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THE USE OF EPPAWELA APATITE FOR TEA IN SRI LANKA†

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An experiment which compared the chemical characteristics of the two phosphate fertilizers, viz: Eppawela apatite and rock phosphate, showed that the former contained higher total P and water-soluble P than the latter. Solubility of rock phosphate in citric and malic acids was slightly higher than that of Eppawela apatite. Malic acid extracted more phosphorus from Eppawela apatite than from rock phosphate mixed with acid soil, and the release was time dependent. In a greenhouse experiment with young tea, the effect of the two fertilizers on nutrient uptake and dry matter accumulation did not differ significantly. It appears, therefore, that Eppawela apatite could be substituted for the imported rock phosphate, for tea.

INTRODUCTION

The importance of phosphate for tea in Sri Lanka was realized at the end of the last century. Since then the application of phosphate fertilizers has become popular, In a long-term trial at St Coombs, Talawakele, it was found that 34 kg P_2O_5 per hectare per annum gave the maximum yield response (Bhavanandan, 1970). Results obtained from several field experiments, both on seedling and clonal tea, showed that the application of higher levels of phosphate may be detrimental to tea (Pearce, 1959).

At the end of sixteen years of experimentation on mature tea, Tolhurst (1963) concluded that both rock phosphate and superphosphate are equally efficient for tea. Rock phosphate is used for both young and mature tea as it is more economical than superphosphate.

An apatite-bearing deposit was discovered in 1971 by the Geological Survey Department of Sri Lanka at Eppawela, situated in the North-Central Province and since then investigations were initiated to study the feasibility of using the local material as a source of phosphorus for various crops in the country. The first batch of samples were received in 1972 and, based on the chemical analysis of the rock and some preliminary investigations made at the Institute, it was reported in 1973 that the local apatite could be used on tea. Subsequently, extensive investigations were undertaken and this paper reports some of the results of laboratory and greenhouse experiments carried out to compare the two types of phosphatic fertilizers.

MATERIALS AND METHODS

Laboratory investigations

The total P was determined by fusing overnight a 1 g sample of soil thoroughly mixed with 6g of anhydrous sodium bicarbonate in a platinum crucible at 850° C. 10ml Conc. HCl was added and the contents digested on a hot plate for half an hour. The dissolved mass was diluted to 1 litre and the P content was determined by the molybdenum blue method (Fogg and Wilkinson, 1958).

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Water-soluble phosphorus

Water-soluble P was determined by leaching a 1 g sample of soil with 250 ml water. P in the leachate was determined as described earlier.

Citric acid-soluble phosphorus

1 g sample of soil was shaken for one hour with 100 ml of 2% citric acid solution at pH 2.05 in a 250 ml shaking bottle and the contents filtered through No. 42 Whatman filter paper. The filtrate was diluted to 500 ml with distilled water and the P content was determined by the molybdenum blue method.

Malic acid-soluble phosphorus

This was determined by a procedure similar to citric acid-soluble P except that 2% malic acid was used in place of 2% citric acid.

Bicarbonate-extractable phosphorus

A 1 g sample of soil was shaken for half an hour with 100 ml 0.5 molar $NaHCO_3$ solution at pH 8.5 in a 250 ml shaking bottle, the contents filtered and P in the filtrate was determined.

Leaching Experiments

Imported rock phosphate and Eppawela apatite containing equivalent amounts of P_2O_5 (lg) were incubated separately or as a mixture with 100g samples of air-dry soil obtained from the TRI Kottawa sub-station, under field moisture conditions in leaching columns overnight. The columns were leached daily with 100 ml of 2% malic acid over a period of four hours and the phosphorus contents in the leachates were determined.

Greenhouse Experiment on Young Tea Plants

Three treatments viz: zero phosphate, 34 kg P_2O_5 as Eppawela apatite, and 34 kg P_2O_5 as rock phosphate per hectare per annum were tested on young tea plants in the greenhouse. The experiment was a randomized block design with eight replicates.

Twenty four uniform, one-year-old plants of clone 2025 were planted in plastic pots. Each pot contained 2 kg of soil obtained from the TRI Kottawa sub-station, the chemical characteristics of which are given in Table 1.

