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STATUS AND RATIONAL USE OF ROCK PHOSPHATE IN AGRICULTURAL CROP PRODUCTION *A REVIEW*

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ABSTRACT

Phosphorus (P) is a one of most important plant nutrient, it called energy currency. But lower concentration of P in indigenous rocks increased cost of production and reduce profit from crop cultivation. Use of easily available options like rock phosphate with crop residues, use of microbial fertilizers, recycling of P from waste materials, application of P fertilizers at optimum time, modification in *Rhizospheric* environment etc. By this means we can reduce yearly P fertilizers import as well as fulfill our demand. These options are cheap as well as environmentally friendly. One way it will supply plant nutrient by enhancing phosphorus use efficiency (PUE), and other way reduces storage space as a waste materials.

Keywords:
Phosphorus, Plant uptake, Phosphorus use efficiency, Rock phosphate

INTRODUCTION

Indigenous as well as modern farming practices enhance the productivity, food and fodder that are helping to feed billions of people and animals. Phosphorous is a structural plant nutrient which is having lot of importance in quantity and quality of food grain production. It includes the application of phosphorus (P) fertilizers manufactured from rock phosphate, a non-renewable resource used increasingly since the end of the 19th century. But in greedy of higher crop production and poor awareness of P fertilizer application or management strategies, enhanced the cost of P fertilizer tremendously in few decades. The dependence of food production on phosphate rock calls for sustainable management practices to ensure its economic viability and availability to farmers. It is the time to think behind the vital source of P fertilizer *i.e.* rock phosphate and search for its alternative sources. While there are commercially exploitable amounts of phosphate rock in several countries, those with no domestic reserves could be particularly vulnerable in the case of global shortfalls (Johnston and Richards, 2003). Phosphorus is the most important key element in the nutrition of plants, next to nitrogen (N). It plays an important role in virtually all major metabolic processes in plant including photosynthesis, energy transfer, signal transduction, macromolecular biosynthesis and respiration (Khan *et al*., 2010). At the time of green revolution more attention of research on agronomic evaluation of P sources has increased considerably in India, due to the rising prices of soluble P fertilizers and the dependency of the country on external P supplies. It is estimated that only one fifth of the P mined in the world is consumed directly or indirectly by humans as food (Schröder *et al*., 2010). Therefore, the search for alternative phosphate fertilizers has been a constant concern. It is one of the major constraints to food production in the India under the poor P status soil (Dotaniya and Datta, 2013). Use of conventional, water-soluble P fertilizers has been limited primarily by the high cost across the globe (Chien *et al*., 1996). Phosphorous utilization efficiency by the crop varying 18 (Fig 1), due to crop-wise and species-wise nature of soil, microbial diversity and climatic factors (Aulakh and Pasricha, 1991). While good agronomic management requires use of fertilizer P to optimize crop growth, excessive application of P may degrade water quality.

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Why phosphorus for plants

Phosphorus is one of the key elements necessary for the growth of all forms of life on planet earth including plants (Dotaniya *et al.,* 2013), animals and micro-organisms as a component of nucleic acids, phospholipids that compose cellular membranes, ATP and ADP molecules and intermediate compounds of respiration and photosynthesis (Taiz and Zeiger, 1998). Long journey of scientific research has been proved that P played a vast role in enhancing and sustainable crop productivity across the globe. Indigenous P finite, non renewable and limited resource on the earth, but continuous supply of P through manure and fertilizers is indispensable for crop production.

Table1 Phosphate rock annual world production capacity (USGS Mineral Commodity Summary, 2011)

Countries	Production (In '000 metric tonnes)
China	65000
United State	26100
Morocco & W Sahara	26000
Russia	10000
Tunisia	7600
Jordan	6000
Brazil	5500
Egypt	5000
Israel	3000
Australia	2800
Syria	2800
South Africa	2300
Algeria	2000
Tago	800
Canada	700
Senegal	650
Other	9500

Availability of rock phosphate (RP)

Rock phosphate is mainly found in sedimentary deposits, have provided about 80- 90 per cent of world production and mostly distributed (Table 1) in Morocco and other African countries, the United States of America, the Near East and China (Jasinski, 2004). New phosphate rock mines have been commissioned in several countries like Australia, Peru and Saudi Arabia, while undiscovered deposits are being widely sought, including in seafloor sediments off the coast of Namibia as well as across the globe (Drummond, 2010). Most sedimentary deposits contain the carbonate-fluorapatite called francolite (McConnell, 1938). Igneous deposits have provided about 10-20 per cent of world production and they are exploited in the Russian Federation, Canada, South Africa, Brazil, Finland and Zimbabwe. Under the Indian conditions total resources of rock phosphate as per United Nations Framework Classification system as on year 2010 are placed at 296.3 million tonnes. Out of these, the reserves constitute only 34.8 million tonnes. There are 261.5 million tonnes remaining resources, of the total resources, 36% are in Jharkhand, 30% in Rajasthan, 17% in Madhya Pradesh, 9% in Uttar Pradesh and 8% in Uttarakhand. Meagre resources are located in Gujarat and Meghalaya. Gradewise, low grade account for 39%, followed by beneficiable (29%), soil reclamation (12%), blendable (9%), chemical fertilizer (6%) and unclassified and not-known grades (about 5%) (Indian Minerals Year book, 2011). On the basis of phosphorus concentration in rock phosphate it categorized into

