Scientific Innovation Magazine
ISSN : 2584-1157

Mobilization of Soil Phosphorus by Impact of Vesicular-Arbuscular Mycorrhizae

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Abstract

The microorganisms play a vital role in sustaining the crop production through improving the soil properties and plant nutrition. Among the microorganisms VAM (vesicular-arbuscular mycorrhizae) is a beneficial fungus that plays an important role in soil nutrient dynamics and improving soil physical, chemical and biological properties. One of the factor that allow plants to grown on poor soil is their associated with vescular arbascular mycorrhizal (VAM) that enable uptake of immobile phosphorous and other nutrients. Though phosphorus is the second macronutrient required in relatively large amounts by plants next to nitrogen, it is one of the most difficult nutrients for plants to acquire because of its low solubility, low mobility and fixation in soil. Plants in VAM symbiosis were better supplied with Phosphorous from low-soluble phosphorus source or rock phosphates. The mycorrhizal symbiotic association between fungi and plants plays an important role in the uptake of phosphorus. Many experiments have specified that VAM is able to alter mobilization of soil phosphorus of its host plants. The paper summarizes about mycorrhizal symbiosis of VAM involving multistep colonization process, soil phosphorus dynamics in the rhizosphere and mycorrhizal mechanism and pathways involved in phosphorus availability and uptake.

Key word: *VAM, Phosphorous, Mycorrhizal*

Introduction

The microorganisms play a vital role in sustaining the crop production through improving the

soil properties and plant nutrition. Soil microorganism are most sensitive to soil heating during a fire, especially nitrifiers, endo and ectomycorrhizae (eg. VAM) are present in the organic matter on or near to the soil surface, and are thus mostly –arbascular mycorrhizae colonization leads to long – term loss in soil productivities. Though the agricultural production has been continued to increase to feed the blooming population in one side, the soil fertility has attained the statue and started to decline because of faulty agricultural practices. Because of that fertile lands are going out of cultivation and increased degradation results increased area under current fallows. In this situation, we must go for a combined use of both organic and inorganic fertilizers in judicious combination based on soil nutrient status to improve and sustain the soil fertility and productivity which is called as integrated nutrient management (INM). Soil microorganism in soil and the nature of organic matter sources. The main beneficial activities of microorganisms are increased availability of plant nutrients, improvement of nutrient uptake, production of plant growth regulators, plant protection against root pathogens etc. According to their relationships with the plant, the microorganisms can be divided into saprophytes, parasitic symbionts (pathogen) and mutualistic symbionts (symbionts). The mutualistic symbionts are commonly used in bio-fertilizers because it carries out functions for the plants that they are unable to perform for themselves. Among the mycorrhizal associations, VAM is most widespread in their distribution both genetically and geographically. These fungi lacks sexual reproduction and are classified on the basis of their characteristic chlamydospore size, shape, colour and wall characters. This group includes members of order Glomales in class Zygomycotina. It encompasses seven genera, viz. Glomus, Gigaspora, Modicella, Acaulospora, Sclerocystis, Endogone and Glaziella with more than 150 species. VAM is beneficial symbionts that colonize a wide range of host roots that include both agricultural and horticultural plants. However, a few plant families such as Amaranthaceae, Brassicaceae, Cruciferae, Chenopodiaceae, Caryophyllaceae, Juncaceae, Cyperaceae and Polygonaceae do not exhibit any association. Soil microorganisms contribute to the PE, thereby impacting soil carbon stabilization. Carbon use efficiently (CUE) is used to understand soil microbial metabolism. Organism with a lower CUE respire a higher proportion

of metabolized carbon as CO_2. Soil microbes indirectly influence the physically protected SOM by improving soil aggregation, thereby enhancing carbon stabilization in soil.

Soil phosphorus is dynamics process in the rhizosphere. The adequate amount of soil phosphorus is required to enhance shoot and root growth and promote early maturity which in turn help to increase water use efficiency (WUE) and yield potential because it is the element, which helps to store and transfer energy produced by photosynthesis. Though phosphorus is the second macronutrient required in relatively large amounts by plants next to nitrogen, it is one of the most difficult nutrients for plants to acquire because of its low solubility, low mobility and fixation in soil. The availability of soil phosphorus is affected by the presence of Fe and Al oxides which fix phosphorus as Fe and Al phosphates and clay minerals in highly weathered alfisol, ultisol and oxisols and as Ca phosphates under calcareous soils. Despite its availability, the phosphorus uptake is influenced by the rooting type, soil properties and soil moisture availability. In the diffusion process, once the phosphate is adsorbed strongly by the soil, its effective diffusion coefficient value becomes low, which creates a steep concentration gradient in the soil. Hence the soil phosphate near the root zone only could reach the root surface to meet the plant requirements and ultimately plant express phosphorus deficiency when the demand is more than the availability exist in soil. The mycorrhizal symbiotic association between fungi and plants plays an important role in the uptake of phosphorus. Many experiments have specified that VAM is able to alter mobilization of soil phosphorus of its host plants. The main beneficial activities of microorganism are increased availability of plant nutrient, improvement of nutrient uptake, production of plant growth, plant protection against root pathogens etc. according to their relationship with the plant, the microorganism can be divided into saprophytes, parasitic symbionts (pathogen) and mutualistic symbionts (symbionts). The mutualistic symbionts are commonly used in bio-fertilizers because it carries out function for the plants that they are unable to perform for themselves. For examples, the host plants recives mineral nutrients by the organism, and the microorganism obtains photo-synthetically derived carbon compound from the host plant. Among these the microorganism VAM is a beneficial