TABLE 1 — *Chemical characteristics of the soil from TRI Kottawa sub-station.*

pH in water	*Phosphorus in ppm*			
(1:2.5)	*Total P*	*Water-soluble P*	*Citric acid-soluble P*	*Malic acid-soluble P*
5.3	225	0.3	3.3	5.0

The above soil was selected in this study as it contained lower amounts of total and available phosphorus compared to soils from other tea growing areas.

All plants received a basal application of 113 kg N, 68 kg K_2O and 34 kg MgO/ha/ annum in four applications.

Assessment

At the end of one year the plants were uprooted and the individual fresh and dry weights were measured. The plant as well as soil samples were analysed for nitrogen, phosphorus, potassium, calcium and aluminium.

Methods of Chemical Analysis

1 — Soil Samples

The soil samples were air-dried in the laboratory, crushed lightly with a rubber-tipped pestle and sieved through a 2 mm mesh. Total nitrogen was estimated by the molybdenum blue method. Exchangeable potassium and calcium were extracted with 1 N ammonium chloride and determined by flame photometry (Sivasubramaniam and Talibudeen, 1972).

2 — Plant Samples

The leaf, root, and stem samples were dried at 85°C overnight and ground to pass through a 60 mesh sieve. Samples were weighed in glass tubes and ashed overnight at 475°C. Ashed samples were treated with 0.5 ml of a digestion mixture (25 ml Conc. HNO_3+25ml Conc. HCl made up to 100 ml with water), and evaporated to dryness. The residue was dissolved in 10 ml of 0.05 N HCl and suitable aliquots of this solution was used for the determination of P, K, Ca and Al.

Phosphorus was determined by the vanadomolybdate method, and calcium and potassium by flame photometry (Jackson, 1958). Aluminium was determined by the modified aluminon method (Jayman and Sivasubramaniam, 1974).

RESULTS AND DISCUSSION

The total phosphorus content of the two types of phosphatic fertilizers and their extractability by various reagents are given in Table 2.

TABLE 2— *pH, total phosphorus, and soluble phosphorus of rock phosphate and Eppawela apatite*

	Rock phosphate	*Eppawela apatite*
pH in water	7.7	7.9
Water-soluble P (ppm)	26.7	86.6
Total P_2O_5 (%)	27.8	33.2
Citric acid-soluble P_2O_5 (%)	9.2	5.2
Malic acid-soluble P_2O_5 (%)	11.7	9.2

The pH of the two types of phosphatic fertilizers were similar. The total phosphorus content and the water-soluble P of the Eppawela apatite were higher than that of the rock phosphate. The latter property of the Eppawela apatite is more desirable since this form is more readily available to plants. The solubility of rock phosphate in citric and malic acid is nearly twice that of the Eppawela apatite. The lower solubility of Eppawela apatite in these two reagents may be due to its higher degree of crystallinity compared to rock phosphate. It was found that both rock phosphate and Eppawela apatite were predominantly composed of calcium phosphate with variable amounts of aluminium and iron phosphates. The difference between rock phosphate and Eppawela apatite was that the former contained a higher proportion of iron phosphate. Aluminium phosphate is more soluble than iron phosphate in these two reagents.

In addition to the standard method of using 2% citric acid, malic acid was also used as one of the extractants as it was found that the roots of tea plants exude predominantly malic acid (Jayman and Sivasubramaniam, 1975) which could chelate with iron and aluminium in the soil and mobilize the phosphate for plant uptake. Further it was found that phosphate uptake is related to aluminium and there is a possibility of formation of organic aluminium-phosphorus complexes in the uptake of phosphorus by the tea plant (Sivasubramaniam and Talibudeen, 1971). Thus the solubility of phosphatic fertilizer in malic acid is an important property in determining the availability of phosphorus to the tea plant. It, therefore, appears that rock phosphate is superior to Eppawela apatite as the malic acid extracts more phosphorus from the former.

The two types of fertilizers were leached separately with 2% malic acid and the cumulative amounts of phosphorus extracted with time are given in Fig. 1.