A) Low grade

As per the international standard for the categorization of low grade, it contains phosphorus concentration below fertilizer grade (+30% P_2O_5). In India, about 190 million tonnes of low grade rock phosphate with an average of 12% P_2O_5. Under these prevailing circumstances utilization of low grade rock phosphate for direct applications or with low energy inputs in eco-friendly way, holds the key in widening the base of phosphate exploitation in India.

B) High grade

India has reserve of 14.7 million tonnes of high grade rock phosphate (+30% P_2O_5) and 145 million tonne is of beneficiable (20-25% P_2O_5), soil reclamation (11-20%) and unclassified grades. Out of the total Indian reserve, Rajasthan has largest reserve of rock phosphate of about 78.8 million tonnes (Jaggi 2000).

Phosphate rock, like oil, is a non-renewable resource and approximately 50-100 years remain of the current known reserves. Further, a peak in global production- peak phosphorus - is estimated to occur by 2035 (Cordell *et al.,* 2009). Solution P, active P and fixed P are the three main pools of P in soil. The solution P pool is very small; usually contain only a fraction of a kg of P per hectare. The solution P will usually be in the orthophosphate form, but small amounts of organic P may exist as well. One pool of P conversing into another pool (Soil solution ↔ active P ↔ *fixed P).*

Factors affecting efficiency of rock phosphate

Among the soil properties, soil pH, exchangeable Ca, P-sorption capacity and organic matter are reported to be the main factors affecting the agronomic potential of PRs (Khasawneh and Doll, 1978) evaluate the agronomic effectiveness of rock phosphates through the use of ^{32}P and related techniques (Zapata, 2000). Increased intensification of agricultural production in existing cultivated land resources requires the rational utilization of high agricultural inputs; in particular fertilizers to replace the nutrients removed by the harvested portion of crops and recycle (Fig 2) the P in ecosystem (Rao *et al.,* 1996; Dotaniya, 2012). Nowadays chemical fertilizers are costly for many developing countries with insufficient foreign exchange for their purchase. In addition, their supplies are limited and irregular for small land holders (Bowen and Zapata, 1991). Alternatives nutrient sources must be sought and evaluated for developing sustainable agricultural production systems. Locally available organic materials of different origin are potential sources of P supply during crop growth (Dotaniya and Datta 2013; Dotaniya *et al.,* 2013). Addition of organic residues decomposed, released organic compounds and plant secreted low molecular organic acids dissolved the *in situ* immobilized P into labile P in soil solution (Dotaniya *et al.,* 2013; Shukla *et al.,* 2013; Pingoliya *et al.,* 2013). Phosphate rocks can be made more effective by different biological and/or technological processes (Kato *et al.,* 1995).

Global use of fertilizers that contain P, nitrogen and potassium increased by 600% between 1950 and 2000 (IFA, 2006). This helped to fulfill the hungry mouth of growing world population, but excessive or inappropriate fertilizer use for crop production has also led to significant pollution problems in

