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Biofertilizers: Reduces human & animal hazards

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Abstract

Biofertilizers are a type of fertilizer that contains living microorganisms, such as bacteria, fungi, and protozoa, that can improve soil health and crop nutrition. These organisms help in the supply of essential nutrients, such as nitrogen, phosphorus, and potassium, to the plants by converting inorganic compounds into organic matter. They also enhance the soil structure, increase water retention capacity, and improve soil fertility. Biofertilizers are eco-friendly and have minimal side effects, making them a preferred choice over chemical fertilizers. However, the effectiveness of biofertilizers depends on the type of microorganism used, the application method, and the environmental conditions. Therefore, the use of biofertilizers can help in sustainable agriculture and food production while reducing the negative impacts of chemical fertilizers on the environment. When the diazotrophic bacteria Pseudomonas fluorescens, *Azotobacter chroococcum*, *Azospirillum lipoferum*, and *Acetobacter* diazotrophicus were combined with the fungi *Trichoderma viride*, the plant height, dry weight, ear length, grain and stover yield, grain quality (58.9 percent protein and 17 percent carbohydrate), nitrogen uptake (grain 59.03 and stover 79.76 kg ha^{-1}) Phosphorus uptake (grain 9.21 and stover 8.73 kg/ha) and B: C ratio over control and single inoculation of pearl millet crop.

Keywords: Biofertilizer, Advantage, Importance, and classification of biofertilizer

Introduction

When applied to seeds, plant surfaces, or soil, biofertilizer—a material containing living microorganisms—promotes development by boosting the host plant's availability or supply of primary nutrients. Through the processes of nitrogen fixation, phosphorus solubilization, and growth-promoting chemical synthesis, it augments plant development with additional nutrients. A substance containing living microorganisms is called biofertilizer. By providing the host plant with more primary nutrients, they increase plant growth when applied to plant surfaces. Bio-fertilizers supplement soil with nutrients by means of organic processes such fixing nitrogen, phosphorus solubilization, and

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boosting plant development by inducing the production of chemicals that promote growth. Since bio-fertilizer is technically alive, it can work in tandem with plant roots to produce reciprocal benefits. Simpler chemicals that are easier for plants to ingest could be produced by the involved microbes from complicated organic material. It keeps the soil in its original state. Growth is increased by 20–30%, artificial nitrogen and phosphorus are substituted by 25%, and plant growth is improved **(Bhattacharjee and Dey, 2014).**

The foundation of biological fertilization is the availability of organic inputs, such as fungi, bacteria, animal dung, organic wastes, fertilizers, and domestic sewage. They improve rhizosphere nutrient fixation, generate growth-stimulating plants, aid in soil stability, provide biological control, break down materials, recycle nutrients, encourage mycorrhizal symbiosis, and advance bioremediation processes in soils tainted with toxic, xenobiotic, and resistant substances. In addition to improving yield per acre in a very short amount of time, bio-fertilizers also use less energy, decrease soil and water contamination, boost soil fertility, and promote biological control and antagonistic interactions with phytopathogenic organisms. Numerous advantages exist for the economy, society, and environment when using biofertilizer **(Carvajal-Muñoz and Carmona-Garcia, 2012).**

Agriculture plays a pivotal role in the growth and survival of nations; therefore, maintaining its quantity and quality is essential for feeding the population and economic exports. Over the years, agriculture has undergone various scientific innovations to make it more efficient **(Ajmal, 2018).** Modern agriculture involves the usage of pesticides and chemical fertilizers with the essence of increasing the world's food production, as these serve as a fast food for plants causing them to grow more rapidly and efficiently. Continuous application of chemical fertilization leads to the decay of soil quality and fertility and might lead to the collection of heavy metals in plant tissues, affecting the fruit's nutritional value and edibility **(Farnia and Hasanpoor, 2015).**

Biofertilizers are good sources for enhancing the nutrient availability in soil and plants. They are ready-to-use, live formulations of beneficial micro-organisms that are agriculturally useful in terms of N fixation, P solubilization, and nutrient mobilization by their biological metabolism to increase the productivity of soil and/or crop on application to seed, root, or soil treatment for mobilizing the availability of nutrients. In India, a systematic study on biofertilizers was started by N. V. Joshi in 1920. Rhizobium was the first isolated from various cultivated legumes, and this was followed by vast research by Gangulee, Sarkaria, and Madhok on the physiology of the nodule bacteria besides its inoculation for better crop production. Rhizobium and blue-green algae (BGA) are considered the traditional biofertilizers, while Azolla, Azospirillum, and Azotobacter are in the middle stage **(Rahimi *et al.*, 2014).**

Advantages of biofertilizers

- It helps in maintaining environmental health by reducing the level of pollution.
- Reduces human & animal hazards by reducing the level of residue in the product.
- Increases the agricultural products and makes them sustainable.
- Ensures the optimum utilization of natural resources.
- Reduces the risk of crop failure.
- Improves the physical and chemical properties of soil.
- Biofertilizers are cost-effective when compared to synthetic fertilizers.
- Their use leads to soil enrichment and the quality of the soil improves with time.
- They are eco-friendly as well as cost-effective.
- They increase the phosphorous content of the soil by solubilizing and releasing unavailable phosphorous.
- Biofertilizers improve root proliferation due to the release of growth-promoting hormones.
- These fertilizers harness atmospheric nitrogen and make it directly available to the plants.
- Microorganism converts complex nutrients into simple nutrients for the availability of the plants.
- Biofertilizers can also protect plants from soil-borne diseases to a certain degree.

