

EPPAWELA ROCK PHOSPHATE AS A SOURCE OF PHOSPHORUS FOR RUBBER

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The elemental phosphorus (P) was first discovered by the German physician and alchemist, Henning Brandt in the 17th century. Since then it was extracted from animal urine and bones until the 19th century, by which time the agronomic usefulness of phosphorus was established. With this the world production from the earth's crust in the form of phosphate rock grew to more than 100 million tons per year. It is expected to reach 200 million tons by the year 1990.

Plant uptake and transport of phosphorus

Phosphorus is one of the 16 nutrients essential for plant growth. This means its functions cannot be performed by any other nutrient and that an adequate supply of P is required for optimum growth and production. Except for nitrogen and potassium, P is required in greater amounts by plants than any other essential nutrient. The total P concentration in agricultural crops can vary from 0.1 to 1.0%.

Phosphorus enters the plants through root hairs, root tips and the outermost layer of root cells. It is usually taken up as the primary orthophosphate iron (H_2PO_4) but can also be absorbed as the secondary orthophosphate (HPO_4). Soil pH determines the ratio of uptake between the two. Once inside the plant root, the inorganic P is stored in the root or transported to the upper portions of the plant. There, through various chemical reactions, it is incorporated into organic compounds, including enzymes, nucleic acids and proteins. It is in these organic forms that P is moved through the plant, where it is available for further reactions.

World production of rock phosphates

Phosphate rock is the only economical source of phosphorus for production of phosphate fertilizers and phosphate chemicals. Identified reserves and reserve bases of this vital resource are shown in Table 1. Morocco has the greatest reserves, followed by South Africa, USA and USSR. China's reserves are actually much greater than indicated, and may rank as high as fourth in the world. World production of phosphate rock ranged from 158 to 163 million tons per year between 1985 and 1987 and can be seen in Table 1. Three areas of the world (USA, USSR and North Africa) provided about two thirds of this supply.

Table 1. World phosphate rock reserves, reserve bases and production

Countries	Reserves* (Million tons)	Reserve Base (Million tons)	Production (Thousand tons)		
			1985	1986	1987
United States (U.S.A.)	1,433	5,730	54,448	42,850	44,763
Israel	—	209	4,492	4,048	4,185
Jordan	132	562	6,686	6,886	7,495
Morocco and Western Sahara (Algeria)	7,714	24,244	24,183	24,664	24,275
Senegal	44	187	1,963	2,040	2,072
South Africa	2,755	2,755	2,737	3,296	2,891
Togo	44	77	2,702	2,550	2,914
Tunisia	22	331	4,992	6,558	7,042
Other Market Economy Countries	441	3,747	—	—	—
China	231	231	7,685	10,469	9,918
U.S.S.R.	1,433	1,433	37,771	37,948	38,350
Other Centrally Planned Economies	358	358	—	—	—
World Total (may be rounded)	14,574	39,865	163,366	157,604	160,765

Apatite in several different forms is the basic compound in commercially important deposits of phosphate rock. As phosphorus in apatite minerals is known to be only slightly soluble its availability to crop is also limited. However, reactive phosphate rock and partially acidulated phosphate rock are satisfactory sources of P for crops grown in some acid tropical soils.

Acidulation or heat treatment of phosphate rock is usually necessary to break the apatite bond to render the contained phosphate more soluble. Wet process sulphuric acid acidulation is the most commonly used technique for improving the agronomic suitability of phosphate rock. The majority of finished P containing materials is based on wet process phosphoric acid with phosphate rock.

Phosphate materials widely used in modern crop production systems are listed in Table 2, with both P and P₂O₅ concentrations expressed as per cent. Some of these products supply other essential plant nutrient including nitrogen, calcium and sulphur.

Table 2. Concentration of P in phosphate products

<i>Material</i>	<i>Concentration P</i>	<i>(per cent) P₂O₅</i>
Super Phosphoric Acid	30 — 35	68 — 80
Wet Process Phosphoric Acid	23 — 24	52 — 55
Concentrated Superphosphate	20	46
Diammonium Phosphate	20 — 21	46 — 48
Monoammonium Phosphate	21 — 24	48 — 55
Normal Superphosphate	7 — 10	16 — 22
Phosphate Rock	12 — 18	27 — 41

Soil resources

Drought, nutrient stress and shallow soils dominate the world's soil as major limitations to crop production. Many of these restrictions to crop production will be difficult to solve. Although nutrient stress is a serious constraint for improved crop production throughout the world, it is one of the few soil limitations that agriculturists can moderate.

Fixation of P in medium to fine textured acid soils by oxides and hydroxides of iron (Fe) and aluminium (Al) is a serious problem. Some tropical soil groups are noted for their high P fixation capacity. Research has shown that some acid soils can fix twice as much P as neutral or calcareous soils with about five times more bonding energy.

