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Mechanisms of Phosphorous Solubilization

Vishwakarma M* and Tagore GS

Department of Soil Science and Agril Chemistry, India

***Corresponding author:** Megha Vishwakarma, Department of Soil Science and Agril Chemistry, JNKVV, Jabalpur, Madhya Pradesh, India, Email: meghavishwakarma007@gmail.com

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Abstract

One macronutrient needed for plants to function properly is phosphorus (P). Deficits in P can hinder plant growth and development because it is essential to all aspects of plant growth and development. Even though organic and inorganic compounds found in soil contain total P, many of these compounds are fix in soil with Fe, Al in acidic soil and Ca in and hence inaccessible to plants. Alternative methods of providing P are required because many farmers cannot afford to use P fertilizers to reduce P deficits. A class of helpful microorganisms known as phosphate solubilizing microbes (PSMs) is able to hydrolyze both organic and inorganic insoluble phosphorus compounds into soluble P form that is readily absorbed by plants. PSM offers a cost-effective and environmentally beneficial way to combat P scarcity and the plants' subsequent uptake of it.

Keywords: Phosphorus; Fertilizers; Phosphate Solubilizing Microbes; Hydrolyze

Introduction

Microorganisms found in biofertilizers have the ability to initiate a biological process that promotes plant development and guarantees healthy growth. These microbes are useful for more than just fertilization. They change the forms of soil elements that are inaccessible for plants to ones that are accessible. After nitrogen, phosphorus (P) is the next most important macroelement [1]. A soluble form of phosphorus is necessary to maximize crop growth and yield. Even though most soils have a sizable amount of inorganic P, the majority of it is in insoluble forms that crops cannot use unless they are solubilized. In acidic soils, soil P is fixed as Fe- and Al-P, and in alkaline soils as Ca-P. These are P in its inorganic form [2,3]. Additionally, organic P found in soils is only useful to plants when it has mineralized. Biofertilizers that P-solubilize or mobilize: These comprise phosphate-solubilizing microorganisms (PSMs) such as Bacillus, Pseudomonas, and Aspergillus, as well as phosphate-solubilizing bacteria (PSB). Mycorrhizae, also called vesicular-arbuscular mycorrhizae, VA-mycorrhizae, or VAM, are nutrient-mobilizing fungi. In addition to their ability to solubilize insoluble forms of inorganic P [4,5], phosphate-solubilizing microorganisms can also mineralize organic forms of P, increasing the availability of native soil P and enhancing their P.

Mechanism of PSM for P solubilization

Lowering Soil pH: Lowering soil pH through microbial production of organic acids or proton release is the main mechanism for solubilization of soil P. These organic acids are byproducts of microbial metabolism, which primarily occurs through fermentation when glucose is utilized as a carbon source or through oxidative respiration. Phosphate can precipitate to form calcium phosphates in alkaline soils. Citric, lactic, gluconic, 2-ketogluconic, oxalic, glyconic, acetic, malic, fumaric, succinic, tartaric, malonic, glutaric, propionic, butyric, glyoxalic, and adipic acid are the main organic acids that solubilize phosphates.

Production of CO_2: It is also known that PSMs cause acidity through CO2 evolution. CO2 is released into soils through the respiration of soil animals, bacteria, fungi, and plant roots. Carbon dioxide is released when decomposers break down dead material from plants and other organisms. Carbonic acid (H2CO3) is a weak acid that breaks down into bicarbonate ions (HCO3-) and hydrogen ions (H+) when combined with water and carbon dioxide. Therefore P ions are produced when H+ is substituted for Ca2+, which increases the solubility of calcium phosphates.

Chelation: Organic molecules known as chelating agents have the ability to encapsulate or trap specific metal ions, such as calcium, magnesium, iron, cobalt, zinc, and manganese, and subsequently release these ions gradually so that plants can absorb them. Phosphate's bound cations are chelated by the hydroxyl and carboxyl groups (anions) generated by organic and inorganic acids, which transforms the phosphate into soluble forms. 2. Ketogluconic acid is an effective calcium chelator.

Mineralization: Mineralization is the process of converting organic P into inorganic P. PSM mineralizes organic phosphate to convert it into a form that can be used. It takes place in the soil at the expense of animal and plant remains, which are rich in organic phosphorus compounds like phospholipids, sugar phosphates, phytic acid, nucleic acids, and phosphonates. PSMs produce phosphatases, such as phytase enzymes, which hydrolyze organic forms of phosphate compounds and liberate inorganic phosphorus, which is how they mineralize soil organic P. The fungi that are frequently reported to produce phytase include *Aspergillus candidus, Aspergillus fumigatus, Aspergillus niger, Aspergillus parasiticus, Aspergillus rugulosus, Aspergillus terreus, Penicillium rubrum, Penicillium simplicissimum, Pseudeurotium zonatum, Trichoderma harzianum, and Trichoderma viride.*

Vesicular-arbuscular mycorrhizae, another name for mycorrhizae, are nutrient-mobilizing fungi. Mycorrhizal fungi coexist in harmony with more than 90% all vascular plant species, including numerous significant crop species, including rice, potatoes, wheat, and maize [6,7]. By creating a bridge between the roots and the soil, mycorrhizal fungi enable the roots to receive nutrients from the soil.

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