus to obtain their P requirements from a small volume of soil. Therefore it is essential that vegetables should receive a relatively large supply of P in a short time from the soil or from added fertilizer for adequate growth.

Field experiments conducted by Chien and Hammond (1978) showed that in the initial crop of bean all phosphate rock sources were less effective than concentrated superphosphate. However, during the second and third cropping periods, the response of bean to the residual P in phosphate rock sources was becoming increasingly significant. Solubility of apatite minerals in acid conditions has been reported and some rock phosphates are used for direct application in certain farming systems (Chien and Black, 1976).

In this study the effectiveness of two rock phosphates of low and high citric acid solubility was compared with triple superphosphate in a long term experiment on vegetables grown on an acid soil.

MATERIALS AND METHODS

A long term field experiment was conducted in a Red Yellow Podzolic Soil (Panabokke, 1967) with pH 4.3, organic matter 2.1%, total N 0.15%, Olsen's P 12.8 ppm and exchangeable K 0.18 me/100 g at the Regional Agricultural Research Centre, Bandarawela. Three levels of P, 25, 50 and 100 kg/ha, and three sources of phosphate, triple superphosphate, high citric acid soluble imported rock phosphate (4.4% citric acid soluble P) and Eppawala rock phosphate (1.5% citric acid soluble P) were factorially combined. A control plot with zero P was also included in the trial. The trial was laid out in a randomized complete block design, and replicated four times. Potato (Desiree)/cabbage (Gloria Fl)/tomato (T—89)/pole bean (KWG)/potato (Krushi)/cabbage (Hercules) and tomato (BN—13) were grown sequentially, one crop per season, commencing from yala 1987. Plan of randomization was kept unchanged so that the same plot got the same treatment combination during the entire period of the experiment. The plot size was 3m × 2.5m.

The spacing and rates of application of N and K for each crop are shown in Table 1. Nitrogen was applied as urea and K as muriate of potash. P was added basally, while N and K were added according to the recommended times of application for each crop.

The crops during all seasons were grown under rainfed conditions with supplementary irrigation whenever necessary. Land was maintained in a weed—free condition throughout the experiment.

Four composite soil samples were collected from each replicate before commencing the experiment. Soil samples were also collected from each plot after each crop for analysis. Leaf samples were collected at harvest in the first cabbage crop and 45 days after planting of the last tomato crop for chemical analysis.

RESULTS AND DISCUSSION

Effect of P sources on yield

The effect of P sources on yield of crops is shown in Table 2. In yala 87, potato crop did not show any significant yield response to the three sources of P tested. However, triple superphosphate (TSP) application gave the highest yield followed by high citric acid soluble rock phosphate (HCRP) and Eppawala rock phosphate (ERP).

In maha 87/88, TSP application gave significantly higher yields of cabbage over the other two P sources. HCRP too gave significantly higher yield over ERP.

In yala 88 tomato yield could not be obtained as the crop was severely damaged by a virus infection.

During yala 89 application of either TSP or HCRP gave significantly higher pole bean yield than ERP. However, TSP and HCRP gave almost similar yields.

In maha 89/90 potato, yala 90 cabbage and maha 90/91 tomato crops the application of TSP showed significant yield increases over the other two P sources. In all seasons excepting the first, HCRP application gave significantly higher yield than ERP.

The soil analysis after the first potato crop (yala 87) showed that the available P content of all the P treated plots was higher than that of the control plot. However, the increases (over the control) with HCRP and ERP were very small compared to that with TSP (Fig. 1). This showed that even ERP was reactive. Similar results were reported by Schuller *et al.* (1975) from a long term field experiment with rock phosphate in Austria. As in first season the same trend was observed in the soil analysis after each crop in the entire cropping sequence. However, the level of available P recorded at the end of each crop varied with the source of P, the highest amount of available P being recorded in the plots treated with TSP. This confirms that P from TSP is more available than from the other two sources. During maha 87/88 and maha 90/91 the P content of cabbage leaves and tomato plants also showed the highest values in plots treated with TSP and lowest in those treated with ERP (Table 3).

Although addition of ERP increased yields of potato and vegetable crops in contrast to its relative ineffectiveness in flooded rice culture (Nagarajah *et al.*, 1979), the increases were very small compared to those obtained from the addition of TSP.

The foregoing results suggest that HCRP and ERP are inferior to TSP as sources of P fertilizer for vegetables.