Successive leaching with malic acid extracted larger amounts of phosphorus from rock phosphate than from Eppawela apatite. The first few extractions removed larger amounts and with time attained a constant value for each type of phosphatic fertilizer.

Single extraction by shaking with 100 ml of malic acid yielded only 11.7 and 5.2 per cent P_2O_5 whereas leaching daily with 100 ml malic acid for a period of 19 days extracted approximately 27% and 20% P_2O_5 from rock phosphate and Eppawela apatite, respectively. During this period malic acid extracted nearly all the phosphate in rock phosphate and only 60% of the total phosphorus in Eppawela apatite, showing that rock phosphate releases phosphorus more readily than Eppawela apatite. The amount of phosphorus extracted by malic acid also depends on the method of extraction, the volume of the reagent, and the duration of extraction.

In Fig. 2 the cumulative amounts of phosphorus released from the two types of fertilizers mixed with the soil, by successive extractions with malic acid, are presented.

From Fig. 2 it is quite evident that when the phosphatic fertilizers were mixed with the soil, the amount and the rate of release of phosphorus have been significantly altered. Mixing with the acid soil has reduced the amount of phosphorus extracted by malic acid and this was more pronounced with rock phosphate than with Eppawela apatite. The first few extractions removed larger amounts of phosphorus from rock phosphate, but the trend was reversed after the fifth day.

It is standard practice to decide the suitability of a phosphatic fertilizer by determining its solubility in either citric acid or ammonium citrate. In this study malic acid was also included as it was found to be more appropriate for tea. Accordingly rock phosphate was found to be more soluble than Eppawela apatite in malic acid (Table 2 and Fig. 1) and as such it could be concluded that the former is superior to the latter. But, after mixing with the soil, malic acid extracted more phosphorus over a longer period of time from Eppawela apatite treated soil than from the rock phosphate treated soil. The two types of phosphatic fertilizers have reacted differently with the acid soil resulting in fixation of more phosphorus from rock phosphate than from Eppawela apatite. Thus the solubility of a phosphatic fertilizer in a particular extracting agent cannot be considered as the only criterion to decide its suitability for a particular crop. It is important to measure the amount of phosphorus that could be extracted from the fertilizer after treatment with the soil. Tea is a perennial crop and grows in acid soil. Because more phosphorus is extracted with malic acid from the acid soil treated with Eppawela apatite than with rock phosphate, the former is more suitable for tea.

