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Role of Biofertilizers in Agriculture

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Biofertilizers are natural fertilizes which are living microbial inoculants of bacteria, algae, fungi alone or in combination and they augment the availability of nutrients to the plants. The role of biofertilizers in agriculture assumes special significance, particularly in the present context of increased cost of chemical fertilizer and their hazardous effects on soil health.

Introduction

Modern agriculture emphasizes in using hybrid seeds and high yielding varieties that are highly responsive to large doses of chemical fertilizers and irrigation. Indiscriminate use of synthetic fertilizers has led to pollution and contamination of soil and water basins. This has resulted in soil being deprived of essential plant nutrients and organic matter. It has led to depletion of beneficial micro-organisms and insects indirectly reducing soil fertility and making crops more prone to diseases. It is estimated that by 2020, to achieve the targeted production of 321 million tons of food grain, the requirement of nutrient will be 28.8 million tons, while their availability will be only 21.6 million tons being a deficit of about 7.2 million tons, thus depleting feedstock/fossil fuels (energy crisis) and increasing cost of fertilizers which would be unaffordable to small and marginal farmers, thus intensifying the depleting levels of soil fertility due to widening gap between nutrient removal and supplies.

Chemical fertilizers which are now being used extensively since the green revolution have depleted soil health by making the soil ecology non - inhabitable for soil micro flora and micro fauna which are largely responsible for maintaining soil fertility and providing some essential and indispensable nutrients to plants. Biofertilizers are the products containing one or more species of microorganisms which have the ability to mobilize nutritionally important elements from non usable to usable form through biological processes such as nitrogen fixation, phosphate solubilisation, excretion of plant growth promoting substances or cellulose and biodegradation in soil, compost and other environments. In other words, biofertilizers are natural fertilizes which are living microbial inoculants of bacteria, algae, fungi alone or in combination and they augment the availability of nutrients to the plants. The role of biofertilizers in agriculture assumes special significance, particularly in the present context of increased cost of chemical fertilizer and their hazardous effects on soil health.

Biofertilizer: The Need of the Hour in Agriculture

At present times, there is a growing concern about environmental hazards and threats to sustainable agriculture. In view of the above stated facts, the long term use of bio-fertilizers proves to be economical, eco-friendly, more efficient, productive and accessible to marginal and small farmers over chemical fertilizers. The need for the use of biofertilizer thus arises primarily for two reasons. First, because increase in the use of fertilizers leads to increased crop productivity, second, because increased usage of chemical fertilizer leads to damage in soil texture and raises other environmental problems.

Classification of Biofertilizers

Several microorganisms and their association with crop plants are being exploited in the production of biofertilizers. They can be grouped in different ways based on their nature and function.

Rhizobium: Rhizobium is a soil habitat bacterium, which colonizes legume roots and fixes atmospheric nitrogen symbiotically. The morphology and physiology of Rhizobium vary from free-living condition to the bacteroid of nodules. They are the most efficient biofertilizer as per the quantity of nitrogen fixed concerned. They have seven genera and are highly specific to form nodule in legumes, referred as cross inoculation group.

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.

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 develop associative symbiotic relationship with graminaceous plants. Apart from nitrogen fixation, growth promoting substance production (IAA), disease resistance and drought tolerance are some of the additional benefits of inoculation with *Azospirillum*.

Cyanobacteria: Both free-living as well as symbiotic cyanobacteria (blue green algae) have been harnessed in rice cultivation in India. Once so much publicized as a biofertilizer for rice crop, it has not presently attracted the attention of rice growers all over India. 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.

Azolla: *Azolla* is a free-floating water fern that floats in water and fixes atmospheric nitrogen in association with nitrogen fixing blue green alga *Anabaena azollae*. *Azolla* either as an alternate nitrogen sources or as a supplement to commercial nitrogen fertilizers. *Azolla* is used as biofertilizer for wetland rice and it is known to contribute 40-60 kg N/ha per rice crop.

Phosphate solubilizing microorganisms **(PSM)***:* Several soil bacteria and fungi, notably species of *Pseudomonas, Bacillus, Penicillium, Aspergillusetc*. 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*.

AM fungi: The transfer of nutrients mainly phosphorus and also zinc and sulphur from the soil *milleu* to the cells of the root cortex is mediated by intracellular obligate fungal endosymbionts of the genera *Glomus, Gigaspora, Acaulospora, Sclerocysts* and *Endogone* which possess vesicles for storage of nutrients and arbuscles for funnelling these nutrients into the root system. By far, the commonest genus appears to be *Glomus*, which has several species distributed in soil.

Silicate solubilizing bacteria (SSB): Microorganisms are capable of degrading silicates and aluminium silicates. During the metabolism of microbes several organic acids are produced and these have a dual role in silicate weathering. They supply H+ ions to the medium and promote hydrolysis and the organic acids like citric, oxalic acid, Keto acids and hydroxy carbolic acids which form complexes with cations, promote their removal and retention in the medium in a dissolved state.

Plant growth promoting rhizobacteria (PGPR): The group of bacteria that colonize roots or rhizosphere soil and beneficial to crops are referred to as plant growth promoting rhizobacteria (PGPR). The PGPR inoculants promote growth through 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. These PGPR are referred to as Biostimulants and the phytohormones they produce include indole-acetic acid, cytokinins, gibberellins and inhibitors of ethylene production.

