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**Review Article**

# Characterization and evaluation of phosphate solubilizing bio-fertilizers

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## ABSTRACT

The ecosystem that makes up soil is crucial to the availability of plant nutrients and is home to a wide variety of helpful microorganisms that can be vital to improving soil fertility. Application of compost, vermicompost, and manures are among the soil fertility management techniques for increasing plant nutrients and agricultural productivity. One of the latest promising solutions for addressing the agricultural issues brought on by the still-increasing need for food is the development of phosphate-solubilizing bio-inoculants. In this context, this review will demonstrate the enormous potential of phosphate-solubilizing microorganisms (PSMs) as bio-fertilizers. In low-input agricultural systems, bio-fertilizer technologies can aid in the effective utilization of scarce phosphorus fertilizers and ensure a livable environment. Being aware of and understanding the procedures for isolating and characterizing phosphate-solubilizing microorganisms and the mechanisms by which they solubilized phosphate to make it available for plant nutrition would help strengthen the use of phosphate-solubilizing bio-inoculants. In addition, it is important to comprehend the numerous bio-inoculant sources employed for the initial isolation and characterization of native phosphate solubilizers, which will be the focus of this review. This review will also give a thorough overview of the various phosphate solubilization mechanisms and their effects on sustainable agriculture.

**Keywords:** Phosphate fertilizer, phosphate solubilization, bio-fertilizers, vermicompost's



## INTRODUCTION

One of the important elements required for plant development and growth is phosphorus (P), which accounts for around 0.2% of a plant's dry weight. When mineral nutrients most frequently prevent crops from growing, it is only second to nitrogen (Azziz et al., 2012; Tak et al., 2012). The usual amount of phosphorus in soil is roughly 0.05% (w/w), however, only 0.1% of this amount is usable by plants e (Zhu et al., 2011). The application of phosphorus fertilizers has historically been used to solve the issue of soil phosphorus deficiency. However, most of the applied fertilizer phosphorus is not available to plants, and adding more inorganic fertilizers than is typically done to counteract this effect can cause environmental issues like groundwater contamination and eutrophication in waterways (Kang et al., 2011). When applied to soils, seeds, or plant surfaces, biofertilizers can be defined as "substances that contain living microorganisms that colonize the rhizosphere or the interior of the plants and promote growth by increasing the supply or availability of primary nutrients to the target crops (Mazid et al., 2011). Sustainable agriculture is the establishment of food systems that are both short- and long-term profitable for society while considering the social, ecological, and economic aspects of agricultural practices (Abawari et al., 2020).

Over time, chemical fertilizers have played a significant part in Ethiopia's agricultural growth productivity. The

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continued use of chemical fertilizers may not be regarded as sustainable given that soil biodiversity may be declining, topsoil may become acidic due to the application of nitrogenous fertilizer, which lowers soil pH, and unstable aggregates may cause erosion that results in the loss of soil fertility, which may cause yields to decline over time despite the continued use of chemical fertilizers (Nyalemegbe et al., 2006). Due to the continued and improper use of chemical fertilizers and pesticides, which have a terrible negative long-term residual effect on the health of the soil and crop productivity as well as contaminating the groundwater table and ultimately becoming a part of the food chain in the ecosystem, there is now a great deal of attention being paid to the impact of the soil environment. Thus, the natural method of feeding the soil with various types of organic inputs such as composts, vermicompost, biofertilizers, farmyard manure, etc. has been established in order to improve the soil's fertility condition to assure continuous productivity (Bhawalkar et al., 1996). The addition of economical and cheap organic fertilizers and bio-inoculants is necessary to maintain major soil qualities for plant development and environmental effectiveness. Utilized as bio-fertilizers to help plants efficiently use nutrients. According to the Food and Agriculture Organization of the United Nations, chemical fertilizers with an estimated annual consumption of 15 million tons of urea worldwide in 2011 could result in soil acidity, damage to soil biodiversity, and a subsequent decrease in production. In this context, good crop production for all agricultural commodities depends on sustainable agriculture and soil fertility management. Given the drawbacks of commercial P fertilizers, phosphorus availability in soil appears to be best solved by microbial P-solubilization intervention. They settle in the rhizosphere next to the plant's interior and promote development by making mineral nutrients more accessible and absorbable by the host plant. (Malusa et al., 2012). They are the preparations containing microorganisms' cells that can fix nitrogen, solubilize phosphorus, oxidize sulfur, or degrade organic materials. They are "eco-friendly" agro-inputs of organic origin that use ordinary metabolic processes to convert unavailable necessary components to an available form. The plant uses only 10% to 40% of applied nutrients; the remaining 60% to 90% are lost due to immobilization, leaching, volatilization, etc. Biofertilizers are a crucial part of Integrated nutrients because they aid in the gradual and continuous release of nutrients through their metabolism. The plant uses only 10% to 40% of applied nutrients; the remaining 60% to 90% are lost due to immobilization, leaching, volatilization, etc. Maintaining agricultural production and biofertilizers play a crucial role in the Integrated Nutrient Management (INM) system by aiding in the slow and continuous release of nutrients through their metabolism (Gothwalrk *et al.*, 2007). This technique is taken advantage of by using such microbes as powerful biofertilizers that serve as an alternative to chemical fertilizers, assist in maintaining soil nitrogen stores, and provide abundant crop yields (Peoples & Craswell, 1992).