fungus that play an important role in soil nutrient dynamics and improving soil physical, chemical, and biological properties. The level of P in the rhizosphere influence the establishment of mycorrhiza with a high-level inhibition of colonization. A total of 80% of terrestrial plants host mycorrhizae which facilitate increased phosphorus uptake and thus removal from soil and water. This symbiotic relationship between fungi and plants facilitates a several-fold increase in phosphorus uptake.

Mycorrhizal Pathway of Phosphorus Uptake

There are two possible ways in which soil phosphorus has been taken up by the plants:

(i) Direct pathway and

(ii) AM pathway

Generally plants uptake phosphorus through direct pathway as negatively charged $H_2PO_4^-$ ions which increase negative electric potential inside the cell membrane because of high cell concentration compared to soil solution.

Hence an additional metabolic energy required for the Pi uptake, and it needs high-affinity transporter proteins. So the pathway is more effective in the root apex which has high-affinity transporter proteins (PiTs) in the epidermis. But after a certain period of time, two things will happen. The first is when loss of root hairs started, the transporter protein (PiT) activity will reduce, and certainly direct uptake will decline. Second, the uptake of phosphorus as orthophosphate (Pi) by root epidermal cells leads to lower the Pi concentrations in the root rhizosphere making zone of depletion.

Phosphatase Soil phosphatase plays an important role in the P nutrition of plants because it mediates the release of inorganic phosphorus from organically bound phosphorus.

Mycorrhizal colonization has been shown to influence the phosphatase activity, particularly the increased alkaline phosphatase activity in the presence of mycorrhizal hyphae (Tarafdar and Marschner 1994). Acid phosphatases have also been reported in mycorrhizal fungi, and although their function is unclear, they may be associated with the growth and development of the fungus within the host tissue as well as with phosphorus acquisition in the rhizosphere. Subramanian

et al. (2009) reported that acid phosphatase activity of VAM-colonized soils was higher irrespective of the stages of observation, but the increase was well exhibited at early stages than in the later stages. Vesicular Arbuscular Mycorrhizal (VAM) is a fungus which has the ability to dissolve the phosphates found in abundance in the soil. Apart from increasing the availability of phosphorus, VAM provides the plants with the strength to resist disease a germs an weather conditions. In this respect, it is beneficial and necessary to introduce salt-tolerant phosphate-solubilizing bacteria (PSB) as well as arbuscular mycorrhizal fungi (AMF), which can provide bioavailable P to plants by the mobilization of P that is bio-unavailable in soil. PSB improves plant nutrition absorption. Mostly recommended for upland crops especially for potted plants and tissue culture plantlets. Commercially it is available as carrier based inoculum. The recommended method of application includes seed treatment, seedling dip and direct soil application along with organic manure. The mycorrhizal biofertilizer helps plant protection from many soil-borne infections, reduces transplantation and acidic shock, and so on. All of these aspects evenly contribute to the increase in crop yield. VAM is commonly referred to as biofertilizers. Mycorrhizal hyphae act as a tunnelling machine, exerting considerable pressure on soil particles and force organic material and clay particles together leading to micro-aggregate formation. The creation of these tunnels will contribute to enhancing air and water penetration and movement.

Conclusions

The fertilizer phosphate is becoming one of the most expensive commodities, and its availability is uncertain; the crop production will be critical, particularly in rainfed regions, where the fertilizer application is mainly based on rainfall distribution. In this situation mycorrhizal plant colonization is very useful in conserving energy by reducing fertilizer requirement of crops and in meeting the production targets in nutritionally deficient soils. The omnipresent nature, increased phosphorous uptake, drought tolerance and increased plant growth benefit by mycorrhizal colonization, which is important to increase the absorption of other relatively immobile elements in soil and a step towards the sustainability of the healthy soil and plant

ecosystem. Infection of crop roots with vesiculararbuscular mycorrhizal (VAM) fungi can improve uptake of phosphorus and increase crop production. The phosphorus additions increased the amounts of easily soluble phosphorus in the soils, which adversely affected the diaspores. No relationships existed between the number of VAM diaspores and other soil parameters such as the amount of difficulty soluble phosphorus, pH, organic matter, or total nitrogen content. A plant-production parameter, estimated as dry matter production, was independent of the presence of VAM diaspores but another plant production related parameter, uptake of phosphorus by the plants, was dependent on the presence of VAM diaspores.

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