Phosphorus as an Important Nutrient for Crops

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Introduction

Phosphorus is the second fertilizer element, and it is a necessary component of all living cells as well as plant and animal nutrition. It is less prevalent in soils than N and K, yet it plays an important role in agriculture's sustainability and growth. Phosphorus is an essential plant nutrient; no plant on the world can complete its life cycle without enough P. The total P concentration of Indian soils varies between 100 and 2000 parts per million. Inorganic and organic P-forms make up the total P in soil. The active form of inorganic phosphorus is inorganic phosphorus bonded to aluminum (Al-P), iron (Fe-P), and calcium (Ca-P). Al-P and Fe-P are more prevalent in acid soils, while Ca-P dominates in neutral-alkaline soils. In most cases, the Al-P and Fe-P fractions are the dominant donors to plant available P. Because only a small fraction (1%-3%) of the total Phosphorus in any soil is in a form that is available to plants, soils are known to differ widely in their capacity to deliver Phosphorus to crops. The capacity of labile P to replenish soil solution P taken up by the plant is dependent on the ability of water soluble fertilizer P applied to soil to rapidly dissolve and increase P in soil solution for adequate P nutrition.

Table 1 Phosphorus scenario in Indian soil

Form of phosphorus	All India (%)	Arid Region (%)
Plant available form	>1 – 3	0.8 – 1.6
Unavailable inorganic form	15 – 79	75 – 79
Organic form	18 – 90	18 – 22

Function of phosphorus in plant

1. The most essential function of phosphorus is in energy storage and transfer.

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2. Adenosine di-and triphosphates (ADP and ATP) act as "energy currency" within plants.
3. Phosphorus is an essential element of deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).
4. Phosphorus stimulates root development and growth in seedling stage to establish the seedling quickly.
5. It encourages the better growth of shoots and roots.
6. It also stimulates the flowering, fruit setting and seed formation and developments of roots.

Phosphorus deficiency in plant

1. The most common visual symptoms include overall stunted of the plant and darker coloration of leaves.
2. Purple leaf coloration is commonly associated with phosphorus deficiency in corn and other grasses.
3. Root and shoot growth is restricted and plant become thin and spindly.
4. Potato tubers show rusty brown lesion.

Table 2: Phosphorus content in selected animal wastes: Animal

	Total P	**Inorganic P**
…………% dry matter …………		
Swine	1.5-2.5	0.8-2.0
Beef cattle	0.7-1.2	0.5-0.8
Dairy cattle	0.5-1.2	0.3-1.0
Poultry	0.9-2.2	0.3-1.2
Horses	0.4-1.4	0.2-0.8

Table 3 Phosphatic fertilizers: Source of Phosphorus:

Name of fertilizer	**Chemical composition**	**Percentage of P2O5**	**Acidity or Alkalinity**
Single superphosphate	Ca (H2PO4). 2H2O	16.0-20.0	Neutral
Double superphosphate	2Ca (H2PO4). 2 H2O	30.0-35.0	Neutral
Triple superphosphate	3Ca (H2PO4). 2 H2O	45.0-50.0	Neutral or acidic

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Basic slag	(CaO)3P2O5SiO2	3.0-8.-	Alkalinity
Dicalcium Phosphate	CaHPO4	35.0-40.0	Acidic
Rock Phosphate	Ca3(PO4)2CaF2	23.0-24.0	
Boanmeal	Ca(PO4)3CaF2	20.0-25.0	Alkalinity

How to exploit native unavailable phosphorus

The advantage of phosphorus is may not loss from the system; therefore, it has every possibility for exploitation. Native P can be mobilized:

1. To increase the activity of phosphates and phytase in the soil through efficient microorganisms or plant species.
2. To inoculate P mobilizing bacteria.
3. To increase organic acid concentration in the soil through efficient plant and microorganisms.
4. To take help of mycorrhizal fungi.
5. To introduce nano-nutrients.

Mobilization of organic Phosphorus

The soils having high organic matter content generally have high Phosphorus. The organic phosphorus compounds can be generally classified into three groups, namely,(i) the inositol phosphates, the major constituent with inositol and pentasphophates, primarily of plant origin, comprising up to 60% of soil organic P; (ii) the nucleic acids; and (iii) the phospholipids.

In all agricultural soils, 18-90 percent of total P is contained in organic form. Clay soils have more organic P than course-textured soils, but they have less than humus soils (Dalal, 1978). Plants can use organic P once the C-O-P bond is hydrolyzed by phosphates and phytase. The efficiency of hydrolysis of various organic P compounds by various fungi ranged from 2.12-4.85 mg min-1 g-1 for glycerophosphate to 0.92-2.10 mg min-1 g-1 for phytin in a fungal mat (Yadav and Tarafdar, 2003). Plant-available inorganic phosphate (Ca-P, Fe-P, AI-P) is released into soil by phosphate dissolving bacteria through the secretion of organic acids from unavailable inorganic phosphate (Ca-P, Fe-P, AI-P).

Many fungus and bacteria, such as Aspergillus, Penicillium, Bacillus, and Pseudomonas, are potential phosphorus solubilizers (Subba Rao, 1977). Under arid field conditions, the effect of inoculating phosphate solubilizing bacteria (Pseudomonus striata and

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Bacillus Polymyxa) was investigated. The genotypes differed in their ability to create phosphobacteria. At crucial growth phases of pearl millet, there was a 64 percent rise in the population of P. striata and a 71 percent increase in the population of B. ploymyxa in the rhizosphere. Organic acids (lactic, formic, citric, malic) also play a role in mobilising native phosphorus in plant-available form (Gharu and Tarafdar, 2004). Arbuscular mycorrhizal fungi can transport inorganic phosphorus to plants both from organic and inorganic sources. It has been found that under field condition with the application of P mobilizers including AM fungi the available P status in the bulk soil never exceeds 5% of the total P as well as the applied P use efficiency does not exceed 20%.

Nanotechnology intervention may improve P use efficiency by increasing enzyme release for P mobilization, resulting in 80-100 times reduced crop demand and the ability to mobilise > 10% of phosphorus in plant-available form. Cuticle, stomata, hydathodes, stigma, root tips, cortex, lateral root connections, and other plant components can all allow nanoparticles to penetrate and pass the cell wall before entering the intact plant cell protoplast. Many enzyme systems may be triggered during their migration, causing increased secretion through roots and forcing plants to be more active in nutrient mobilisation in the rhizosphere. Plants can increase their phosphatase and phytase release by up to 70% when given 10 ppm nano-Zn and 30 ppm nano-Fe. They also up to 2.5-fold increase the release of P mobilising enzymes.

References

Dala, R.C (1978). Organic phosphorus, *Advances in Agronomy*, **27**, 83-117.

Gharu, A. And Tarafdar, J. C. (2004). Influence of organic acids on mobilization of organic and inorganic phosphorus in soil. *Journal of Indian Society of Soil Science*, ***52***, 248-253.

Subba Rao, N. S. (1977). Soil micro-organisms & plant growth. Oxford & IBH Publishing CO; New Delhi.

Yadav, R.S. and Tarfdar, J. C. (2003). Phytase nad Phosphatase producing fungi in arid & semi-arid soils & their efficiency in hydrolyzing different organic P. *Soil Biology and Biochemistry*, **35**, 745-751