Although the experimental soil had a relatively low available P content of 12.8 ppm P at the commencement of the experiment, values as high as 50—400 ppm P are found in most of the intensively cultivated vegetable tracts in upcountry of Sri Lanka. In such soils, a mixture of TSP and ERP may be suitable, the former as a starter for the rapid initial growth of crop and the latter as a maintenance supplier. This idea could be tested in long term field experiments to determine the proper combination of the TSP—ERP mixtures to suit different crop and soil situations.

Effect of P levels on yield

The effect of different levels of P on yield of vegetable crops is shown in Table 4. In yala 87, a yield increase in potato was not observed with the application of P up to 100 kg/ha.

During maha 87/88 cabbage yields were significantly increased by the application of 100 kg P/ha. The same trend was observed during yala 89 pole bean crop, maha 89/90 potato crop, yala 90 cabbage crop and maha 90/91 tomato crop. However, in the yala 89 pole bean crop and the maha 90/91 tomato crop the difference in yield between 50 and 100 kg P/ha was not significant.

The failure of the first potato crop to respond to added P may be due to the adequacy of native soil P to meet its P requirements. The significant response of subsequent crops to added P at 100 kg/ha could be attributed to high P removal by these vegetable crops (FAO, 1984) and depletion of P from the soil due to continuous cropping on the same land (Fig. 2). However, the last tomato crop (maha 90/91) showed response only up to 50 kg/ha added P. This may be due to the unusual low yield during this season and therefore a low P requirement.

Further, the available P content in the soil and P in plants showed that higher the level of application of all the sources, higher the available P in soil and P in plants (Fig. 3 and Table 3).

The foregoing results suggest that the application of P at 100 kg/ha is needed to get high yield from upcountry vegetables such as potato, cabbage, pole bean and tomato.

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REFERENCES

Chien, S. H. and C. A. Black. 1976. Free energy of formation of carbonate apatites in some phosphate rocks. Soil Sci. Am. J. 40: 234—239.

Chien, S. H. and L. L. Hammond. 1978. A comparison of various laboratory methods for predicting the agronomic potential of phosphate rocks for direct application. Soil Sci. Soc. Am. J. 42: 935—939.

FAO, 1984. Fertilizer and plant nutrition guide. Fertilizer and Plant Nutrition Bulletin No. 9, FAO, Rome. 172p.

Nagarajah, S., M. M. M. Jauffer and B. M. Nizar. 1979. Phosphorus studies in the lowland rice soils of the mid country wet zone. Tropical Agriculturist 135: 1—22.

Panabokke, C. R. 1967. The Soils of Ceylon and Use of Fertilizers. Metro Printers Ltd., Colombo, Sri Lanka. 151 p.

Schuller, H., T. Reicherd and K. Nemeth 1975. Relationship between P fertilization, yield, P uptake and soil tests. Land Forsch 23: 147—157.

Table 1. Plant spacing and level of N and K for the different vegetable crops

Crop	*Spacing* *(cm)*	*N level* *(kg N/ha)*	*K level* *($kg\ K_2O/ha$)*
Potato	60×30	150	100
Cabbage	50×40	200	100
Tomato	50×50	200	100
Pole bean	50×50	150	100

Table 2. Effect of P sources on crop yields (Mean of 3 levels and 4 replicates)

	Crop yield (t/ha)					
P Source	*Potato (yala 87)*	*Cabbage (maha 87/88)*	*Pole bean (yala 89)*	*Potato (maha 89/90)*	*Cabbage (yala 90)*	*Tomato (maha 90/91)*
TSP	13.4	74.5	17.1	8.4	47.5	6.3
HCRP	13.0	58.6	15.4	6.9	39.4	5.3
ERP	11.8	33.4	12.5	5.2	14.1	2.4
LSD(P=0.05)	NS	7.4	2.4	0.7	4.8	1.0
CV(%)	20.9	17.2	19.4	12.9	19.0	26.7

*NS—Not significant

Table 3. Effect of sources and levels of P on P content of cabbage (maha 87/88) and tomato (maha 90/91)

	P content (%)				*P content (%)*			
	Cabbage				*Tomato*			
	Level of applied P (kg P/ha)				*Level of applied P (kg P/ha*			
Source	*25*	*50*	*100*	*Mean*	*25*	*50*	*100*	*Mean*
TSP	0.17	0.23	0.31	0.24	0.34	0.44	0.46	0.41
HCRP	0.16	0.20	0.25	0.20	0.23	0.25	0.28	0.25
ERP	0.12	0.16	0.17	0.15	0.20	0.22	0.24	0.22

