*Review Article*

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# Beneficial Interaction of Arbuscular Mycorrhizal Fungi in Plant to Improve the Uptake of Phosphorus

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**Abstract**

Arbuscular mycorrhizal fungi (AMF) and plant symbiosis– is the oldest, fascinating and beneficial relationship on Earth for plant. AMF is the most common symbiotic association of crop plants occurring in most natural habitats and providing a range of essential ecological services i.e. mobilize nutrients form mainly phosphorus to plants, enhancing plant growth, induction of resistance and improving soil structure and fertility. AMF is commonly used bio-inoculants for most of the agricultural, horticultural and plantation crops, therefore they receive increasing attention now a days. The current mini review provides a comprehensive up-to-date understanding of AMF and its effect on host plants, their benefits and applications, and therefore the significance of the relationships between different plant nutrients and AMF.

**Keywords:** Arbuscular mycorrhizal fungi; Phosphorus; Soil; Plant growth.

## Introduction

In the current scenario of increasing the price of synthetic fertilizers and the widening gap between the supply and demand of these nutrients, the utilization of phosphate solubilization or mobilization and biological nitrogen fixation offers a remarkable opportunity to use low-cost and environmentally friendly nutrients supplement to crops. Phosphorous (P) is the main nutrient required for the productivity and growth of plants, which is commonly applied to crops in the form of single super phosphate (SSP), triple super phosphate (TSP), monoammonium phosphate (MAP), and diammonium phosphate fertilizers in order to supply phosphorous to the soil (Azzizet al., 2012). On average, 0.05% (w/w) of P is present in the soil, out of which 0.1% is transfer or accessible to the plants(Zhu et al., 2011). The inorganic form of phosphates (Pi) is available in large concentration i.e. 35-70% in the soil. Inorganic phosphate is present in 10 µM of concentration in soil which is much less than the concentration of Pi in plant tissues i.e. 5-20 µM (Harrison, 1987; Shen et al., 2011). Due to the poor mobility and low concentration of P available to the plant, the application of manure and chemical P fertilizer have improved the fertility of soil which have raised the crop from past decades but damaged the environment by disturbing the phosphorous cycling (Mitra et al., 2020).

### *Phosphorusand plant system*

Plant architecture is a complex characteristic and a significant influence on crop yield. The plant yield is often determined by a tiller number, height, and tiller angle as the most important agricultural

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characteristic (Smith and Smith, 2011; Wang et al., 2018). Phosphorous is needed for the growth of plant and constitute about 0.2% of dry weight, but it is the most difficult nutrient to acquire. Plant colonized the terrestial environment through the development of multiple organs that can absorb the water and nutrients needed for the development and growth. The root organ is the major organ through which plant can absorb water and nutrients from the soil (Huang et al., 2018).

### *Arbuscular mycorrhizal fungi and soil phosphorus*

Associating and incorporating arbuscular mycorrhizal fungi (AMF) or AMF-based formulations is another approach to cultivation that has played a major role in sustainable agriculture for a few decades. *Glomus, Funneliformis, Rhizophagus, Gigaspora, Claroideoglomus, Sclerocystis and Acaulospora* to be the predominant AMF species in soil (Mitra et al., 2021; Wang et al., 2019). The symbiotic association between fungus and plant raise the ability of the plant to access P, in exchange the fungus gets carbohydrates, and other from the host plant. Two pathways are existing in the uptake of P in the association of AMF: the AM fungal pathway and the direct pathway (Smith and Smith, 2011). By the help of AM pathway, the volume of soil from which P can be accessed is raised. Additionally, the fungal hyphae can access the pool of P that are not accessible to the roots of plant. Understanding the genetic and physiologic controls of the plant-AMF interaction may allow root infection to occur at the large concentration of P, which may improve the uptake of P over a broad range of soil P concentration that present recently (Mitra et al., 2021; Smith and Smith, 2011 Fig. 1).

