Potential of Biofertilizers Over Chemical Fertilizers

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Abstract- *The make use of chemical fertilizers (e.g. urea, calcium nitrate, ammonium sulphate, diammonium phosphate etc.) have a great impact for the world's food manufacture as it works as a fast food for plants causing them to grow more rapidly and proficiently. While unfavorable effects are being noticed due to the extreme and excessive use of these artificial inputs. Moreover, continual use of conventional chemical fertilizers subverts the soil ecology, disturb environment, degrade soil fertility and as a result shows harmful effects on human health and contaminates ground water. For these reasons, biofertilizers, the organic substances, which make use of microorganisms to raise the fertility of soil, has been identified as harmless input help in conservation the soil health and also the value of crop products. Biofertilizers add nutrients through the natural process of nitrogen fixation, solubilizing phosphorus, and stimulating plant growth through the synthesis of growth promoting substances. They are also environment friendly and responsible for continuous availability of nutrients from natural sources. This paper will review the facts and observations regarding biofertilizers, types and their potential for crop production based on relevant literature and research work carried out by many researchers.*

Keywords- Nutrients, Chemical fertilizers, Biofertilizers, Microorganisms.

I. INTRODUCTION

The significance of 16 essential plant nutrients (such as N, P, K, Ca, Mg and S are called macronutrients, while Fe, Zn, Cu, Mo, Mn, B and Cl are called micronutrients) in required quantities to attain the maximum yield in crop production is well-established. N, P and K are required in enhancing the natural ability of plants to resist stress from drought and cold, pests and diseases (1). Sustainable agriculture offers the potential to meet our agricultural requirements as it encompasses advances in agriculture by using special farming, management practices and technology at the same time ensuring that no harm done to the same(2). Chemical fertilizers and their exploitation cause air and ground water pollution by eutrophication of water bodies (3). Conventional, chemically processed fertilizers also weaken the soil ecology, disrupt environment, degrade soil fertility and consequently shows harmful effects on human health (4). Hence, the practice of chemical farming put the long-run sustainability of agriculture and the survival of the farming community at risk. In this context, biofertilizers have emerged as an important component of the integrated nutrient supply system and have great potential to improve crop yields through environmentally better nutrient supplies (5). This review highlights the role of biofertilizers in modern agriculture, future prospects and aspects based on relevant literature.

II. BIOFERTILIZER

'Biofertilizer' is a substance which contains living microorganism which, when applied to seed, plant surfaces, or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant(6). Fertilizers directly increase soil fertility by adding nutrients. Biofertilizers add nutrients through the natural processes of fixing atmospheric nitrogen, solubilizing Phosphorus, and stimulating plant growth through the synthesis of growth promoting substances(7). Biofertilizers are defined as preparations containing living cells or latent cells of efficient strains of microorganisms that help crop plants' uptake of nutrients by their interactions in the rhizosphere when applied through seed or soil. They accelerate certain microbial processes in the soil which augment the extent of availability of nutrients in a form easily assimilated by plants. Very often microorganisms are not as efficient in natural surroundings as one would expect them to be and therefore artificially multiplied cultures of efficient selected microorganisms play a vital role in accelerating the microbial processes in soil. Use of biofertilizers is one of the important components of integrated nutrient management, as they are cost effective and renewable source of plant nutrients to supplement the chemical fertilizers for sustainable agriculture(8). Several microorganisms and their association with crop plants are being exploited in the production of biofertilizers.

Bio-fertilizers provide "eco-friendly" organic agro-input. Bio-fertilizers such as *Rhizobium*, *Azotobacter*, *Azospirilium* and blue green algae (BGA) have been in use a long time. *Azotobacter* can be used with crops like wheat, maize, mustard, cotton, potato and other vegetable crops.