Table 4. Effect of P levels on crop yields (Mean of 3 forms and 4 replicates)

	Crop yield (t/ha)					
P level (kg/ha)	*Potato (yala 87)*	*Cabbage (maha 87/88)*	*Pole bean (yala 89)*	*Potato (maha 89/90)*	*Cabbage (yala 90)*	*Tomato (maha 90/91)*
0	12.4	14.4	9.5	2.4	0.2	0.9
25	12.0	42.4	13.3	4.6	24.8	3.6
50	12.9	58.1	15.2	7.1	33.8	4.8
100	13.4	66.0	16.6	8.9	42.5	5.6
LSD P_0 vs levels ($P=0.05$)	NS	10.5	3.3	1.0	6.8	1.4
LSD between levels ($P=0.05$)	NS	7.4	2.4	0.7	4.8	1.0
CV(%)	20.9	17.2	19.4	12.9	19.0	26.7

*NS—Not significant

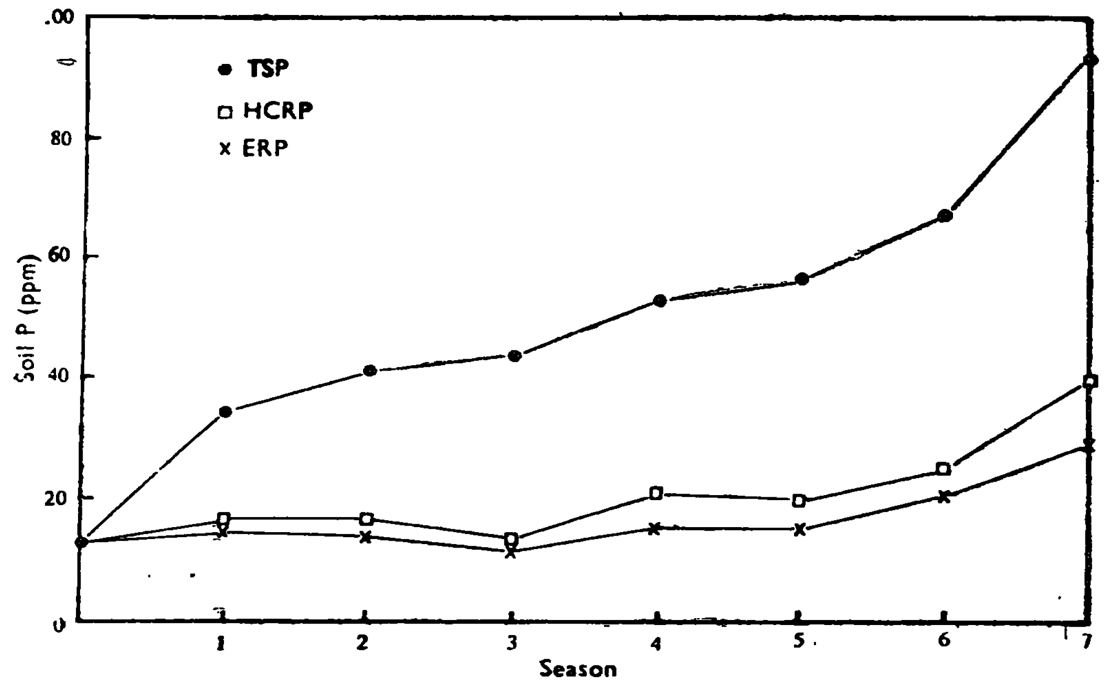

Fig. 1. Available P content in soil after each crop with application of 100 kg P/ha