Importance of biofertilizers

- Biofertilizers improve soil texture and yield of plants.
- They do not allow pathogens to flourish.
- They are eco-friendly and cost-effective.
- Biofertilizers protect the environment from pollutants since they are natural fertilizers.
- They destroy many harmful substances present in the soil that can cause plant diseases.
- Biofertilizers are proven to be effective even under semi-arid conditions.

Classification of biofertilizers (Rakesh Kumar *et al.*, 2017)

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		

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4.	Bacteria	*Bacillus* megaterium var. phosphaticum, *Bacillus* subtilis, *Bacillus* circulans.
5.	**Fungi**	*Penicillium spp*, Aspergillus awamori**.**
P Mobilizing Biofertilizers		
6.	Arbuscular mycorrhiza	Glomus spp, Gigaspora spp, Scutellospora spp &Sclerocystis
7.	Ectomycorrhiza	Laccaria spp, Pisolithus spp, Boletus spp, Amanita spp.
Biofertilizers for micronutrients		
8.	Silicate and Zinc solubilizers	*Bacillus spp.*
Plant Growth Promoting Rhizobacteria		
9.	Pseudomonas	Pseudomonas fluorescens

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

Fig: Some images for available biofertilizers in powder and liquid form

Rhizobium: Legume roots are colonized by the soil-dwelling bacterium Rhizobium, which symbiotically fixes atmospheric nitrogen. Rhizobium can exist in a variety of environments, from free-living nodules to bactericide. In terms of the amount of fixed nitrogen involved, they are the most effective biofertilizers. Known as the cross-inoculation group, they belong to seven genera and are extremely specialized to produce nodules in legumes.

Azotobacter: Of the several species of Azotobacter, A. cerococcid happens to be the dominant inhabitant in arable soils capable of fixing N_2 (2-15 mg N_2 fixed /g of carbon source) in culture media. The bacterium produces abundant slime which helps in soil aggregation. The numbers of A. cerococcid in Indian soils rarely exceed 105/g soil due to lack of organic matter and the presence of antagonistic microorganisms in the soil.

Azospirillum: Gramineous plants' major residents of soil, the rhizosphere, and the intercellular spaces

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of the root cortex include A. linoleum and A. Brasiliense (*Spirillum lipomeria* older literature). With gramineous plants, they form associative symbiotic partnerships. In addition to nitrogen fixation, inoculation with Azospirillum also confers disease resistance and drought tolerance, as well as the production of growth-promoting substances (IAA).

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 crops, it has not presently attracted the attention of rice growers all over India. The benefits due to alkalization could be to the extent of 20-30 kg N/ha under ideal conditions but the labor-oriented methodology for the preparation of BGA biofertilizer is a limitation.

Azolla: The nitrogen-fixing blue-green algae *Anabaena azollae* collaborate with the free-floating water fern Azolla to fix atmospheric nitrogen. Azolla can be added to commercial nitrogen fertilizers or used as a substitute for nitrogen. Azolla is known to contribute 40–60 kg N/ha per rice crop when used as a *biofertilizer* for wetland rice.

Phosphate solubilizing microorganisms (PSM): 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 the dissolution of bound phosphates in soil. Increased yields of wheat and potato were demonstrated due to inoculation of peat-based cultures of *Bacillus polymyxin* and *Pseudomonas striata*.

Plant growth-promoting rhizobacteria: The group of bacteria that colonize roots or rhizosphere soil and are beneficial to crops are referred to as (PGPR). The PGPR inoculants promote growth through suppression of plant disease (termed Bioprotectants), improved nutrient acquisition (Biofertilizers), or phytohormone production (Biostimulants). Species of *Pseudomonas* and *Bacillus* can produce 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 PGPRs are referred to as bio stimulants and the phytohormones they produce include indole-acetic acid, cytokinin's, gibberellins, and inhibitors of ethylene production.

Conclusions: Biofertilizers are an eco-friendly and sustainable alternative to chemical fertilizers. They help to improve soil health, increase crop yields, and reduce the need for synthetic fertilizers. Biofertilizers are made from natural sources, such as microorganisms, plant materials, and animal byproducts, and are rich in nutrients that are essential for plant growth. They also help to improve soil structure, nutrient cycling, and soil fertility.

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