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Biofertilizers and Their Role in Agriculture

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Biofertilizers have emerged as a potential environment friendly inputs that are supplemented for proper plant growth. They hold vast potential in meeting plant nutrient requirements while minimizing the use of chemical fertilizers. Biofertilizers are defined as preparations containing living cells or latent cells of efficient strains of microorganisms that help crop plants in uptake of nutrients by their interactions in the rhizosphere. They accelerate certain microbial processes in the soil which augment the extent of availability of nutrients in a form easily assimilated by plants. They help in restoring soil health and thus provide a cost effective way to manage crop yield along with balancing the environment.

Biofertilizers

Biofertilizers are low cost, renewable sources of plant nutrients which supplement chemical fertilizers. Biofertilizer is one of the best modern tools for agriculture. Use of Biofertilizer is one of the important components of integrated nutrient management, as they are cost effective and renewable sources of plant nutrients to supplement the chemical fertilizers for sustainable agriculture. The beneficial effect of legumes in improving soil fertility was known since ancient times. The commercial history of Biofertilizers began with the launch of 'Nitragin' by Nobbe and Hiltner, a laboratory culture of *Rhizobia* in 1895, followed by the discovery of *Azotobacter* and then the blue green algae and a host of other micro-organisms. *Azospirillum* and Vesicular-Arbuscular Micorrhizae (VAM) are fairly recent discoveries. In India the first study on legume *Rhizobium* symbiosis was conducted by N. V. Joshi and the first commercial production started as early as 1956. Commonly explored Biofertilizers in India are mentioned below along with some salient features.

Different Types of Biofertilizers

Rhizobium: *Rhizobium* belongs to bacterial group and is symbiotic nitrogen fixer. They are the most efficient Biofertilizer as per the quantity of nitrogen fixed concerned. The bacteria infect the legume root and form root nodules within which they reduce molecular nitrogen to ammonia which is utilized by the plant to produce valuable proteins, vitamins and other nitrogen containing compounds. It has been estimated that 40-250 kg N/ha/year is fixed by different legume crops by the microbial activities of *Rhizobium* (Table 1).

Table 1. Quantity of Biological N fixed by Liquid *Rhizobium* in different crops

Host Group	Rhizobium Species	Crops	N fix kg/ha
Pea group	*Rhizobium leguminosarum*	Green pea, Lentil	62-132
Soybean group	*R.japonicum*	Soybean	57-105
Lupini Group	*R. lupine orinthopus*	Lupinus	70- 90
Alfafa grp.Group	*R.melliloti*	Melilotus	100-150
Beans group	*R. phaseoli*	Phaseoli	80-110
Clover group	*R. trifoli*	Trifolium	130
Cowpea group	*R. species*	Moong, Redgram, Cowpea, Groundnut	57-105
Cicer group	*R. species*	Bengal gram	75-117

(**Source**:http://agritech.tnau.ac.in/org_farm/orgfarm_biofertilizertechnology.html)

Azotobacter: It is important and well known free living nitrogen fixing aerobic bacterium. It is used as a Bio-Fertilizer for all non leguminous plants especially rice, cotton, vegetables etc. Of the several species of *Azotobacter, A. chroococcum* happens to be the dominant inhabitant in arable soils capable of fixing N_2 (2-15 mg N_2 fixed/g of carbon) in culture media. The lack of organic matter in the soil is a limiting factor for the proliferation of *Azotobacter* in the soil.

Azospirillum: It belongs to bacteria and fix the considerable quantity of nitrogen in the range of 20- 40 kg N/ha in the rhizosphere in non-leguminous plants such as cereals, millets, oilseeds, cotton etc. The organism proliferates under both anaerobic and aerobic conditions. It do not form root nodules and live inside plant roots. It stimulates for the production of growth promoting substance (IAA), disease resistance and drought tolerance.

Cyanobacteria: These are free-living as well as symbiotic cyanobacteria (blue green algae) and described by a group of one-celled to many-celled aquatic organisms. These can be brown, purple or red in colour, found in wet and marshy conditions, only used for rice cultivation and do not survive in acidic conditions.

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* is used as biofertilizer for wetland rice and it is known to contribute 40-60 kg N/ha per rice crop.

Besides its cultivation as a green manure, *Azolla* has been used as a sustainable feed substitute for livestock especially dairy cattle, poultry, piggery and fish.

Phosphate solubilizing microorganisms (PSM): The species of *Pseudomonas*, *Bacillus*, *Aspergillus etc*. secrete organic acids and lower the pH in their vicinity to bring about dissolution of bound phosphates in soil.

AM fungi: An arbuscular mycorrhiza (AM fungi) is a type of mycorrhiza in which the fungus penetrates the cortical cells of the roots of a vascular plant.

Silicate solubilizing bacteria (SSB): 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 carboxylic acids which from complexes with cations, promote their removal and retention in the medium in a dissolved state.

Plant Growth Promoting Rhizobacteria (PGPR)*:* This group of bacteria colonize roots or rhizosphere soil. These PGPR are referred to as biostimulants and the phytohormones as they produce indole-acetic acid, cytokinins, gibberellins and inhibitors of ethylene production.

