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Phosphate solubilizing microbes: an incredible role for plant supplements

Abstract

Plants procure phosphorus from soil as the phosphate anion. It is the most un-portable component in plant and soil in comparison to other macronutrients. It's very well known that phosphorus is the second most significant supplement after the nitrogen required/ needed in plant growth. It is a fundamental component in every single living system. Barely 1%-2% of phosphorous is provided to different parts of the plants. It precipitates in soil as orthophosphate or is adsorbed by Fe and Al oxides through legend exchange.

Phosphorus-solubilizing bacteria play a substantial part in phosphorus nutrition by increasing phosphorus' accessibility to plants through discharge from inorganic and natural soil P pools by solubilization and mineralization. Lowering the pH of the soil through microbial generation of natural acids and mineralization of natural phosphorus by acid phosphates is the key element in the soil for mineral phosphate solubilization. Chemical composts are used as an additional source of phosphorous to satisfy the plant's need. Additionally, co-inoculating P solubilizing microorganisms with other beneficial bacteria and mycorrhiza has shown to increase their efficiency. Microbial inoculants or biofertilizers can thus be used as an alternative source because they are both economical and environmentally favourable.

Keywords: phosphorous, manure, vegetables, nutrition, soil, microorganisms

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Introduction

Despite its excess in both organic and inorganic soil structures, phosphorus (P) plays a vital role in plant development and is the major supplement that restricts plant growth.[1] The main features of phosphorous nourishment are Metabolic cycles as- photosynthesis, energy move and signal transduction and assurance from plant ailments, Nitrogen obsession in vegetables, crop quality.[2,3] Plants consume it in the form of orthophosphate (H_2PO_4-and HPO_4 2-).[4] Grains collect a significant portion of the phosphorus that plants use as phytase[5] and its inadequacy influences the grains yield very badly and make the unfavorable impact on crops. Stem and stalk strength, blossom, root development, seed arrangement, yield development and production, nitrogen-fixation in vegetables, crop quality, and protection from plant diseases are a few characteristics that are related to phosphorus nutrition. Since microbial inoculants have been utilized to increase soil fertility for the past 100 years, studies has been conducted on Phosphorous solubilization in contrast with the N-fixation. In soil, phosphorus elements are primarily defined by natural (immobilization-mineralization) and physicochemical processes (sorption-desorption). Massive amounts of phosphorus are added as manure, and through precipitation, it reaches stable pools with exceptionally receptive Ca2+ in calcareous water and Fe3+ and Al3+ in acidic water.[1,6,7] The phosphorus elements in the soil are greatly influenced by soil microorganisms, which makes phosphate available to plants.[8]

Phosphorus solubilizing microorganisms

As compared to the parasite, the bacteria are more effective in phosphorus solubilization.[9] In Phosphorous solubilization potential the phosphorus solubilizing fungi (PSF) are simply 0.1 to 0.5 % whereas the PSB comprise of 1 to 50 % in the entire microbial populace in soil.[10] Microorganisms associated with phosphorus securing incorporate mycorrhizal growths and PSMs.[11] From the bacterial community of soil ectorhizospheric strains have been depicted from the Pseudomonas and Bacilli whereas the endosymbiotic rhizobia have been depicted as a strong P solubilizers.[12] The most remarkable P solubilizers are the fungi - Penicillium and Aspergillus along with strains of bacterial enera- Rhizobium, Bacillus, Pseudomonas and Enterobacter.[13] According to Subbarao;[14] Kucey et al.,[15] the *B. subtilis, B. polymyxa, Bacillus megaterium, B. sircalmous, B. circulans*, and *Pseudomonas striata* could be considered as main strains. For the solubilization of phosphate rocks a nematofungus called as Arthrobotrys oligospora is considered as the most.[16]