Azospirillum inoculations are recommended mainly for sorghum, millets, maize, sugarcane and wheat[9]. Blue green algae belonging to a general cyanobacteria genus, *Nostoc* or *Anabaena* or *Tolypothrix* or *Aulosira*, fix atmospheric nitrogen and are used as inoculations for paddy crop grown both under upland and low-land conditions. *Anabaena* in association with water fern *Azolla* contributes nitrogen up to 60 kg/ha/season and also enriches soils with organic matter[10].

Other types of bacteria, so-called phosphate-solubilizing bacteria, such as *Pseudomonas putida* strain P13, are able to solubilize the insoluble phosphate from organic and inorganic phosphate sources. In fact, due to immobilization of phosphate by mineral ions such as Fe, Al and Ca or organic acids, the rate of available phosphate (P_i) in soil is well below plant needs[11]. In addition, chemical P_i fertilizers are also immobilized in the soil, immediately, so that less than 20 percent of added fertilizer is absorbed by plants. Therefore, reduction in P_i resources, on one hand, and environmental pollutions resulting from both production and applications of chemical P_i fertilizer, on the other hand, have already demanded the use of phosphate-solubilizing bacteria or phosphate bio-fertilizers.

They can be grouped in different ways based on their nature and function.

S. No.	Groups	Examples
N2 fixing Biofertilizers		
1.	Free-living	*Azotobacter, Beijerinkia, Clostridium, Klebsiella, Anabaena, Nostoc*
2.	Symbiotic	*Rhizobium, Frankia, Anabaena azollae*
3.	Associative Symbiotic	*Azospirillum*
P Solubilizing Biofertilizers		
1.	Bacteria	*Bacillus megaterium* var. *phosphaticum, Bacillus subtilis Bacillus circulans, Pseudomonas striata*
2.	Fungi	*Penicillium sp, Aspergillus awamori*
P Mobilizing Biofertilizers		
1.	Arbuscular mycorrhiza	*Glomus sp.,Gigaspora sp.,Acaulospora sp., Scutellospora sp. & Sclerocystis sp.*
2.	Ectomycorrhiza	*Laccaria sp., Pisolithus sp., Boletus sp., Amanita sp.*
3.	Ericoid mycorrhizae	*Pezizella ericae*
4.	Orchid mycorrhiza	*Rhizoctonia solani*
Biofertilizers for Micro nutrients		
1.	Silicate and Zinc solubilizers	*Bacillus* sp.
Plant Growth Promoting Rhizobacteria		
1.	Pseudomonas	*Pseudomonas fluorescens*

Types of biofertilizers

Rhizobium: *Rhizobium* is a soil habitat bacterium, which can able to colonize the legume roots and fixes the atmospheric nitrogen symbiotically. The morphology and physiology of *Rhizobium* will vary from free-living condition to the bacteroid of nodules. They are the most efficient biofertilizer as per the quantity of nitrogen fixed concerned[12]. They have seven genera and highly specific to form nodule in legumes, referred as cross inoculation group. Initially, due to absence of efficient brady rhizobial strains in soil, soybean inoculation at that time resulted in bumper crops but incessant inoculation during the last four decades by US farmers has resulted in the buildup of a plethora of inefficient strains in soil whose replacement by efficient strains of brady rhizobia has become an insurmountable problem.

Azospirillum: *Azospirillum lipoferum* and *A. brasilense* (*Spirillum lipoferum* in earlier literature) are primary inhabitants of soil, the rhizosphere and intercellular spaces of root cortex of graminaceous plants. They perform the associative symbiotic relation with the graminaceous plants. The bacteria of Genus *Azospirillum* are N2 fixing organisms isolated from the root and above ground parts of a variety of crop plants[13]. They are Gram negative, *Vibrio* or *Spirillum* having abundant accumulation of polybetahydroxybutyrate (70 %) in cytoplasm. Five species of *Azospirillum* have been described to date *A. brasilense*, *A.lipoferum*, *A.amazonense*, *A.halopraeferens* and *A.irakense*. The organism proliferates under both anaerobic and aerobic conditions but it is preferentially micro-aerophilic in the presence or absence of combined nitrogen in the medium. Apart from nitrogen fixation, growth promoting substance production (IAA), disease resistance and drought tolerance are some of the additional benefits due to *Azospirillum* inoculation.[14]