### *Intervention of AMF, phosphorus uptake and benefits*

The interaction of AMF with the roots of plant can be treated as a positive way for the sustainable production of crops. Example, the cultivation of rice under aerobic condition not only save the usage of water but also opens up a scope for the effective usage of beneficial root symbionts in the rice unlike the conventional cultivation of rice where water logged condition act as limitation for the proliferation of beneficial microorganism such as AMF and AMF associated bacteria(Panneerselvam et al., 2017; Mitra et al., 2019). Research has determined the production of crops in the variable ecology is severely affected due to the low acquisition of P and chemical fertilizers. The AMF symbiotic association majorly recognized to improve the growth of plant under challenging conditions like P lacking conditions (Huang et al., 2018).

Crops associated with AMF can grow well under variable stressful circumstances such as salinity, drought, and nutrient deficiency. Regarding the uptake of P from the soil, extra radical mycelia

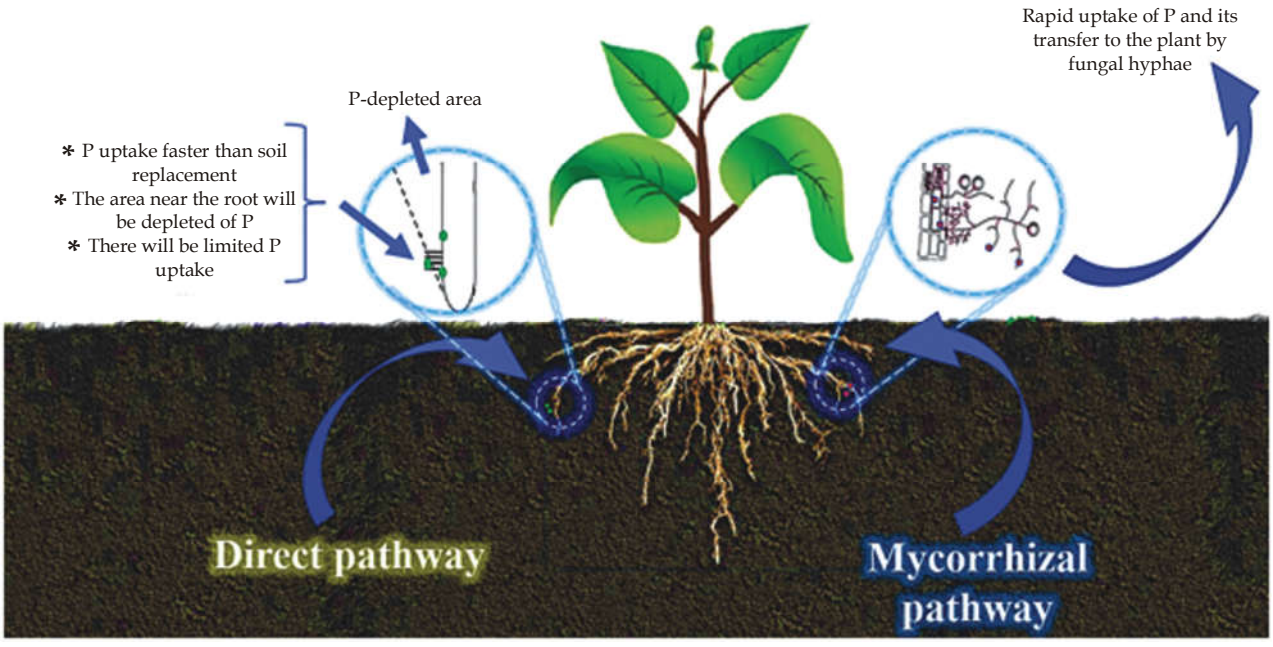


**Fig. 1:** Pathway of nutrient mobilization to plant by AMF interaction.

can also improve the performance, nutrition, and growth by raising the surface area of root nutrient uptake and improving their absorption capacity. It is reported that the crop plants with more colonization of AMF and sporulation shows better biomass, wider conductance of stomata, greater volume of PSII, greater P and N nutrient uptakes, inhibition of pathogen, improve the fertility of soil, synergistic interaction, alleviation of stress, yield, and bioremediation (Mitra et al., 2020; Panneerselvam et al., 2017, Begum et al., 2019). So, AMF application has appeared to be a beneficial and useful option to address this limitation.

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***Competing interests***

The authors declare that they have no competing interests.