Mechanism of action of phosphorus solubilizing microorganisms

According to Ahmed and Hamid,[17] the efficiency of P compost worldwide ranges from 10 to 25%, and the exceptionally low bioavailable content of P in soil (1.0mg kg-1) is quite low.[7] Plants can absorb phosphorus only in soluble form. The phosphorus (P) elements in the soil are greatly influenced by soil microbes, which make phosphate available to plants.[5] The Phosphate Solubilizing Microorganisms, specifically Phosphate Solubilizing Bacteria, improve the solubilization of a mixture of insoluble phosphorous by the influx of phosphatase, natural acids, and phytase complexes[18] and this is mostly accessible in a wide assortment of the soil microorganisms. Sclerotium, Penicillium, and Aspergillus are three examples of species that are dynamic in change. Micrococcus, Mycobacterium, Pseudomonas, and Flavobacterium are four bacteria species that are also dynamic in change. While some phosphorous is consumed by microbes during the transformation cycle, the total amount is first rendered soluble and then provided in excess to the microorganisms' needs. As a result, the extra phosphorus is subsequently transported and made available to the plants. Natural acid plays a big part in this transition process. Similar to how nitric acid does, sulfuric acid also plays significant role in it. Thus, through these natural and inorganic acids, calcium phosphate is then converted to di or monobasic phosphates and is thereafter efficiently available to the plants.[10,18–20] Because the sulphuric and nitric acids are delivered by oxidation of the nitrogenous materials, acts on the rock phosphate, the carbohydrates that are being oxidized by the heterotrophs have an enormous impact

upon the solubilization interaction.[21] During this process by the nitrification of ammonium salts a huge impact was observed in the solubilization of phosphate. By and large, by the production of acid the solubilization of phosphate is accomplished.[22] Preparation of ferric phosphate requires specific microscopic organisms which liberates the hydrogen sulfide. Various phosphate solubilizing microorganisms are furthermore well known in soil. It is furthermore understood that root area is amply affluent in phosphate solubilizing microorganisms. Because of this, process of the phosphate osmosis by the advanced plants increases rapidly. The soil fertility increases up to a moderate degree through v the mycorrhizal organism.[23] Also the numerous microbes, growths, and the actinomycetes discharge bound P in yield deposits and the organic soil matter which is eventually accessible for pSlants. Likewise, hemophilic and mesophilic microscopic organisms' effectively take part in the mineralization of phosphorus.[18] Warm temperature ordinarily leans toward deterioration and because of this thermophilic species play a significant role.[24] PH of soil also plays a significant role in it.[25] Similar to the nitrogen, phosphorous is also mineralized as well as immobilized in soil. These both cycle work in the soil and are administered by how much phosphorus deposits in the plant going through deterioration and the supplements is expected for related population of microbes. Phosphate is formulated when the proportion limits with period on account of the CO_2 volatization (Table 1).

Table 1 Some important Phosphate solubilizing microorganisms along with mode of action

Sr. No.	Phosphate solubilizing microorhganisms	Metabolite forms (acids)	References
1	A. niger, Penicillium sps	Lactic acid	Sperber JI[22]
2	A. niger	Oxalic, Gluconic	Chuang et al.,[26]
3	E. freundii	Lactic acid	Sperber JI[22]
4	Aspergillus flavus, A. niger, penicillium canescens	Oxalic, Citric, gluconic, succinic	Maliha et al.,[27]
5	P. fluorescens	Citric, malic, tartaric, gluconic	Fankem et al.,[11]
6	Penicillium rugulosum	Citric, gluconic	Reyes et al.,[28]
7	Enterobacter intermedium	2-Keto gluconic	Hwangbo et al.,[29]
8	P. trivialis	Lactic, formic	Vyas & Gulati,[30]
9	Enterobacter sps Fs 11	Malic,gluconic	Shahid et al.,[31]
10	Enterobacter	Citric, alic,tartaric,gluconic,funaric	Huang & Ge,[32]
11	Psedomonas nitroreducens	Indole acetic acid	Chitraselvi et al.,[33]
12	Arrhrobacter	Citric, malic, tartaric, gluconic	Huang & Ge,[32]
13	Pseudomonas putida M5TSA, Enterobacter sakazakii, M2PFe and bacillus megaterium M1PCa		Lopez et al.,[34]
14	A. nigerFS 1,Penicillium canescens FS23,Eupenicillium ludwigii FS 27, Penicillium islandicum FS 30	Citric,gluconic,oxalic	Mendes et al.,[35]

