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Importance and Application of Biofertilizers in Indian Agriculture

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Abstract
Most of the agricultural production in Indian consists of marginal farmers who need the development of sustainable technologies, with costs according to their economic condition. Biofertilizers composed of free-living microorganisms promote plant's growth, improve future soil fertility and productivity through the strengthening of its roots, and reduce the amount of inorganic chemical fertilizer applied to the crops. The eco-friendly approaches inspire a good range of applications of plant growth-promoting rhizobacteria (PGPRs), endo- and ectomycorrhizal fungi, cyanobacteria and lots of other useful microscopic organisms led to encouraging soil nutrient uptake, plant growth, and plant tolerance to biotic and abiotic stress. The main objective of this article is to highlight the microorganisms commonly used in agriculture as biofertilizers.

Keywords: Agriculture, Biofertilizers, Microbes, Soil fertility

Introduction
This growing human population demands conventional agriculture to satisfy its needs for food which makes farmers depend upon the usage of chemical fertilizers and pesticides for increased productivity (Santos et al. 2012). Recent agriculture emphasizes in using high-yielding varieties that are highly responsive to large doses of inorganic chemical fertilizers. Indiscriminate and imbalanced use of inorganic chemical fertilizers has led to pollution and contamination of soil and water basins. This has resulted in soils leading to the depletion of beneficial Microorganisms, essential plant nutrients, and organic matter.

Biofertilizers are one of the best natural gifts of our agricultural science as a replacement for chemical fertilizers. Biofertilizer contains microorganisms that encourage the adequate supply of nutrients to the host plants and ensure their proper development of growth, development, and regulation in their physiology. Bio-fertilizers play a really significant role in improving future soil fertility through fixing atmospheric nitrogen. Bio-fertilizers being important components of sustainable agriculture play a significant role in maintaining future soil fertility, productivity and sustainability of crop production.

Biofertilizers
It can be defined as a product containing living microorganisms that colonizes in rhizosphere accompanying interior of the plant and stimulates growth by increasing the accessibility and uptake of mineral nutrients to the host plant.

Different Types of Biofertlizers

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

Table 1: Different Group of Biofertlizers (barman *et al.*, 2017)

Classification of biofertilizer

Rhizobium: It is belong to family Rhizobiaceae are gram-negative motile, non-sporulating rods, symbiotic in nature, and can fix atmospheric nitrogen 50-300 kg/ha in association with legumes. It is useful for pulse legumes like chickpea, red-gram, lentil, black gram, etc., oil-seed legumes like soybean and groundnut and forage legumes like berseem and Lucerne. They are the most effective biofertilizer for legumes as far as the volume of nitrogen fixation is concerned (Jehangir *et al.* 2017).

Cross inoculation Group	Rhizobium species	Host legume
Pea group	R. leguminosarum	Pea, sweet pea
Alfalfa group	R. meliloti	Sweet clover
Clover group	R. trifoli	Clover/ berseem
Bean group	R. phaseoli	All beans
Soybean group	Badyhizobium japonicum	Lupins
Cowpea group	Rhizobium sp.	Cowpea, arhar, urd, moong and groundnut

Table 2: Major inoculation groups with inoculant & host plants (S. Kumar *et al*., 2018)

Azotobacter: It is belong to family of Azotobacteriaceae, non- symbiotic, aerobic, free living, and chemo-heterotrophic in nature. Azotobacters are mostly present in neutral or alkaline soils and A. Chroococuum is that the most ordinarily occurring species in arable soils. The genus Azotobacter comprises of different species, like A. chroococcum, A. vinelandii, A. beijerinckii, A. paspali, A. armeniacus, A. nigricans and A. salinestri (Gothandapani *et al.* 2017). Azotobacter spp. are motile and mesophilic with capability of fixing on an average 20-25 kg N/ha/per year (Rawia *et al.* 2009). The occurrence of this organism has been discoverd from the rhizosphere of variety of crop plants like as rice, maize, sugarcane, bajra, vegetables and plantation crops.

Azospirillium: Azospirillum are gram-negative, chemo-heterotropic, associated in nature, non-nodule-forming, aerobic, nitrogen-fixing bacteria belonging to the family Spirillaceae. It's capable of fixing 20 to 40 kg nitrogen under micro-aerobic conditions. They are associated with roots of mainly C4 crops having dicarboxylic pathway (Hatch-Slack pathway) of photosynthesis because they grow and fix nitrogen on the organic salts of malic and aspartic acid (Mishra and Dash, 2014).

Blue Green Algae (Cyanobacteria): These are free-living microorganism also known as symbiotic cyanobacteria (blue green algae) and described by a gaggle of one-celled to many-celled aquatic organisms. They also promote plant growth by producing auxins (indole acetic acid), gibberllic acid and may fix around 20– 30 kg N/ha in submerged rice fields. Under low land rice conditions, application of BGA + Azospirillum proved beneficial in improving LAI and all yield attributes.

