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Phosphate Solubilizing Bacteria: A Promising Approach For Improving Phosphorus In Agricultural Soils

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Abstract

One of the most crucial elements for crop growth and advancement is phosphorus (P), a key macronutrient in soil. Plant yields are decreased as a result of the P shortage caused by the insolubility of P resources in the soil. Fertilisers containing phosphate are widely used to remedy soil P deficiency. P deficiency in soils is caused by a decrease in the overall P content of the soil as well as the fixation of extra P from chemical fertilisers and other organic sources, such as manures. Even in the presence of an acceptable level of P stress, plants don't react very significantly. P's availability is primarily constrained by its solubilization because P is fixed in both acidic and alkaline soils. These PSMs' capability to solubilize P varies and is mostly influenced by the solubilization process employed, their molecular makeup, and their ability to release P in soil. A healthy way to alleviate the P deficiency in the soil is to employ PSMs as biofertilizers. The investigation of efficient PSM cultivars for use as biofertilizers is one of the key focus areas for improving agricultural productivity by reducing P scarcity. The goal of this review was to understand the ecology and diversity of PSMs, how P is soluble, and how PSMs are used as biofertilizers.

Keywords: Phosphorus, phosphate solubilizing microorganisms (PSMs), biofertilizer

Introduction: -

Phosphorus (P) is one of the most important essential nutrients for the proliferation as well as growth of plants. It takes up between 0.2% and 0.8% of the dry weight of plants and is found in phospholipids, nucleic acids, enzymes, coenzymes, and nucleic acids. Phosphorus is the second-most important macronutrient for plants, behind nitrogen. Plants can only absorb 0.1 percent of the typical soil's weighted phosphorus content. Plant roots may still absorb phosphorus in the form of t
he orthophosphates $H_2P0_4^-$ or $H_2P0_4^-$ even when the ratio of these ions in the soil is in the micromolar range. Insoluble calcium, aluminium, and iron phosphates are the soil's most common types of phosphates.

Phosphorus plays a crucial role in biochemical processes including photosynthesis, root and stem growth, and crop maturity, which affect agricultural production and disease resistance. Historically, soil phosphate shortages have been treated with phosphorus fertilisers. Phosphate anions in chemical fertilizers are highly reactive and inaccessible to plants. Only 5-25% of effective fertilisers develop insoluble complexes of phosphate salts, making them ineffective for plants. Additionally, the prolonged use of phosphorus fertilisers results in eutrophication, water contamination, and soil acidification. Therefore, increasing the absorption of soil-insoluble phosphate for plants is one of the key goals of agricultural and forestry growth.

The biological functions of soil microorganisms include regulating nutrient uptake by plants and phosphorus mineralization. By solubilizing and mineralizing phosphorus, these microbes make the soil more appealing to plants. Due to their benefits, including environmental safety, low cost, and great efficiency, phosphate-solubilizing microorganisms are gaining popularity. The production of several micronutrients can be boosted using a practical approach that includes phosphate biofertilizers, improving biological nitrogen fixation, and phytohormone synthesis. It has been demonstrated that phosphorus-solubilizing microbe inoculations enhance plant growth and phosphorus absorption in both indoor and outdoor plants. Phosphorus must be absorbed and used by plants for both practical and environmental reasons. Through the solubilization of soil microorganisms, phosphate-solubilizing bacteria are an efficient technique to increase plant phosphorus absorption.

Importance of Phosphate Solubilizing Bacteria

Studies have shown that phosphate solubilizing bacteria (PSB) may convert inorganic immobilized phosphate into a form that plants can use. PSBs can chelate the cations associated with phosphate and convert them into soluble forms by producing low-molecular-weight acids such as organic acids. *Microbacterium sp.*, *Pseudomonas sp.*, and *Rhizobium* are a few of the most significant phosphate-solubilizing microorganisms. During inoculation or cultivation, PSB can be used to enhance the quantity of phosphate in the soil. Phosphorus biofertilizer in the form of microorganisms can also be applied to phosphate-deficient soil. Nitrogen fixation in plants is enhanced by using PSB derived from PVK (Pikovaskaya's medium) as a bio-fertiliser and permitting phosphate solubilization and availability.