Liquid Biofertilizers*:* Biofertilizers such as *Rhizobium*, *Azospirillum* and Phosphobacteria are be effectively utilized for rice, pulses, millets, cotton, sugarcane, vegetable and other horticulture crops as liquid formulations. As an alternative, liquid formulation technology has been developed in the Department of Agricultural Microbiology, TNAU, Coimbatore which has more advantages than the carrier inoculants.

The advantages of Liquid bio-fertilizer over conventional carrier based Bio-fertilizers are longer shelf life of 12-24 months, no contamination, no loss of properties due to storage upto 45º c, greater potentials to fight with native population, high populations can be maintained, easy identification by typical fermented smell, quality control protocols are easy and quick, better survival on seeds and soil, easy to use by the farmer, dosages is 10 time less than carrier based powder bio-fertilizers, high export potential and very high enzymatic activity since contamination is nil.

Application of Biofertilizers

Seed treatment: The seeds are uniformly mixed in the slurry of inoculant and then shade dried for 30 minutes. The shade dried seeds are to be sown within 24 hours. One packet of the inoculant (200 g) is sufficient to treat 10 kg of seeds.

Seedling root dip: This method is used for transplanted crops. Two packets of the inoculant are mixed in 40 litres of water. The root portion of the seedlings is dipped in the mixture for 5 to 10 minutes and then transplanted.

Main field application: Four packets of the inoculant are mixed with 20 kgs of dried and powdered farm yard manure and then broadcasted in the main field just before transplanting.

Set treatment: This method is recommended generally for treating the sets of sugarcane, cut pieces of potato and the base of banana suckers. Culture suspension is prepared by mixing 1 kg (5 packets) of bio-fertilizer in 40-50 litres of water and cut pieces of planting material are kept immersed in the suspension for 30 minutes. The cut pieces are dried in shade for some time before planting. For set treatment, the ratio of bio-fertilizer to water is approximately 1:50.

Potential Role of Biofertilizers in Agriculture

Nitrogen-fixers (NF) and Phosphate solubilizers (PSBs): The incorporation of bio-fertilizers (N fixers) plays major role in improving soil fertility, yield attributing characters and thereby final yield. In addition, their application in soil improves soil biota and minimizes the sole use of chemical fertilizers (Subashini *et al.*, 2007). It is an established fact that the efficiency of phosphatic fertilizers is very low (15-20%) due to its fixation in acidic and alkaline soils and unfortunately both soil types are predominating in India. Therefore, the inoculations with PSB and other useful microbial inoculants in these soils become mandatory to restore and maintain the effective microbial populations for solubilization of chemically fixed phosphorus and availability of other macro and micronutrients to harvest good sustainable yield of various crops.

Mycorrhizae: The fungi that are probably most abundant in agricultural soils are arbuscular mycorrhizal (AM) fungi. They account for 5– 50% of the biomass of soil microbes. Potential Role of AM) fungi in Agriculture are as follows:

Improved nutrient uptake (macro and micronutrients): The improvement of P nutrition of plants has been the most recognized beneficial effect of mycorrhizas. It is also reported that the AM- fungi also increases the uptake of K and efficiency of micronutrients like Zn, Cu, Fe etc. By secreting the enzymes, organic acids which makes fixed macro and micronutrients mobile and as such are available for the plant.

Better water relation and drought tolerance: AM fungi play an important role in the water economy of plants. Their association improves the hydraulic conductivity of the root at lower soil water potentials and this improvement is one of the factors contributing towards better uptake of water by plants.

Soil structure (A physical quality): Mycorrhizal fungi contribute to soil structure by growth of external hyphae into the soil to create a skeletal structure that holds soil particles together, creation of conditions by external hyphae that are conducive for the formation of micro-aggregates, enmeshment of micro aggregates to form macro aggregates and directly tapping carbon resources of the plant to the soils.

Enhanced phytohormone activity: The activity of phytohormones like cytokinin and indole acetic acid is significantly higher in plants inoculated with AM. Higher hormone production results in better growth and development of the plant.

Crop protection (interaction with soil pathogens) : AM-inoculation considerably increases production and activity of phenolic and phytoalexien compounds due to which the defense mechanism of plant becomes stronger there by imparts the resistance to plants.

Constraints in Biofertilizer Use

Production level constraints: Unavailability of appropriate and efficient strains, unavailability of suitable carrier, mutation during fermentation.

Market level constraints: Lack of awareness of farmers, inadequate and inexperienced staff, lack of quality assurance, seasonal and unassured demand.

Resource constraint: Limited resource generation for Biofertilizer production.

Field level constraints: Soil and climatic factors, native microbial population, etc.

Conclusion

Application of organic manures particularly Biofertilizers is the only option to improve the soil organic carbon for sustainance of soil quality and future agricultural productivity (Ramesh 2008). Biofertilizer have an important role to play in improving nutrient supplies and their crop availability in the years to come. They are of environment friendly non-bulky and low cost agricultural inputs. A biofertilizer is an organic product containing a specific micro-organism in concentrated form which is derived either from the plant roots or from the soil of root zone *(Rhizozsphere)*. Among the biofertilizers *Azotobacter*, *Azospirillum*, *Acetobacter* are the important for nitrogen fixation, *Bacillus* sp. and *Aspergillus* sp. are important for phosphate solubilisation and other soil mineral nutrients.

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