## MATERIALS AND METHODS

### Availability of phosphate in soil

Since most phosphorus is insoluble, it remains due to plants only absorbing it in two soluble forms–monobasic and dibasic–it is unable to stimulate plant development. P is unavailable organic material (phosphodiesters, inositol phosphate, apatite) is present. Soluble inorganic P fertilizers are immobilized, rendering them unavailable to plants. To make bound phosphate and fixed phosphorus available for plants, phosphorus-solubilizing bacteria (PSB) in the soil, such as Pseudomonas putida and Bacillus megaterium, as well as fungi, such as Aspergillus and Penicillium, solubilize the phosphate. PSB and PSF meet the 20–25% phosphorus needed by plants. As a result, its usage in agriculture lowers the cost of producing phosphate fertilizers and helps soils mobilize insoluble fertilizers (Chang & Yang 2009). According to (Chen et al., 2006) bacteria (PSB) make up 1 to 50% of the P solubilizing Microbial Population in Soil, while fungi (PSF) only have a 0.1 to 0.5% P Solubilization Potential. Due to additional benefits like the capacity for P-solubilization, some actinomycetes are becoming more and more popular producing antibiotics and substances that resemble phytohormones to survive harsh situations like drought. According to (Hamdali et al., 2008), 20% of actinomycetes, including those from the common genera Streptomyces and Micro mono sport, may solubilize (Figure 1).

Bio-fertilizers make atmospheric nitrogen available to plants by fixing it in the soil and root nodules of legume crops. They scavenge phosphates from soil layers, solubilize insoluble phosphate forms, including tricalcium, iron, and aluminum phosphates, into usable forms, and create hormones and anti-metabolites that encourage root growth. Bio-fertilizers aid in soil mineralization by breaking down organic materials. After being applied to the soils or seeds, they increase the nutrients' availability and raise the yield by 10% to 20% without harming the soil or the environment (Roychowdhury et al., 2014).

**Phosphate solubilizing microbes**

Numerous microbiological species, including bacteria, fungi, actinomycetes, and algae, can solubilize and mineralize P. Pseudomonas spp., Agrobacterium spp., and Bacillus circulants are examples of soil bacteria that have been shown to mobilize sparsely available phosphorus by solubilization and mineralization (Babalola & Glick, 2012b). Numerous strains of the bacteria Azotobacter (Kumar et al., 2014), Bacillus (Jahan et al., 2013; David et al., 2014), Burkholderia (Mamta et al., 2010; Zhao et al., 2014; Istina et al., 2015), Enterobacter, Erwinia a (Chakraborty et al., 2009), Kushneria (Zhu et al., 2011), Paenibacillus (Fernández Bidondo et al., 2011), Ralstonia, Rhizobium (Tajini et al., 2012), Rhodococcus, Serratia, Bradyrhizobium, Salmonella, Sinomonas, and Thiobacillus are among those that mineralize and solubilize phosphorus (Postma et al., 2010; David et al., 2014). Microorganisms that operate as biofertilizers, some of which are briefly addressed in this section, solubilize or absorb phosphorus.