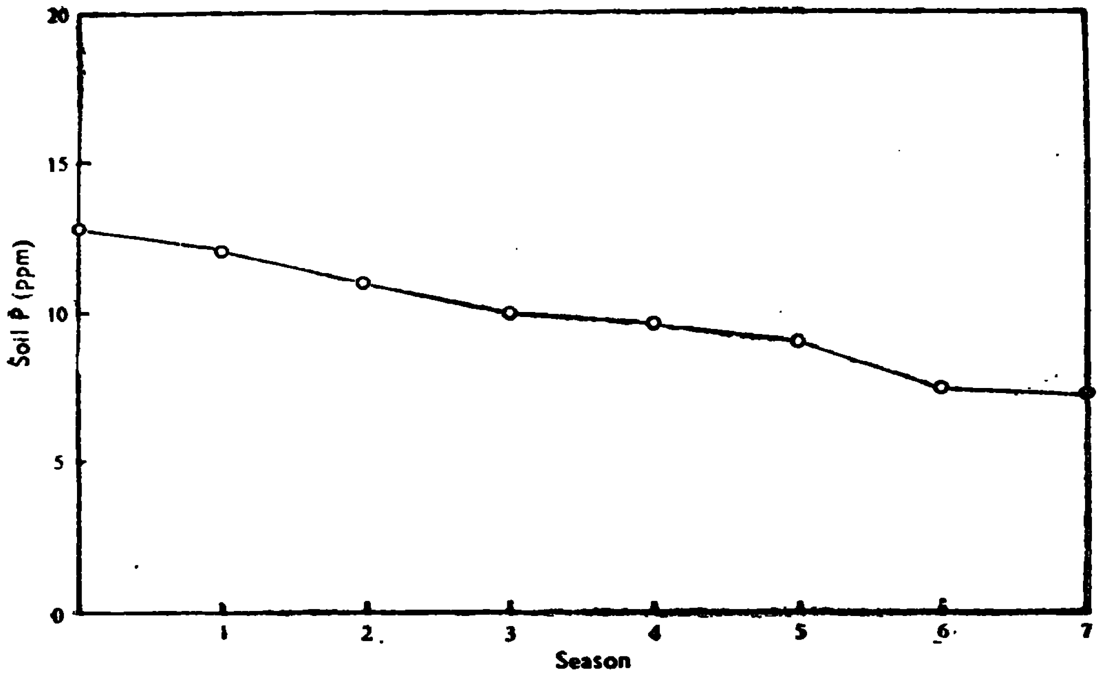

Fig. 2. Depletion of soil P in control plot

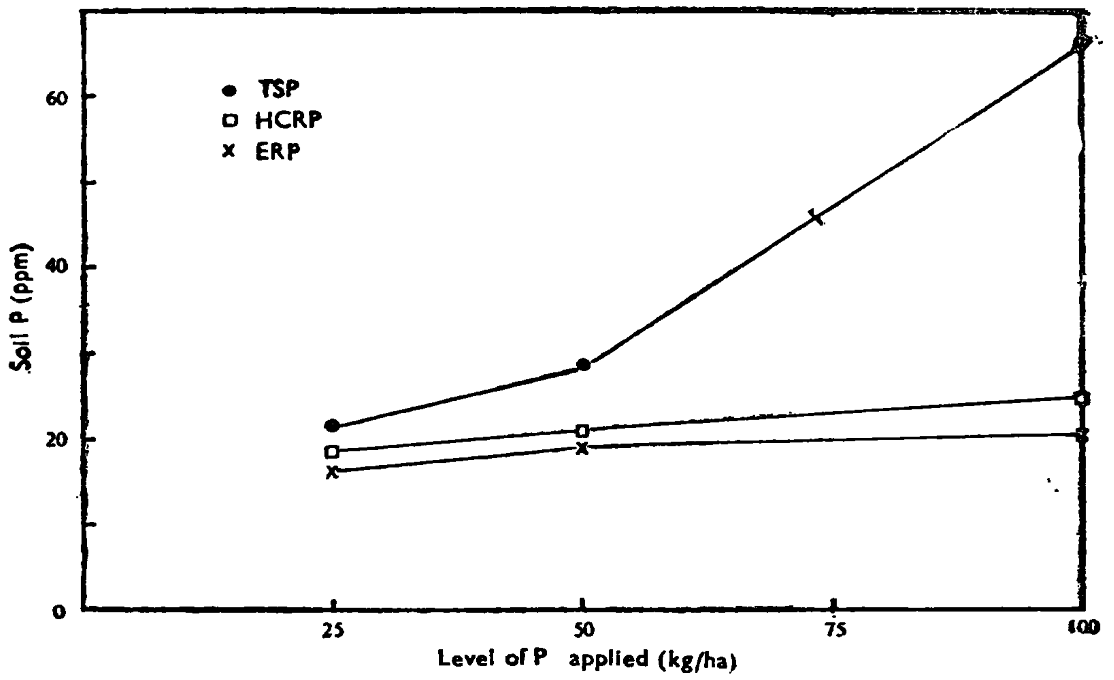

Fig. 3. Soil P after sixth crop (Cabbage. yala 90)