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Biofertilizers – What Next?

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Even though, hundreds of bacteria and fungi are identified for enhancing plant growth, only few have been commercially exploited as biofertilizers, which include *Rhizobium, Azospirillum, Azotobacter, Gluconacetobacter,* cyanobacteria (for N_2 fixation), *Bacillus, Pseudomonas, Aspergillus, Penicillium* (for P solubilization and PGPR), *Bacillus* (K solubilization) and arbuscular mycorrhiza (for P mobilization). These organisms are commercially formulated either as liquid or carrier-based, and supplied for various crops. Bioinoculants have shown great potential as a supplementary, renewable and environmental-friendly source of plant nutrients, and are an important component of Integrated Nutrient Management (INM) and Integrated Plant Nutrient System (IPNS). It is necessary that bioinoculants play a more significant role in the production systems, and maintain ecological equilibrium and sustainability, as well. In future, the bioinoculants technology should be a major component of INM or IPSM, when considering the ever-increasing chemical fertilizer prices. It is cheap, non-renewable, eco-friendly and sustainable technology which needs quality improvement, to prove its effects for obtaining farmer's faith.

The major concern about this efficient technology is its quality standards. Present quality standards as prescribed by regulatory agencies of a country, will not authenticate the strain used for commercial production. Hence, the most urgent need for the biofertilizer technology is to develop a simple protocol for strain authentication. Being in biotechnological era, it could be possible to use PCR based techniques for strain authentication, as well as quantification at different stages of commercial production, and even in inoculated fields. Sequence Characterized Amplified Region (SCAR) marker based fingerprintings, are based on genomic variations between strains, allowing for rapid PCR identification of a single strain in a complex sample, which can be used for each strain of biofertilizers. SCAR marker coupled with quantitative PCR, will allow for assessing the cell loads per g/ml of inoculants, in addition to authentication.

Precision farming is an integrated management system which emphasizes on maintaining and increasing soil fertility, by optimizing all possible sources (organic and inorganic) of plant nutrients required for crop growth and quality. Precision agriculture merges the new technologies born of information age with a mature agricultural industry, which ensures yield maximization with efficient use of water and nutrient inputs. Biofertilizer formulations for precision agriculture, in the form of mixed inoculants for major nutrients are the need of the hour. The liquid formulation or water dispersible carrier based formulation, easy to supply through laterals (known as biofertigation), will ensure the proper delivery of the biofertilizer organisms, directly to the root zone of the crop. The major concern of using biofetilizers through fertigation system is the chance of chemical inputs' toxicity to the microbial cells. Hence, study on temporal and spatial differentiation between biological and chemical inputs of precision farming, has to be focused.

Plant growth promoting rhizobacteria (PGPR), associated with major agricultural crops like rice, wheat, maize and sugarcane, stimulate plant growth through various direct and indirect mechanisms. The direct effects include growth hormone production, dinitrogen fixation, mineral solubilization, and some indirect effects like biocontrol against soil pathogens and inducing abiotic stress tolerance to the plants. There are several genera of Proteobacteria and Firmicutes, in particular, possess multifaceted beneficial activities to the plants. Exploring the genetic and functional diversity of these PGPRs from various agro-climatic zones, and developing as multi-functional bioinoculants, would be a novel approach to enhance the biofertilizer use efficiency in agriculture.

Biofertilizer is one of the viable technologies which are less explored by the farmers, due to its slow action, less-visible effects to the crops and less persistence in soil. The quality is another major concern, which ranks the biofertilizers as "Not-Satisfactory" among the farmers. Hence, it is the duty of the scientific communities and biofertilizer entrepreneurs, to eliminate these bottle necks so as to take this eco-friendly technology, in a progressive way to the modern agriculture.

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