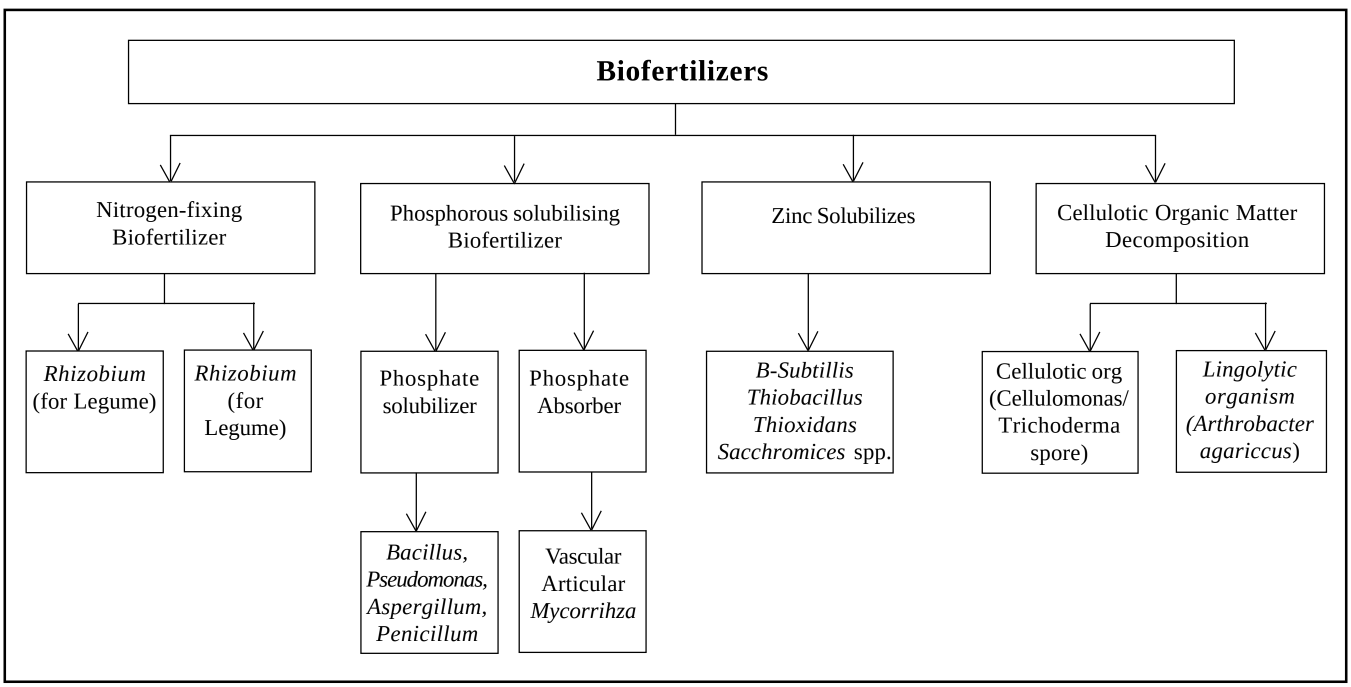


Figure 1: Simplified classification of biofertilizer

**Phosphorous solubilizing/absorbing bio-fertilizers**

Since 1903, researchers have known about naturally occurring rhizospheric phosphorus solubilizing microorganisms (PSM) (Khan et al., 2009). Numerous research has investigated the potential for a wide variety of bacterial species to dissolve insoluble inorganic phosphate compounds, such as rock phosphate, dicalcium phosphate, tricalcium phosphate, and hydroxyapatite (Karpagam et al., 2014). Inorganic phosphorus is solubilized by the actions of low molecular weight organic acids, which are made by a variety of soil bacteria. In contrast, organic phosphorus is mineralized by synthesizing various phosphatases, which catalyze the hydrolysis of phosphoric esters, with phosphate solubilization and mineralization/absorption typically occurring in the same bacterial symbiont (Rathi et al., 2016). *Pseudomonas*, *Bacillus*, *Rhizobium*, *Burkholderia*, *Achromobacter*, *Agrobacterium*, *Microccocus*, *Aereobacter*, Flavobacterium, and *Erwinia* are bacterial genera that possess this ability.

**The benefit of phosphorous solubilizing microorganisms**

PSMs with the ability to convert insoluble phosphorus to soluble forms can act as biofertilizers to improve the utilization of the phosphorus collected in soils. This raises the amount of soluble phosphorus present (Zhu et al., 2012). It is preferable to use an environmentally friendly approach (i.e., a paradigm that emphasizes the use of biological soil amendments in place of chemicals) to solve the problems of infertile soil, and the use of phosphorus biofertilizers is a promising method of improving food production through increasing agricultural yield (Babalola & Glick, 2012). Figure 2 depicts the impact of PSM (Pseudomonas sp.) inoculation on a maize plant. Compared to the control, which was not inoculated, the growth of maize that received PSM inoculation was better. PSM functions as biofertilizers by supplying growing plants with P that might not otherwise be accessible. By boosting the effectiveness of biological nitrogen fixation, synthesizing phytohormones, and

**A** **B**

Figure 2: Biofertilizer pf pseudomonas sp. On maize. (A) Maize is not included with PSM. (b) Maize inoculated with a PSM Pseudomonas sp.

increasing the availability of some trace elements like zinc and iron, phosphorus-solubilizing bacteria may also help plants flourish (Wani et al., 2007).