Azotobacter: Of the several species of *Azotobacter*, *A. chroococcum* happens to be the dominant inhabitant in arable soils capable of fixing N2 (2-15 mg N2 fixed /g of carbon source) in culture media. The bacterium produces abundant slime which helps in soil aggregation. The numbers of *A. chroococcum* in Indian soils rarely exceeds 105/g soil due to lack of organic matter and the presence of antagonistic microorganisms in soil.[15]

Cyanobacteria: Both free-living as well as symbiotic cyanobacteria (blue green algae) have been harnessed in rice cultivation in India. A composite culture of BGA having heterocystous *Nostoc*, *Anabaena*, *Aulosira etc.* is given as primary inoculum in trays, polythene lined pots and later mass multiplied in the field for application as soil based flakes to the rice growing field at the rate of 10 kg/ha. The final product is not free from extraneous contaminants and not very often monitored for checking the presence of desired algal flora[16].

Once so much publicized as a biofertilizer for the rice crop, it has not presently attracted the attention of rice growers all over India except pockets in the Southern States, notably Tamil Nadu. The benefits due to algalization could be to the extent of 20-30 kg N/ha under ideal conditions but the labour oriented methodology for the preparation of BGA biofertilizer is in itself a limitation. Quality control measures are not usually followed except perhaps for random checking for the presence of desired species qualitatively.

Phosphate solubilizing microorganisms: Several soil bacteria and fungi, notably species of *Pseudomonas, Bacillus, Penicillium, Aspergillus etc*. secrete organic acids and lower the pH in their vicinity to bring about dissolution of bound phosphates in soil. Increased yields of wheat and potato were demonstrated due to inoculation of peat based cultures of *Bacillus polymyxa* and *Pseudomonas striata*.(17) Currently, phosphate solubilizers are manufactured by agricultural universities and some private enterprises and sold to farmers through governmental agencies. These appear to be no check on either the quality of the inoculants marketed in India or the establishment of the desired organisms in the rhizosphere.

Plant Growth Promoting Rhizobacteria: The PGPR inoculants currently commercialized that seem to promote growth through at least one mechanism; suppression of plant disease (termed Bioprotectants), improved nutrient acquisition (termed Biofertilizers), or phytohormone production (termed Biostimulants). Species of *Pseudomonas* and *Bacillus* can produce as yet not well characterized phytohormones or growth regulators that cause crops to have greater amounts of fine roots which have the effect of increasing the absorptive surface of plant roots for uptake of water and nutrients.(18) These PGPR are referred to as Biostimulants and the phytohormones they produce include indole-acetic acid, cytokinins, gibberellins and inhibitors of ethylene production. Recent advances in molecular techniques also are encouraging in that tools are becoming available to determine the mechanism by which crop performance is improved using PGPR and track survival and activity of PGPR organisms in soil and roots.(19) The science of PGPR is at the stage where genetically modified PGPR can be produced. PGPR with antibiotic, phytohormone and siderophore production can be made.

III. CONCLUSION

In current agriculture, chemical fertilizers have degraded the fertility of soil making it inappropriate for raising crop plants. In addition the severe use of these inputs has also led to severe health and environmental hazards such as soil erosion, water contamination, pesticide poisoning, falling ground water table, water logging and depletion of biodiversity. Biofertilizers naturally activate the microorganisms found in the soil being cheaper, valuable and environmental friendly are gaining importance for use in crop production, restoring the soil's natural fertility and protecting it against drought, soil diseases and therefore stimulate plant growth. For the success of biofertilizer technology, further research and development is needed to understand the mechanisms of action of various biofertilizers and to find out more competent rhizobacterial strains and carrier materials to make agriculture practices more sustainable and economical.

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