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Microbial inoculants : Enhancing nutrient use efficiency

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Abstract : An ecologically supreme way of improving nutrient use efficiency is harnessing plant microbe interactions, as it causes zero damage to the ecosystem. It is widely believed that a vast diversity of microorganisms inhabiting rhizosphere, phylloplane and as endophytes assists plant in uptake of mineral nutrients and various other growth factors and through which they ensure better plant productivity and hence an improved nutrient use efficiency. Agriculturally important micro-organisms can positively influence the use efficiencies of different plant nutrients like N, P, K and many other secondary and micronutrients.

Introduction : Low efficiency of applied nutrients is one of the main constraints in crop production and it is a major global concern with regards to food security for an ever increasing global population. In India in the past few decades use efficiencies for major nutrients like N, P and K has remained constant. This means large quantities of nutrients applied are lost which not only adds to the cost of production but also imparts detrimental effects on the environment like nitrate pollution. Nutrient use efficiency can be increased through various means like manipulation of application techniques, coating fertilizers like in the case of urea which is coated with different materials like *Neem,* sulfur, gypsum, plastic and mud ball so as to enable slow release of nitrogen.

Microbes for use efficiency of nitrogen : Nitrogen is the primary nutrient and it is an important constituent of proteins, enzymes, nucleic acids and plays a major role in the establishment and maintenance of photosynthetic capacity, photosynthetic activity and sink capacity. Since the availability of nitrogen in the easily absorbable form is limited, soil external application of nitrogen becomes an absolute need. But much of the N applied to the soil does not find its fate in plant absorption. Only 30-35 per cent of the applied nitrogen is taken up by plants and the remaining is either fixed in soil or lost to the environment in the form of leaching and gaseous loss. Considering the cost of fertilizer nitrogen and the ill effects of lost nitrogen it is necessary to improve the nitrogen use efficiency. The use of microbial inoculants to improve nitrogen use efficiency is an ecofriendly option available to the farmers.

Barneix *et al.* (2005) found out that inoculation with rhizobacteria, *Bacillus simplex* and *Bacillus flexus* in wheat improved nitrogen use efficiency and grain quality.

In another study. Adesemoye and his group of researchers have shown that reduction of chemical fertilizers by 25 per cent than the recommended dose and supplementing with application of a PGPR formulation (*Bacillus amyloliquefaciens* IN937a and *Bacillus pumilus* T_4), has resulted in the same level of plant growth, yield, nitrogen and phosphorus uptake as that of full dose of fertilizers. When it was further supplemented with AMF *Glomus intraradices* the same effect was achieved even with 70 per cent of recommended dose of fertilizers. Nitrogen fixing bacteria both symbiotic (Rhizobia) and free living (*Azotobacter*, *Azospirillum* and various N fixing cyanobacteria) are also known to improve nitrogen use efficiency and also can provide atmospheric nitrogen.

Microbes for use efficiency of phosphorus: Phosphorus is the second most important plant nutrient after nitrogen and it is an integral component of nucleic acids, phospholipids, important in cellular membrane and provides compounds for photosynthesis in plants. In soil, P is present in large amounts but only a fraction of it is available to plants owing to very low solubility of phosphate salts in soils. Much of fertilizer phosphate applied to crop plants is fixed in soil and the total available phosphate has very low mobility. Plants have evolved a multitude of strategies to increase P uptake thereby increasing P use efficiency.

Arbuscular mycorrhizal (AM) symbioses is the most wide spread strategy used by plants to improve P use efficiency. AM symbioses is a special kind of symbiotic relationship in which the micro partner (fungi) helps in P uptake and mobility in the macro partner (plants) and macro partner provides sugars and space for colonisation to the micro partner. AM symbioses, because of its large

surface area can contribute to plant nutrition uptake especially phosphorus uptake. Since phosphorus is highly immobile element, the left over phosphates which are not absorbed by plants are easily absorbed in the bulk soil and hence a phosphate free zone occurs in the rhizosphere. But, the extraradical mycelium formed by fungal partner can extend beyond this phosphate free zone and help plants in absorbing phosphate available at a far off distance from roots thereby making the otherwise unavailable phosphates to available phosphates.

Glomus, *Gigaspora*, *Scutellospora*, *Acaulospora* and *Entrophospora* are the most commonly occurring AM fungi (AMF).The role of AM fungi in improving P use efficiency and general growth parameters is established in different crops by various research groups.

Apart from AM fungi there is one more function group of micro-organism called phosphorus solubilizers which improve phosphorus use efficiency alike AM fungi. Unlike AM fungi phosphorus solubilizers are not involved in P mobilization, but they solubilize fixed phosphates to available phosphates.

A number of phosphorus solubilizing micro-organisms have been utilized for tackling the phosphorus fixation problem in the soil. A few to name are *Pseudomonas striata*, *P.fluorescens*, *Bacillus megaterium* and *Aspergillus* sp. Such phosphorus solubilizing micro-organisms can be used singly or in combination with other microbial inoculants like AM fungi and nitrogen fixers.

Microbes for use efficiency of potassium: Potassium (K) is the third most important plant nutrient which plays a key role in growth, metabolism and development of plants. An adequate supply of potassium to crop plants leads to well developed roots, fast growth and increased resistance to pests and diseases. Potassium, once thought of being adequate in Indian soils has been reported to be low in 21 per cent of Indian soils and medium in 51 per cent of arable land. Hence, there is a need of immediate K fertilization of 72 per cent of Indian agricultural soils. Since the cost of potash fertilizer is dependent on global market, it's getting costlier every year which increases the cost of cultivation. An alternate option is use of microbe mediated technologies to improve potash use efficiency so that the input of potash fertilizer can be kept at a bare minimum.

K use efficiency can be improved by inoculation of crop plants with potash solubilizing micro-organisms and AM fungi. Organic acids produced by microbial inoculants are able to chelate metal and mobilize K from K containing minerals. Field trial were carried out with a PGPR (*Bacillus* sp.) and AMF (*Glomus intraradices*) in maize across two tillage system (no till and conventional tillage). It was shown that treatment of AMF in combination with PGPR improved the uptake of K along with N and P across the tillage systems.

Microbes in use efficiency of other minerals: Microbial inoculants have been shown to improve use efficiency of many other elements in addition to N, P and K. *Mesorhizobium mediterannium* when inoculated in barley and chickpea has shown to improve uptake of Ca and Mg along with N, P and K uptake. *Pseudomonas mendocina* in combination with AMF (*Glomus intraradices* and *G. mosseae*) have shown to improve the uptake of Ca, Fe and Mn along with improved uptake of N and P in lettuce.

Benefits: Inoculation with nitrogen fixing bacteria either at the time of sowing or at frequent intervals in the crop growth stages can reduce the application of chemical fertilizers. Arbuscular mycorrhizal fungi is known for increasing uptake of nitrogen and other plant nutrients just as they improve the uptake of phosphorus.

AM fungi have been shown to improve use efficiency of all major and micronutrients since they increase the surface area of roots. Incorporation of microbial inoculants technology as a component of integrated nutrient management has dual benefits of high crop productivity in the short term and sustained production without deteriorating the soil health in the long term.

Conclusion: Although a plenty of microbial inoculants are available to increase nutrient use efficiency, it has to be considered that no microbial inoculants is universal as their activity depends on soil type, plant grown and various other edaphic and climatic factors. Hence, there is a need for widespread studies on different microbial inoculants for improving nutrient use efficiency of different crops under varied agroclimatic conditions.

References:

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