**References**

1. Azziz, G., Bajsa, N., Haghjou, T., Taulé, C., Valverde, Á., Igual, J.M. and Arias, A., 2012. Abundance, diversity and prospecting of culturable phosphate solubilizing bacteria on soils under crop–pasture rotations in a no-tillage regime in Uruguay. Applied Soil Ecology, 61, pp.320-326.
2. Begum, N., Qin, C., Ahanger, M.A., Raza, S., Khan, M.I., Ashraf, M., Ahmed, N. and Zhang, L., 2019. Role of arbuscular mycorrhizal fungi in plant growth regulation: implications in abiotic stress tolerance. Frontiers in plant science, 10, p.1068.
3. Harrison A.F. 1987.Soil organic phosphorus. a review of world literature, AF Harrison I. No. 631.85 H3, Wallingford, UK: Commonwealth Agricultural Bureaux.
4. Huang, J., Yu, H., Liu, J., Luo, C., Sun, Z., Ma, K., Kang, Y. and Du, Y., 2018. Phosphorus addition changes belowground biomass and C: N: P stoichiometry of two desert steppe plants under simulated N deposition. Scientific reports, 8(1), pp.1-11.
5. Mitra, D., Anđelković, S., Panneerselvam, P., Senapati, A., Vasić, T., Ganeshamurthy, A.N., Chauhan, M., Uniyal, N., Mahakur, B. and Radha, T.K., 2020. Phosphate-solubilizing microbes and biocontrol agent for plant nutrition and protection: current perspective. Communications in Soil Science and Plant Analysis, 51(5), pp.645-657.
6. Mitra, D., Djebaili, R., Pellegrini, M., Mahakur, B., Sarker, A., Chaudhary, P., Khoshru, B., Del Gallo, M., Kitouni, M., Barik, D.P., Panneerselvam, P., Das Mohapatra, P.K. 2021. Arbuscular mycorrhizal symbiosis: plant growth improvement and induction of resistance under stressful conditions. Journal of Plant Nutrition. https://doi.org/10.1080/01904167.2021.1881552
7. Mitra, D., Uniyal, N., Panneerselvam, P., Senapati, A. and Ganeshamurthy, A.N., 2019. Role of mycorrhiza and its associated bacteria on plant growth promotion and nutrient management in sustainable agriculture. International Journal Of Life Sciences and Applied Sciences, 1(1), pp.1-10.
8. Panneerselvam, P., Kumar, U., Sugitha, T.C.K., Parameswaran, C., Sahoo, S., Binodh, A.K., Jahan, A. and Anandan, A., 2017. Arbuscular mycorrhizal fungi (AMF) for sustainable rice production. In Advances in soil microbiology: recent trends and future prospects (pp. 99-126). Springer, Singapore.
9. Shen, J., Yuan, L., Zhang, J., Li, H., Bai, Z., Chen, X., Zhang, W. and Zhang, F., 2011. Phosphorus dynamics: from soil to plant. Plant physiology, 156(3), pp.997-1005.
10. Smith, S.E. and Smith, F.A., 2011. Roles of arbuscular mycorrhizas in plant nutrition and growth: new paradigms from cellular to ecosystem scales. Annual review of plant biology, 62, pp.227-250.
11. Wang, J., Wang, G.G., Zhang, B., Yuan, Z., Fu, Z., Yuan, Y., Zhu, L., Ma, S. and Zhang, J., 2019. Arbuscular mycorrhizal fungi associated with tree species in a planted forest of eastern China. Forests, 10(5), p.424.
12. Wang, X., Wang, C., Sui, J., Liu, Z., Li, Q., Ji, C., Song, X., Hu, Y., Wang, C., Sa, R. and Zhang, J., 2018. Isolation and characterization of phosphofungi, and screening of their plant growth-promoting activities. Amb Express, 8(1), pp.1-12.
13. Zhu, F., Qu, L., Hong, X. and Sun, X., 2011. Isolation and characterization of a phosphate-solubilizing halophilic bacterium Kushneria sp. YCWA18 from Daqiao Saltern on the coast of Yellow Sea of China. Evidence-Based Complementary and Alternative Medicine, 2011.