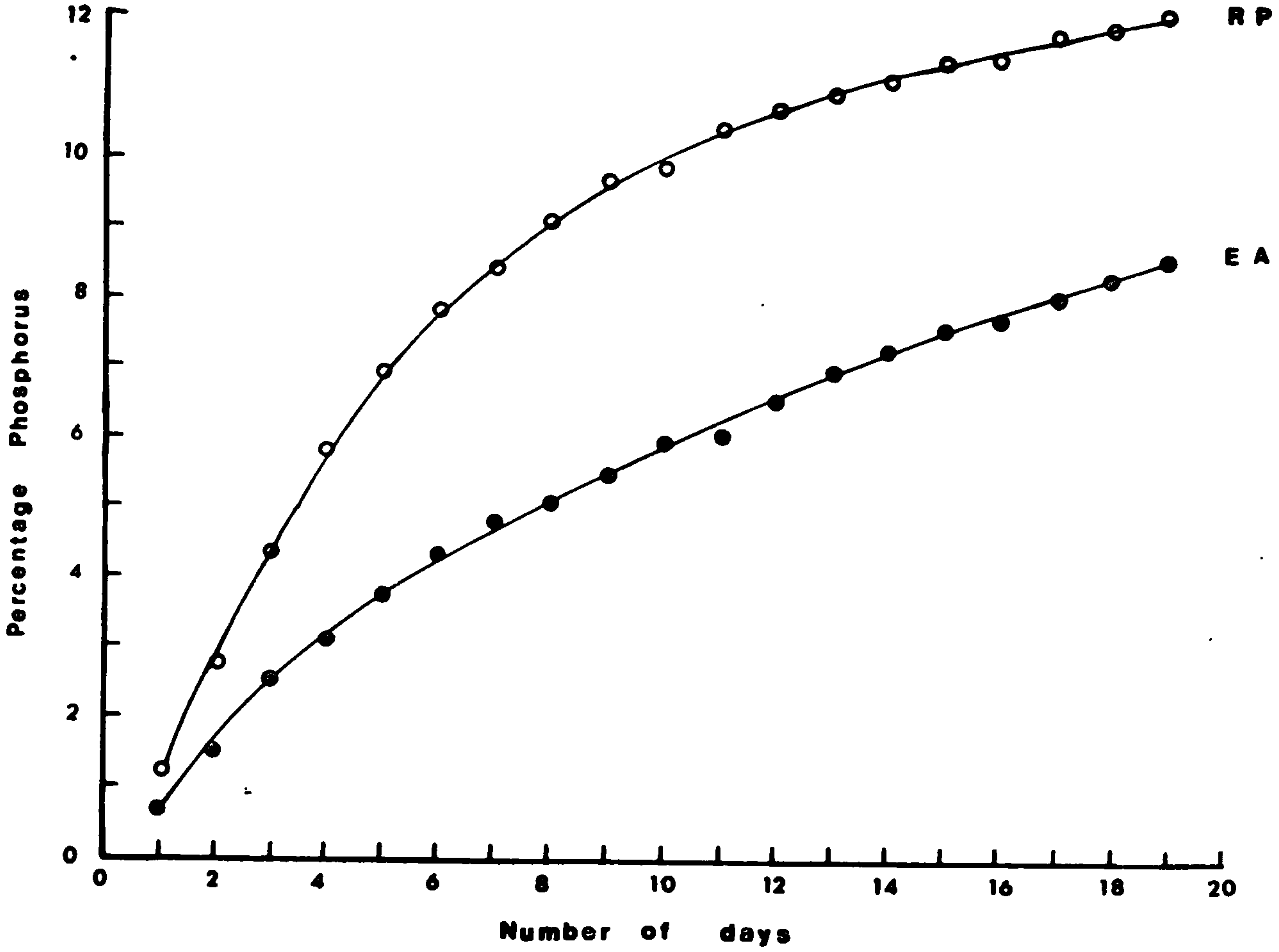

Fig. 1. — *Cumulative amounts of phosphorus extracted by malic acid from Eppawela apatite (EA) and rock phosphate (RP)*

