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Eco-friendly Microbial Inoculants for Improving Soil P Availability

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Though, mineral fertilizers are considered as best means to combat soil phosphorus (P) deficiency, but their high cost and undesirable effect on soil environment restrict their use at farmer's level. The use of natural resources in the form of efficient phosphate solubilising /mineralizing microorganisms is an eco-friendly option for improving crop P nutrition and may help the marginal farmer to replenish soil P more economically compared to chemical fertilizer.

Introduction

Low availability of soil phosphorus (P) is a major constraint for plant productivity in tropical regions and commonly compensated by application of high rate of chemical P fertilizers. This not only increases the cost of cultivation and puts financial burden on marginal farmer but also leads to net accumulation of total soil P. Despite the high content of total P (ranging between 400-1200 mg kg^{-1} soils), the availability of soil P is limited only to 2-3 mg kg^{-1}. The reduced P availability is attributed to adsorption of phosphate ions on surface of soil minerals and precipitation of calcium, iron and aluminium ions. The question is how to make the recalcitrant form of P available to plants. Farmer friendly and economical alternate means that can improve the availability of soil phosphorus and protect the soil from further impoverishment need to be explored.

Role of Microbial Flora on Improving P Availability in Soil

Soil P occurs in both organic and inorganic forms. The organic P enters the soil through plants and animal residues and microbial flora whereas; inorganic P is added to soil through chemical fertilizers. Soil harbours diverse population of microorganisms with different functional traits. Among them, the microorganisms with potential to solubilise inorganic phosphate and mineralize organic phosphate are of great importance. They can improve the availability of accumulated soil P to plants through their specific trait. The microbial transformation of both organic and inorganic phosphate compounds facilitate the release of inorganic P (Pi) that can be taken up by the plant roots. The listed below are some of the microbiological strategies that can improve the availability of soil phosphorus.

- Seed inoculation of soil grown plants with P solubilising bacteria and fungi
- Seed inoculation with phosphate mineralizing microorganisms
- Introduction of mycorrhizal fungal inoculants in soil
- Development of P-enriched compost with undesired crop residue and live-stock manure and its application to soil.
- Input of organic matter

Phosphate Solubilizing Microorganisms

Phosphate solubilising microorganisms improve the availability of P to plants by bringing favourable changes in soil reaction and soil micro-environment that may result in solubilisation of inorganic phosphate. The potential P solubilizers belong to genera *Pseudomonas, Bacillus, Aspergillus*, and *Penicillium.* The strains of *Rhizobium* and *Bradyrhizobium* have also been reported to possess the phosphate solubilization potential. The inorganic and insoluble phosphate solubilisation can be brought about by both plants and microorganisms that produce different type of organic acids in varying concentrations. Commonly reported organic acids produced by microorganisms include gluconic, 2-ketogluconic, citric and oxalic acids (Richardson 2001), while plants most commonly produce citric, oxalic, and malic acids (Zheng et al. 2005). Besides, citric, oxalic and gluconic acids, traces of fumaric acid, malic acid, succinic acid, acetic acid and lactic acid have also been detected in cell free filtrate of several phosphate solubilising microorganisms. The extracellular production of tartaric acid in the culture filtrate of *Pseudomonas striata* has also been reported (Gaind 2013). *Aspergillus niger, Aspergillus clavatus*, *Sclerotium rolfsii* and *Penicillium* spp. are known to produce oxalic acid as the major organic acid (Gaur, 2006).

Phosphate Mineralizing Microorganisms

As tropical soils tend to have large capacity to adsorb phosphate, the role of organic P in providing P to plants becomes more important. Typically 2/5 of total P in surface layer of tropical soils is in organic form. Phytate is the most abundant form of organic P and constitutes > 50 % of the total organic P. The release of Pi from phytate can be mediated by microbially produced specific enzyme called phytases. The potential phytate mineralizing fungi include members of genus *Aspergillus* and *Trichoderma*. The inoculation of phytate minearlizing fungi into organically fertilized soil under crop cultivation has been reported to enhance the availability of Pi (Ramesh et al, 2010).