Azolla: It's a free floating aquatic fern and fixes atmospheric N2 in symbiotic association with BGA (Anabaena azollae). Azolla either as an alternate nitrogen sources or as a supplement to commercial nitrogen fertilizers. Azolla is employed as biofertilizer for wetland rice and it's known to contribute 40-50 kg N/ha per rice crop.

Frankia: It is symbiotic association with trees and shrubs and fix atmospheric N_2.

Phosphate solubilizing microorganisms (PSMs): Several heterotropic soil microorganisms like bacteria and fungi, notably species of Pseudomonas, Bacillus, Penicillium, and Aspergillus etc. secrete organic acids (citric, oxalic, tartaric, maleic, etc.) and lower the pH in their vicinity to cause dissolution of insoluble mineral phosphates in soil. Increased yields of wheat and potato thanks to demonstrated due to inoculation of peat based cultures of Bacillus polymyxa and Pseudomonas striata.

Phosphate absorbers / Arbuscular mycorrhiza (AM): It is mutually beneficial (symbiotic) relationships between fungi and plant roots. The AM fungi are endomycorrhiza and obligate symbionts. VAM fungi infect and spread inside the basis. They possess special structures referred to as vesicles and arbuscules.

Plant growth promoting rhizobacteria (PGPRs): This group of bacteria that colonize rhizosperes soil and benefical to crop plant's are known as Plant Growth promoting rhizobacteria. It is fixing nitrogen, increasing the nutrient availability in the rhizosphere, positively influencing root growth and morphology and increasing other plant microorganisms. The Plant growth promoting rhizobacteria belong to several genera, *viz.*, Agrobacterium, Bacillus, Rhizobium, Xanthomonas, pseudomonas, Azotobacter, etc.

Methods of Application of Biofertilizers

Seed treatment: This is the most common practice for applying all types of biofertilizers. In this method, seeds are uniformly mixed in the slurry of the inoculants and then a seed spreads on cemented floor. The dried seeds are to be sown within 24 hours. One packet (200 g) of the inoculant is sufficient to treat 10 kg of seeds.

Seedling root dip: It is mostly used for transplanted crops. In this method, the seedlings required for one hectare are inoculated using 4–5 kg biofertilizers. Two packets (400g) of the inoculant are mixed in 40- 50 litres of water. The root portion of the seedlings is dipped into the mixture for 5 to 10 minutes and then transplanted.

Foliar application: Liquid biofertilizer can be applied by fertigation as well as foliar application to the suitable crop. It can also applied by seed treatment and root dipping.

Soil treatment: For soil treatment depending upon the total number of plants per hectare 5-6 kg of Azotobacter / Azospirillium and 4-5 kg PSB are required for one hectare.

Set treatment: Set treatment method is generally recommended for treating the banana suckers, sets of sugarcane, and potato. Its suspension prepared by mixing 1 kg of bio-fertilizer in 45-50 liters' of water and cut pieces of planting material are kept immersed in the suspension for 25-30 minutes. The treated cut pieces are dry in shade place for some time.

Importance of Bio–Fertilizers in Agriculture

1. Bio-fertilizers supplement synthetic fertilizers and fulfill the nutrient requirement of crops.
2. Bio-fertilizers add 30-180 kg N/ha to soil and enhance crop production and nutrient use efficiency in a particular optimum environment.
3. Application of Bio-fertlizers can be protected Plants against drought and other strict conditions.
4. Bio-fertlizers effectively reduce use of chemical fertilizers and create chemical free yields.
5. Application of bio-fertilizers results in improved nutrient and water uptake, soil quality, rhizosphere development, etc.
6. Bio-fertilizers Improve growth of plants through release of growth-stimulating substances.
7. Bio-fertilizers improve soil fertility, physical properties of soil, tilth, and crop-productivity
8. Microbes in bio-fertilizers provide atmospheric nitrogen directly to plants.
9. Application of bio-fertilizers increase availability of hormones, vitamins, auxins, and other growth-promoting substances improves plant growth.
10. Bio-fertilizers are not costly and even poor farmers can make use them.
11. They are environmental friendly and protect the environment against pollutants.

Conclusion

There is a little question that bio-fertilizers are the potential tools for sustainable agriculture not only in India but also globally. Bio-fertilizers being essential components of sustainable agriculture play vital role in maintaining future soil fertility and productivity through fixing atmospheric di-nitrogen, mobilizing fixed macro and micro nutrients within the soil into forms available to plants. They're of environment friendly, non-bulky, and low cost agricultural inputs. During In this context, biofertilizers would be the viable option for farmers to extend productivity per unit area.

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