Types of Biofertilizers

S. No.	Types of biofertilizers	Examples
N_2 fixing Biofertilizers		
1.	Free-living	*Azotobacter, Beijerinkia, Clostridium, Klebsiella, Anabaena, Nostoc*
2.	Symbiotic	*Rhizobium, Frankia, Anabaena azollae*
3.	Associative Symbiotic	*Azospirillum*
P Solubilizing Biofertilizers		
4.	Bacteria	*Bacillus megaterium* var. *phosphaticum, Bacillus subtilis, Bacillus circulans, Pseudomonas striata*
5.	Fungi	*Penicilliumsp, Aspergillus awamori*
P Mobilizing Biofertilizers		
6.	Arbuscularmycorrhiza	*Glomussp., Gigaspora sp., Acaulospora sp., Scutellospora sp. & Sclerocystis sp.*
7.	Ectomycorrhiza	*Laccaria sp., Pisolithus sp., Boletus sp., Amanita sp.*
8.	Ericoid mycorrhizae	*Pezizellaericae*
9.	Orchid mycorrhiza	*Rhizoctonia solani*
Biofertilizers for Micro nutrients		
10.	Silicate and Zinc solubilizers	*Bacillus* sp.
Plant Growth Promoting Rhizobacteria		
11.	Pseudomonas	*Pseudomonas fluorescens*

Methods of Application of Biofertilizers

Seed Treatment: 200 g of biofertilizer is suspended in 300- 400 mL of water and mixed gently with 10 kg of seeds using an adhesive like gum acacia, jiggery solution, etc. The seeds are then spread on a clean sheet/cloth under shade to dry and used immediately for sowing.

Seedling Root Dip: This method is used for transplanted crops. For rice crop, a bed is made in the field and filled with water. Recommended biofertilizers are mixed in this water and the roots of seedlings are dipped for 8-10 h and transplanted.

Soil Treatment: 4 kg each of the recommended biofertilizers is mixed in 200 kg of compost and kept overnight. This mixture is incorporated in the soil at the time of sowing or planting.

Advantages of Using Biofertilizers

Some of the advantages associated with biofertilizers include:

- They are eco- friendly as well as cost effective
- Their use leads to soil enrichment and the quality of the soil improves with time.
- Though they do not show immediate results, but the results shown over time are spectacular.
- These fertilizers harness atmospheric nitrogen and make it directly available to the plants.
- They increase the phosphorous content of the soil by solubilising and releasing unavailable phosphorous.
- Biofertilizers improve root proliferation due to the release of growth promoting hormones.
- Microorganism converts complex nutrients into simple nutrients for the availability of the plants.
- Biofertilizer contains microorganisms which promote the adequate supply of nutrients to the host plants and ensure their proper development of growth and regulation in their physiology.
- They help in increasing the crop yield by 10-25%.
- Biofertilizers can also protect plants from soil born diseases to a certain degree.

Amount of Nutrients Fixed by Some Biofertilizers in Various Crops

Microorganisms used as biofertilizer	Nutrient fixed (kg/ha/year)	Beneficiary crops
Rhizobium	50 to 300 kg N / ha	Groundnut, Soybean, Redgram, Green-gram, Black-gram, Lentil, Cowpea, Bengal-gram and Fodder legumes
Azotobacter	0.026 to 20 kg N / ha	Cotton, Vegetables, Mulberry, Plantation Crop, Rice, Wheat, Barley, Ragi, Jowar, Mustard, Safflower, Niger, Sunflower, Tobacco, Fruit, Spices, Condiment, Ornamental Flower
Azospirillum	10-20 kg N /ha	Sugarcane, Vegetables, Maize, Pearl millet, Rice, Wheat, Fodders, Oil seeds, Fruit and Flower
Blue Green Algae	25 kg N /ha	Rice, banana
Azolla	900 kg N /ha	Rice
Phosphate solubilizing bacteria and fungi	Solubilize about 50-60% of the fixed phosphorus in the soil	All Crops (non specific)

Constraints in Biofertilizer Technology

Though the biofertilizer technology is a low cost, eco-friendly technology, several constraints limit the application or implementation of the technology. The constraints may be:

- Technological constraints like unavailability of good quality carrier material and lack of qualified technical personnel in production units.
- Infrastructural constraints like lack of essential equipments, power supply, etc.
- Financial constraints like non-availability of sufficient funds and problems in getting bank loans.
- Environmental constraints like seasonal demand for biofertilizers, simultaneous cropping operations and short span of sowing/planting in a particular locality, etc.
- Human resources and quality constraints like lack of technically qualified staff in the production units, lack of suitable training on the production techniques.
- Unawareness on the benefits of the technology due to problem in adoption of the technology by the farmers due to different methods of inoculation, no visual difference in the crop growth immediately as that of inorganic fertilizers.
- Marketing constraints like non availability of right inoculant at the right place at the right time, lack of retail outlets or the market network for the producers.
- The different constraints in one way or the other affect the technique at production, or marketing or usage.

Conclusion

Biofertilizers being essential components of organic farming play a vital role in maintaining long term soil fertility and sustainability by fixing atmospheric di-nitrogen, mobilizing fixed macro and micro nutrients in the soil into forms available to plants. Currently there is a gap of ten million tons of plant nutrients between removal of crops and supply through chemical fertilizers. In context of both the cost and environmental impact of chemical fertilizers, excessive reliance on chemical fertilizers is not practicable in the long run because of the cost, both in domestic resources and foreign exchange involved in setting up of fertilizer plants and sustaining the production. In this context, biofertilizers would be the viable option for farmers to increase productivity per unit area.