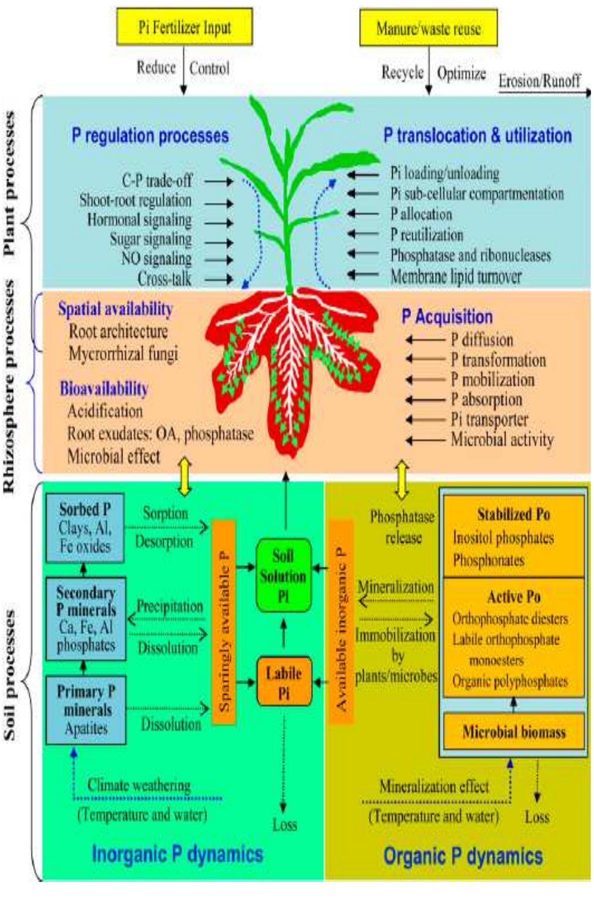

Fig1 Phosphorus dynamics in soil/rhizosphere-plant continuum (Adopted from Shen et al., 2011)

some parts of the world. This situation is more alarming in developing countries compared developed.

In the last half century, the P concentrations in freshwater and terrestrial systems have increased by at least 75 % while the estimated flow of P to the ocean from the total land area has risen to 22 million tonnes per year (Bennett *et al.,* 2001). This critical amount of P exceeds the world's annual consumption of P fertilizer, estimated at 18 million tonnes in 2007 (FAOS, 2009). While much of the P accumulated in terrestrial systems would eventually be available for plant growth, there is poor practical way to recover P lost to aquatic systems. The cost of recovery from aquatic system also very costly which is limit the researcher for further use of this P fractions in crop production. This P fraction reached by point or non point sources to aquatic systems and results in eutrophication, which promotes excessive algal and aquatic plant growth along with undesirable impacts on biodiversity, water quality, fish stocks and the recreational.

Strategies to enhanced P use efficiency

- The rock phosphate and bone-meal are applied directly in large amounts to acid soils, where the sparingly soluble phosphates are converted into a form usable by plants.
- Broadcasted applications of water-soluble P fertilizers where less effective than banding the fertilizer.
- Guano materials are natural organic nutrient sources of different animal origin, normally found in deposits mainly in coastal areas. Normally, when fresh and rich in urine, they are mainly a source of nitrogen (12 to 15% N and 8-10 % P_2O_5) and when dry and old, they became a good source of P (15-20 % P_2O_5).
- Increasing the root surface/soil contact area, this can be achieved by modifying the root morphology.
- Application of rock phosphate with compost as a enrich compost.
- Modification in the size and physiochemical properties of rock phosphate as per crop need.
- The integration of inorganic and organic nutrient sources is widely advocated as a rational strategy for efficient use of scarce resources to increase and sustain crop yields and soil fertility status.
- Recycling of P from organic wastes.

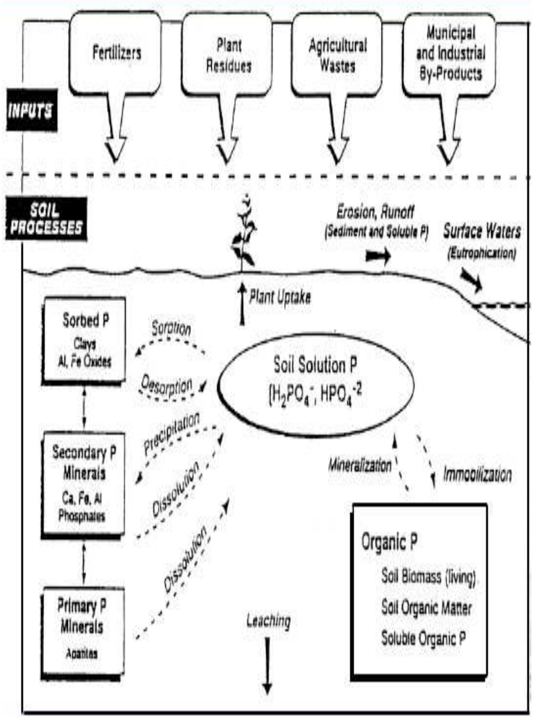

Fig 2Soil phosphorus cycle (Pierzinski *et al.,* 1994)

CONCLUSIONS

Phosphorus is an integral part of plant nutrition. It involves many metabolic activities in plant. But due to totally import fertilizer from foreign countries, and low P use efficiency limit our agricultural production, and directly and indirectly affect the national growth and a big challenge for policy maker. Due to immense research in this field gives us some clue to reduce phosphatic fertilizers import. Use of tradition P sources, integrated nutrient management, suitable agronomic practices, use of agro waste and enrich indigenous low grade rock phosphate for crop production. Evolved high P efficient crop varieties by natural selection or biotechnological ways. Reduce P immobilization and loss, which can help to reduce requirement of P during crop production and also reduce environmental pollution across the globe.

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