Interaction of PSB with other Microorganism

In accordance with several studies (Perez et al., 2007), the symbiotic relationship between PSB and plants is mutually beneficial since the bacteria produce soluble phosphate while the plants supply root-borne carbon molecules, mostly sugars, that may be metabolized for bacterial development. The PSM and other beneficial rhizospheric microbes increase crop production. It has been shown that the combined application of Rhizobium with PSM or AM fungi promotes plant development more than simply their solo inoculation in specific situations when the soil is P-deficient. Synergistic effects on plant growth have been seen by inoculating PSB with nitrogen fixers like *Azospirillum* and *Azotobacter* or with VAM fungi.

Bio-Fertilizer Preparation Using Phosphate Solubilizing Bacteria

10 days were spent shaking a loop of liquid medium with PSB inoculums in it. After being sterilized, broth is added, inoculated with mother culture, and autoclaved for three hours. Following that, broth and lignite powder are combined and left at room temperature for 6–10 days. It is then placed in an airtight bag and kept at 15°C for six months.

Effect of PSB on Crop Production

Mycorrhiza with arbuscules Crop yields can rise by up to 70% when phosphatic rock is inoculated, which boosts the absorption of both natural and phosphatic rock minerals. Crop yields are raised as a result of the solubilization of applied phosphates and deposited soil P by PSB. Microorganisms with phosphate solubilizing activity improve the supply of soluble P and promote plant development by improving biological nitrogen fixation. Pseudomonas spp. enhanced the soybean crop's nodule count, dry weight, yield-related factors, crop yield, and nutrient availability and absorption, according to Son et al. (Son et al., 2006). On the other hand, without affecting the output of maize, co-inoculation of PSM and PGPR lowered P application by 50%. The length of chickpea seedlings was enhanced by bacteria that solubilized phosphate. Production of sugarcane rose 12.6% as a result of PSB inoculation. The biological yield in the production of wheat grain is increased by mycorrhizae. Double inoculation with P fertilizer outperforms P fertilization alone by 30% to 40%, whereas double inoculation without P fertilization outperforms P fertilization by up to 20%. Pseudomonas putida and mycorrhiza increased the chlorophyll content of barley leaves. Microorganisms in the rhizosphere can work together to support plant development and N and P absorption. Following a triple inoculation with *Bradyrhizobium, Glomus fasciculatum, and Bacillus subtilis, Green grame* seed output increased by 24%.

Pseudomonas fortinii infiltrated two Carex nigricans species, which grew more quickly and contained more phosphorus. When NP fertiliser and biofertilizer are used together, crop yields are equivalent to those attained with full fertiliser applications. Additionally, production costs are decreased and net returns are increased by using less fertiliser.

CONCLUSION

Acid phosphatase and the synthesis of organic acids make soil phosphate (P) available to plants. Bacteria, including those from the genus *Bacillus*, *Pseudomonas* and *Enterobacter* increase microbial activity, improving phosphate absorption and fostering crop growth and productivity. To use the naturally available stocks of phosphate rocks and the rising fixed P in the soil, phosphate solubilizing bacteria must be utilized for environmental friendly biofertilization. Using PSB as a bio-fertilizer enables increased crop output and soil sustainability. More research is required on the biofertilizer for these crop plants since phosphate deficiency often impacts agriculturally important crops like wheat, paddy, and rice. As a result, phosphate biofertilizer is an advantageous alternative to synthetic fertilizer. Therefore, more research and assessment are needed to determine the resilience and tolerability of agriculturally important crop plants under various abiotic and biotic circumstances.

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