Role of Arbuscular Mycorrhizal (AM) Fungi

AM symbiosis contributes significantly to plant P nutrition on soils that have low P availability. These fungi form a critical link between the above ground parts and soil by influencing plant nutrient cycling and soil structure. The most important benefit of AM fungi is the improved growth rate on its inoculation in soil. Mycorrhizal plants deplete phosphate to lower level and to a much larger soil volume per unit root length than non mycorrhizal plants. Influx of P in roots colonized by AM fungi is 3 to 5 times compared to non mycorrhizal plants.

Phospho-compost as P Source

India has 260 m.t of rock phosphate reserve. The low grade material is not suitable for production of chemical fertilizer. However, it can either be used for preparation of phospho-compost or can be incorporated in soil in conjunction with rock phosphate solubilising microbial inoculants. The dissolution of rock phosphate results in the release of Pi in solution to be available for plant uptake. The composting of bio-degradable material in the form of crop residue and its supplementation with rock phosphate and subsequent decomposition under controlled conditions can result in the production of phospho-compost that has high content of available P. The application of phospho-compost in soil-plant interaction studies have been reported to improve the availability of P for plant uptake. The effectiveness of rock phosphate depends on chemical composition, reactivity, soil and plant factors. Organic acids,

humic acids and chelating substances produced during decomposition of organic matter, help in the liberation of phosphate from rock phosphate.

Influence of Organic Matter on P Availability

Organic matter has a direct and indirect effect on the availability of nutrients for plant growth. In addition to serving as a source of P through its mineralization by soil microorganisms, organic matter influences the supply of nutrients from other sources (for example, organic matter is required as an energy source for N-fixing bacteria). The inoculation of phosphate mineralizing and solubilising fungi in compost amended soil improves the acid and alkaline phosphatase activity. *Pencillium chrysogenum* is most effective in enhancing the phytase activity of soil. The improved availability of soil may be attributed to

- The formation of phospho-humic complexes,
- Replacement of phosphate by humate ions and
- Coating of sesquioxide particles by humus to form protective cover which reduce phosphate fixing capacity of soil are favourable effects of organic matter in enhancing P availability

Addition of organic residues decreases the P adsorption capacity and increase the P availability in soil. Negatively charged, high molecular weight, humic substances can form strong bonds with metal hydrous oxide surface through both electrostatic bonding and specific adsorption i.e ligand exchange. Ligand exchange occurs through displacement of hydroxyl groups at oxide surface. Organic materials generally contain large amount of P which is mineralized during decomposition of organic residues and orthophosphate is released in to soil solution. In general a residue with C: P ratio < 100 leads to net mineralization, while a C:P ratio > 300 leads to net immobilization. Where net release of P occurs during decomposition of the residue, the P is then rapidly adsorbed on to soil surface, thus increasing the proportion of adsorption sites occupied by P. As a result, P adsorption capacity of the soil decreases with respect to subsequently applied P. In addition, the organic matter serves as a source of carbon and energy for microbial proliferation. The microbial biomass serves as a source of P for soil during turn over.

Conclusion

Utilization of natural resources in the form of microorganisms, organic matter and phospho-compost developed from organic waste after supplementation with low grade rock phosphate and phosphate solubilising/mineralizing microorganisms hold great potential as P provider in sustainable agriculture. These are environment friendly, economical technologies that can be easily adopted by farmers and improve the nutrient use efficiency of chemical P fertilizer. However, use of the microbial inoculants with efficient phosphate solubilising strain is highly desirable to get the promising results.

References

Gaind Sunita. 2013. *J Crop Improvement*. 27 (3): 255-271.

Gaur AC. 2006. Biofertilizers in Sustainable Agriculture. ICAR, New Delhi.

Ramesh A, Sharma SK, Joshi OP and Khan IR. 2011. *Indian J Microbiol*.51: 94-99.

Richardson, AE. 2001. *Aust J Plant Physiol* 28: 897–906

Zheng SJ, Yang JL, He YF, Yu XH, Zhang L, You JF, Shen RF and Matsumoto H. 2005. *Plant Phys* 138: 297-303.