Conclusion

It is intriguing to speculate that PSM could influence plant growth and nutritional requirements through their component of activity. The capacity of plant growth hormones to create phosphate makes it clear that these phosphate-stimulating microorganisms could be used as a successful substitute for inorganic phosphate composts in the future and should be utilised more frequently. However, P solubilizing inoculants can enhance microbial activity, which may significantly improve in P uptake by the plants. Phosphorus solubilizing microorganisms (PSM) including Pseudomonas, Bacillus, and Enterobacter are very effective at enhancing the amount of P that plants can access for growth and productivity. In this respect, the use of phosphate solubilizing microorganisms (PSM) in bio-fertilization offers enormous potential for utilising fixed P in the soil. Along with this it also enhance the natural stocks of phosphate rocks.

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Conflicts of interest

The authors declared that there is no conflict of interest.

References

1. Gyaneshwar P, Naresh Kumar G, Parekh LJ, et al. Role of soil microorganisms in improving P nutrition of plants. *Plant and soil*. 2002;245(1):83–93.
2. Sperber JI. Solution of apatite by soil microorganisms producing organic acids. *Australian Journal of Agricultural Research*. 1958;9(6):782–787.
3. Khan MS, Zaidi A, Ahmad E. *Phosphate solubilizing microorganisms*. Springer International Pu. 2016.Alam S, Khalil S, Ayub N, et al. In vitro solubilization of inorganic phosphate by phosphate solubilizing microorganisms (PSM) from maize rhizosphere. *Int J Agric Biol*, 2002;4(4):454–458.
4. Hinsinger P. Bioavailability of trace elements as related to root–induced chemical changes in the rhizosphere. *Trace elements in the rhizosphere*. 2001:25–41.
5. Pankhurst CE, Doube BM, Gupta VVSR, et al. *Soil biota: management in sustainable farming systems*. East Melbourne, Vic: CSIRO Information Services; 1994.
6. Hao X, Cho CM, Racz GJ, et al. Chemical retardation of phosphate diffusion in an acid soil as affected by liming. *Nutrient Cycling in Agroecosystems*. 2002;64(3):213–224.
7. Goldstein AH. Involvement of the quinoprotein glucose dehydrogenase in the solubilization of exogenous phosphates by gram–negative bacteria. Phosphate in microorganisms: cellular and molecular biology. Washington DC: ASM Press; 1994:197–203.
8. Richardson AE. Prospects for using soil microorganisms to improve the acquisition of phosphorus by plants. *Functional Plant Biology*. 2001;28(9):897–906.