Eppawela Rock Phosphate (ERP)

The importance of phosphate in agriculture was realized in Sri Lanka at the end of the last century. Since then the application of phosphate fertilizers has become popular. With the discovery of an apatite bearing deposit in 1971 by the Geological Survey Department of Sri Lanka at Eppawela, situated in the North-central province, interest was created in Sri Lanka on the possibility of using this source of phosphate in Sri Lankan agriculture. Several investigations were initiated to study the feasibility of using this locally available material as a source of phosphate for various crops in the country. The first batch of samples were distributed for investigation in 1972. To achieve maximum benefits from the investment in fertilizer phosphate evaluations on the agronomic performance of the sources under local conditions and on Sri Lankan soils is of paramount importance.

A consistent large amount of imported rock phosphate has been used as fertilizer by the plantation sector of Sri Lanka. The extensive use of rock phosphate is because it is cheaper and as effective as soluble super phosphate when applied to Sri Lankan acid soils which is contrary to the practice in temperate countries where in general soluble superphosphate is considered agronomically far more superior than sparingly soluble rock phosphate.

The types of rock phosphate available in the world market are given below. Cost had been the over-riding factor in the past in the choice of any particular source of rock phosphate as fertilizer and less attention had been given to the agronomic efficiency of the individual sources.

Table 3. Total P₂O₅ content and citric solubility of some rock Phosphates

Phosphate			Total P ₂ O ₅	Citric solubility
			(%)	(%)
Christmas Island	...	...	36	16.84
Citraphos	...	...	30	19.47
Jordanian	...	...	32	13.63
Egyptian	...	...	30	15.46
Highlands	...	...	30	16.89
Polyphos	...	...	31/32	13.52
Hyperphosphate	...	...	30	20.96
Togo	...	...	36/38	19.00

It is also however known that the phosphate content of a given source of rock phosphate fluctuates with different consignments and even the characteristics of rock phosphate from a single source can change considerably when exploitation moves from one layer to another. This is particularly evident in the locally available material. At times, the variability observed has been large. However, to ensure the quality of the product marketed standards have been specified and that the permissible limit of variation for the actual phosphate content P (P₂O₅) is also specified.

Another important characteristic that has to be considered with regard to agronomic performance is fineness, as grinding rock phosphate to a fine particle size has been known to enhance its agronomic effectiveness.

The total phosphorus content of the two types of phosphate fertilizers used and their extractability by various reagents are given in Table 4.

These analyses showed that Eppawela rock phosphate contained higher total P and water soluble P than the imported source of phosphate. However, the solubility of imported rock phosphate in citric and malic acids was slightly higher than the Eppawela rock phosphate. It has also been reported that malic acid extracted more phosphorus from Eppawela rock phosphate than from imported rock phosphate mixed with acid soil, and the release was time dependent.

Table 4. pH, total phosphorus and soluble phosphorus of imported rock phosphate and Eppawela rock phosphate

		Imported Rock Phosphate	Eppawela Rock Phosphate
pH in water	...	7.7	7.9
Water soluble P (ppm)	...	26.7	86.6
Total P ₂ O ₅ (%)	...	27.8	33.2
Citric acid soluble P ₂ O ₅ (%)	...	9.2	5.2
Malic acid soluble P (%)	...	11.7	9.2

Use of ERP in rubber

Phosphate availability is one of the major problems in the management of soil fertility for rubber cultivation. Since most of the soils in the rubber growing areas are known to contain a high amount of sesquioxides, the phosphate absorption capacity of these soils can be expected to be high. It is for this reason that the current phosphate fertilizer recommendation of the Rubber Research Institute involves split application and using the less soluble rock phosphate instead of the more soluble super phosphate.

Investigations on the use of ERP as a source of phosphate for rubber were started by the Rubber Research Institute of Sri Lanka in 1972. Although the results obtained during the early stages of the investigations suggested that growth of immature budded stumps will not be retarded if this product is used as the source of phosphate from subsequent investigations it appeared that Eppawela rock phosphate may not be suitable for immature rubber plants.

Table 5. Effect of phosphates on yield of rubber

	<i>Yield of rubber. (kg/ha/yr)</i>						
	1981	1982	1983	1984	1985	1986	1987
Zero phosphate	1011	875	1102	940	1673	1339	1555
Eppawela rock phosphate							
Current recommendation	1025	918	1108	1040	1897	1494	1662
Double	1071	940	1209	1034	1986	1494	1656
Imported rock phosphate							
Current recommendation	1007	948	1147	1051	1880	1472	1718
Double	1098	910	1130	1139	2009	1499	1751

When efficiency of fertilizer utilization by rubber in production is concerned it has been demonstrated as can be seen from the data presented below, the both Eppawela and imported rock phosphate are equally effective at the currently recommended rates.

Moreover, fertilizers to mature rubber are now recommended on the basis of leaf analysis and the use of ERP had been recommended on a 50% substitution basis since January 1981. The leaf P values from most of the estates where this recommendation has been implemented also suggest that the use of Eppawela rock phosphate had not had any adverse effect on Leaf P levels in these plantations. Most of the values were within the category of medium to high and in some cases very high levels of leaf P suggesting efficient uptake of P from ERP.

The RRI has taken all these and several other aspects of phosphate fertilization of rubber and associated ground cover crops under our soil conditions into consideration and had recommended the use of Eppawela rock phosphate as the only source of phosphate for rubber in production in Sri Lanka. The use of imported rock phosphate is however recommended for immature rubber.