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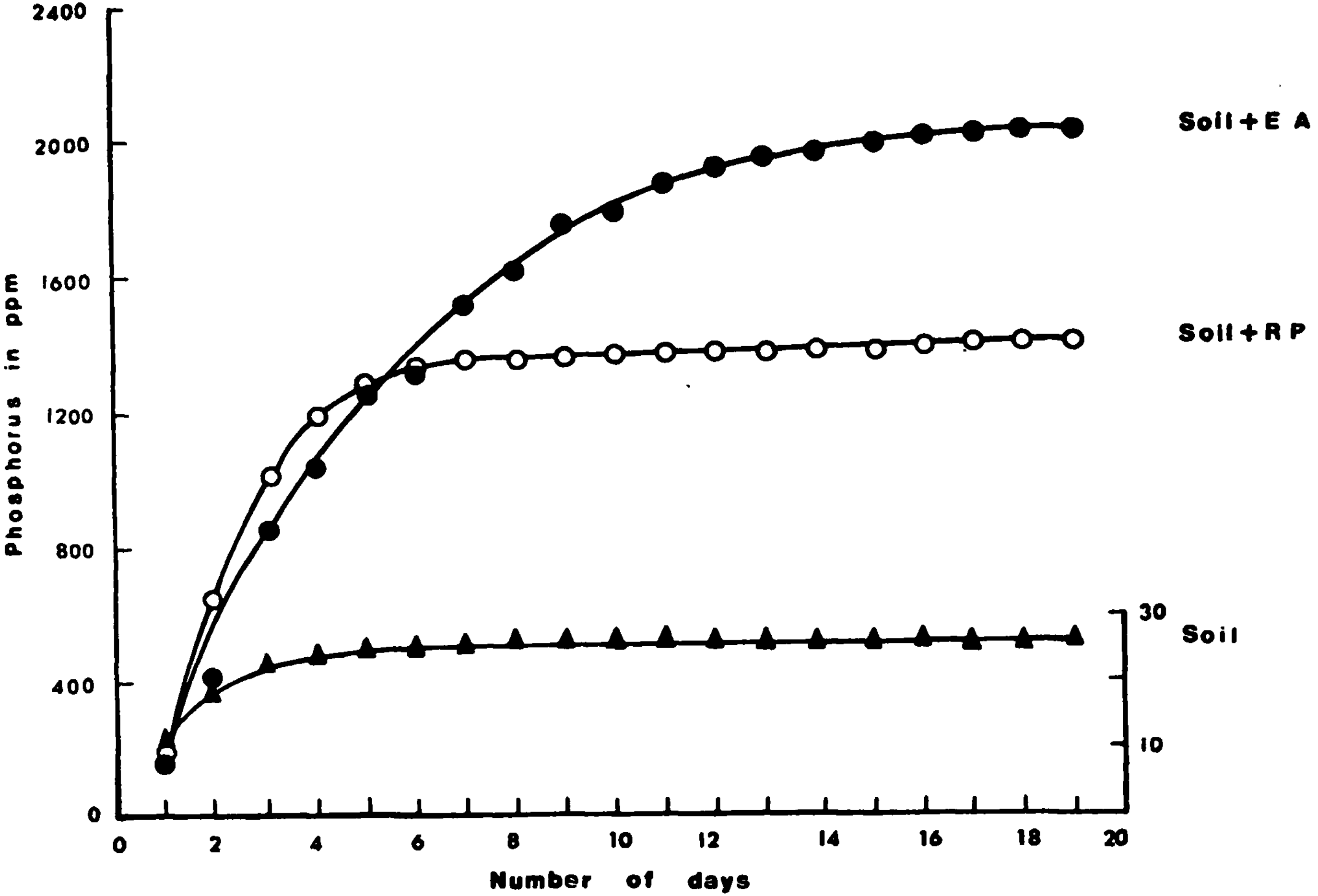

Fig. 2. — *Cumulative amounts of phosphorus extracted by malic acid from untreated soil, soil treated with Eppawela apatite (EA) and soil treated with rock phosphate (RP).*

Equomenides and Pichot (1974) found that for acid soils which have greater phosphate fixation properties the plant availability of phosphorus could be achieved only by the use of fertilizer of low solubility. Our results were in agreement with their findings. Thus, Eppawela apatite may prove to be equally or more efficient than rock phosphate for tea.

Assessment of growth of young tea plants in the greenhouse was made by taking the individual fresh and dry weights of entire plant and their respective components as leaves, stems, and roots separately in order to evaluate whether any of the treatments had any significant effect on growth. Statistical analysis of the results did not show any significant difference in growth between the rock phosphate and Eppawela apatite treated plants.

Soil and plant analyses showed that the two types of phosphatic fertilizers did not differ significantly in respect of their effect on the nutrient status of the soil and on the uptake of nutrients such as nitrogen, phosphorus, potassium, calcium and aluminium. Although it is not significant, the effect of the two types of fertilizers on the dry weight and on the uptake of phosphorus by the various components of the plant are given in Table 3, in order to show this trend.

TABLE 3—*Yield of dry matter and phosphorus uptake by young tea plants*

Treatment	*Dry weight per plant (g)*	*Phosphorus uptake in mg*			
		Leaf	*Stem*	*Root*	*Total per plant*
Zero phosphate	94.8	15.4	22.0	11.0	48.4
Rock phosphate	98.1	17.0	20.0	20.0	59.0
Eppawela apatite	102.7	20.1	23.5	20.2	63.8

The application of rock phosphate and apatite have increased the yield of dry matter and the uptake of phosphorus by the plants but this was not significant. This increase was more marked in the case of Eppawela apatite.

Rock phosphate has been recommended for young and mature tea. It appears that tea being a perennial crop, a slow and steady supply of phosphate is quite adequate, and the plant has some mechanism by which it could utilize insoluble phosphates in acid soils. The evidence from the present investigation indicates that the local Eppawela apatite could be substituted for the imported rock phosphate that is presently used for tea.

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