9. Alam S, Khalil S, Ayub N, et al. In vitro solubilization of inorganic phosphate by phosphate solubilizing microorganisms (PSM) from maize rhizosphere. *Int J Agric Biol*, 2002;4(4):454–458.
10. Chen YP, Rekha PD, Arun AB, et al. Phosphate solubilizing bacteria from subtropical soil and their tricalcium phosphate solubilizing abilities. *Applied soil ecology*. 2006;34(1):33–41.
11. Fankem H, Nwaga D, Deubel A, et al. Occurrence and functioning of phosphate solubilizing microorganisms from oil palm tree (*Elaeis guineensis*) rhizosphere in Cameroon. *African J Biotech*. 2006;5:2450–2460.
12. Igual JM, Valverde Portal Á, Cervantes E, et al. Phosphate–solubilizing bacteria as inoculants for agriculture: use of updated molecular techniques in their study. 2001.
13. Whitelaw MA. Growth promotion of plants inoculated with phosphate solubilizing fungi. *Adv Agron*. 2000;69:99–151.
14. Subbarao NS. Phosphate solubilizing micro–organism. *Biofertilizer in agriculture and forestry. Regional Biofert Dev Centre, Hissar, India*. 1988:133–142.
15. Kucey RMN, Janzen HH, Leggett ME. Microbially mediated increases in plant–available phosphorus. *Advances in agronomy*. 1989;42:199–228.
16. Duponnois R, Kisa M, Plenchette C. Phosphate□solubilizing potential of the nematophagous fungus Arthrobotrys oligospora. *Journal of Plant Nutrition and Soil Science*. 2006;169(2):280–282.
17. Isherword Kf. Fertilizer use and environment. In: N Ahmed, A Hamid. editors. Proc. Symp. Plant Nutrition Management for Sustainable Agricultural growth. NFDC, Islamabad; 1998:57–76.
18. Khan MS, Zaidi A, Wani PA. Role of phosphate solubilizing microorganisms in sustainable agriculture–a review. *Sustainable agriculture*. 2009:551–570.
19. Kang SC, Ha CG, Lee TG, et al. Solubilization of insoluble inorganic phosphates by a soil–inhabiting fungus Fomitopsis sp. PS 102. *Current Science.* 2002:439–442.
20. Pradhan N, Sukla LB. Solubilization of inorganic phosphates by fungi isolated from agriculture soil. *African Journal of Biotechnology*. 2006;5(10).
21. Sharma K. *Manual of Microbiology*. Ane Books Pvt Ltd; 2007.
22. Sperber JI. The incidence of apatite–solubilizing organisms in the rhizosphere and soil. *Australian Journal of Agricultural Research*. 1958;9(6):778–781.
23. Bolan NS. A critical review on the role of mycorrhizal fungi in the uptake of phosphorus by plants. *Plant and soil*. 1991;134(2):189–207.
24. Karpagam T, Nagalakshmi PK. Isolation and characterization of phosphate solubilizing microbes from agricultural soil. *International Journal of Current Microbiology and Applied Sciences*. 2014;3(3):601–614.
25. Sharma SB, Sayyed RZ, Trivedi MH, et al. Phosphate solubilizing microbes: sustainable approach for managing phosphorus deficiency in agricultural soils. *Springer Plus*. 2013;2(1):1–14.
26. Chuang CC, Kuo YL, Chao CC, et al. Solubilization of inorganic phosphates and plant growth promotion by Aspergillus niger. *Biology and Fertility of Soils*. 2007;43(5):575–584.
27. Maliha R, Samina K, Najma A, et al. Organic acids production and phosphate solubilization by phosphate solubilizing microorganisms under in vitro conditions. *Pak J Biol Sci*. 2004;7(2):187–196.
28. Reyes I, Baziramakenga R, Bernier L, et al. Solubilization of phosphate rocks and minerals by a wild–type strain and two UV–induced mutants of Penicillium rugulosum. *Soil Biology and Biochemistry*. 2001;33(12–13):1741–1747.
29. Hwangbo H, Park RD, Kim YW, et al. 2–Ketogluconic acid production and phosphate solubilization by Enterobacter intermedium. *Current microbiology*. 2003;47(2):0087–0092.
30. Vyas P, Gulati A. Organic acid production in vitro and plant growth promotion in maize under controlled environment by phosphate–solubilizing fluorescent Pseudomonas. *BMC microbiology*. 2009;9(1):1–15.
31. Shahid M, Hameed S, Imran A, et al. Root colonization and growth promotion of sunflower (Helianthus annuus L.) by phosphate solubilizing Enterobacter sp. Fs–11. *World Journal of Microbiology and Biotechnology.* 2012;28(8):2749–2758.
32. Yi Y, Huang W, Ge Y. Exopolysaccharide: a novel important factor in the microbial dissolution of tricalcium phosphate. *World Journal of microbiology and biotechnology*. 2008;24(7):1059–1065.
33. Chitraselvi RPE, Kalidass S, Rajiv K. Efficiency of rhizosphere bacteria in production of indole acetic acid, siderophore and phosphate solubilization. *International Journal of ChemTech Research*. 2015;7(6):2557–2564.
34. Lopez BR, Bashan Y, Bacilio M. Endophytic bacteria of Mammillaria fraileana, an endemic rock–colonizing cactus of the southern Sonoran Desert. *Archives of microbiology*. 2011;193(7):527–541.
35. Mendes GO, Dias CS, Silva IR, et al. Fungal rock phosphate solubilization using sugarcane bagasse. *World Journal of Microbiology and Biotechnology*. 2013;29(1):43–50.

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