## RESULTS AND DISCUSSION

The review articles provided information about PSMs' potential as biofertilizers (phosphate-solubilizing microorganisms). You may get a discussion of the molecular mechanisms underlying the usage of PSM as biofertilizers in the review, the mechanisms of inorganic phosphate solubilization by PSM and organic phosphorus mineralization are highlighted. It also discusses the benefits of using PSMs as biofertilizers, such as enhanced phosphorus uptake that can reduce the demand for environmentally hazardous chemical fertilizers. Also this review articles offer a number of conclusions about the usage of phosphate-solubilizing microorganisms (PSMs) as biofertilizers. The importance of PSMs in converting organic P compounds into soluble forms that are available to plants is highlighted in the review. PSMs can be used as biofertilizers, which is a sustainable solution to the soil's P deficit. The review in this article examines the molecular mechanics of using PSMs as biofertilizers and their advantages, such as high efficacy, low cost, and environmental safety. Increasing awareness of the significance of nematophagous fungi and their role in phosphorus solubilization to improve plant availability is the goal of this review.

Both alkaline and acidic soils can benefit from these biofertilizers, it is determined after evaluating the performance of two carrier materials for phosphate solubilizing bacteria (PSB). Additionally, it suggests that employing phosphate biofertilizers is a viable method for increasing crop yields and raising food production. The review covers a variety of soil microorganisms that have the potential to be used as biofertilizers since they can solubilize phosphorus. The benefits of using PSMs as biofertilizers are also emphasized, including enhanced phosphorus uptake that can reduce the demand for chemical fertilizers that have a negative environmental impact. The assessment emphasizes the potential for using biofertilizers either by themselves or in combination with chemical fertilizers. Lastly, it reveals that phosphate-solubilizing bio-fertilizers are beneficial bacteria that can be crucial for managing soil fertility and increasing strategies for enhancing plant growth.

Role of Plant growth promoting Rhizobacteria in Phosphorus Solubilization (PGPRS)

1) Direct Mechanism
2) Biological nitrogen fixation

One of the most crucial nutrients for plant development and production, as well as a necessary component of proteins, nucleic acids, and other vital biomolecules, is nitrogen (Bockman et al., 1997). The amount of nitrogen in the atmosphere that is inaccessible to plants is greater than 80%. It needs to be transformed into ammonia, which is a form that is accessible to eukaryotes like plants. A sophisticated enzyme system known as nitrogenase is used by microorganisms in biological nitrogen fixation to convert nitrogen to ammonia (Kim et al., 1994). PGPMs that are known to fix atmospheric molecular nitrogen through symbiotic, symbiotic, or associative nitrogen-fixing processes, including those from the genera *Acinetobacter*, *Alcaligenes*, *Arthrobacter*, *Azospirillium*, *Azotobacter*, *Bacillus*, *Beijerinckia*, *Burkholderia*, *Enterobacter*, *Erwinia*, *Flavobacterium*, *Rhizobium*, *Mycobacterium*, and S*erratia* (Kumar et al., 2014).

## CONCLUSION

This review has demonstrated the enormous potential of phosphate-solubilizing bacteria as bio-fertilizers. Utilizing soil PSM to mobilize soil inorganic phosphate and increase its bioavailability for plant use encourages sustainable agriculture, boosts soil fertility, and thus increases crop productivity. Using PSM as microbial inoculants opens up new possibilities for increased plant productivity. PSM technology can help create cleaner environments and low-input farming methods. However, it is necessary to develop PSB technologies unique to different regions, and farmers should be informed of this quickly. Rhizobacteria that promote plant growth have a significant function in agriculture for plant growth and yield as well as soil fertility maintenance. The effective PGPR strains may perform better under farming systems that decrease the input of chemicals and fertilizers into the soil. It is a technology for sustainable agriculture that is affordable. Rhizobacteria that promote plant growth have the capacity to engage in a variety of interactions with plants in soil microbial populations, from mutualism to commensalism. This plant microbes-PGPR relationship contributes significantly to the growth and health of a variety of plants and soils. A good potential to create environmentally friendly phosphorus biofertilizers to be used in addition to or instead of chemical fertilizers is provided by phosphate-solubilizing microorganisms (PSMs). They can aid in the efficient use of scarce phosphorus fertilizer resources in low-input farming systems and ensure a safe environment for human habitation. PSMs mobilize inorganic phosphate in the soil to increase its bioavailability for plant use, advance sustainable agriculture, raise soil fertility, and therefore boost crop production.

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