



AGRI MAGAZINE

(International E-Magazine for Agricultural Articles)

Volume: 03, Issue: 10 (October, 2026)

Available online at <http://www.agrimagazine.in>

© Agri Magazine, ISSN: 3048-8656

Biofertilizers and Crop Responses

Rakesh Kumar, Ramdev Sutaliya and *Mahendra Junjariya

Department of Agronomy, College of Agriculture, Agriculture University,
Jodhpur-342304, Rajasthan India

*Corresponding Author's email: mahijunjariya@gmail.com

Biofertilizers are eco-friendly microbial formulations that enhance soil fertility, nutrient availability, crop growth and productivity. Beneficial microorganisms such as *Rhizobium*, *Azotobacter*, *Azospirillum*, mycorrhizae, and phosphate-solubilizing microbes play important roles in nutrient mobilization. They improve nitrogen fixation, phosphorus and zinc availability, root development, and nutrient uptake in crops. Biofertilizers also promote plant growth through the production of phytohormones such as auxins, gibberellins, and cytokinins. They help plants tolerate abiotic stresses including drought, salinity, heat, and waterlogging. Beneficial microbes also suppress pathogens by producing antibiotics, siderophores, enzymes, and inducing plant defense mechanisms. Thus, biofertilizers improve soil health, reduce dependence on chemical fertilizers, and minimize environmental pollution. Their wider adoption can contribute significantly to sustainable agriculture, safe food production, and long-term food security.

Keywords: Biofertilizers, microbial inoculants, nitrogen fixation, nutrient solubilization, soil health, sustainable agriculture.

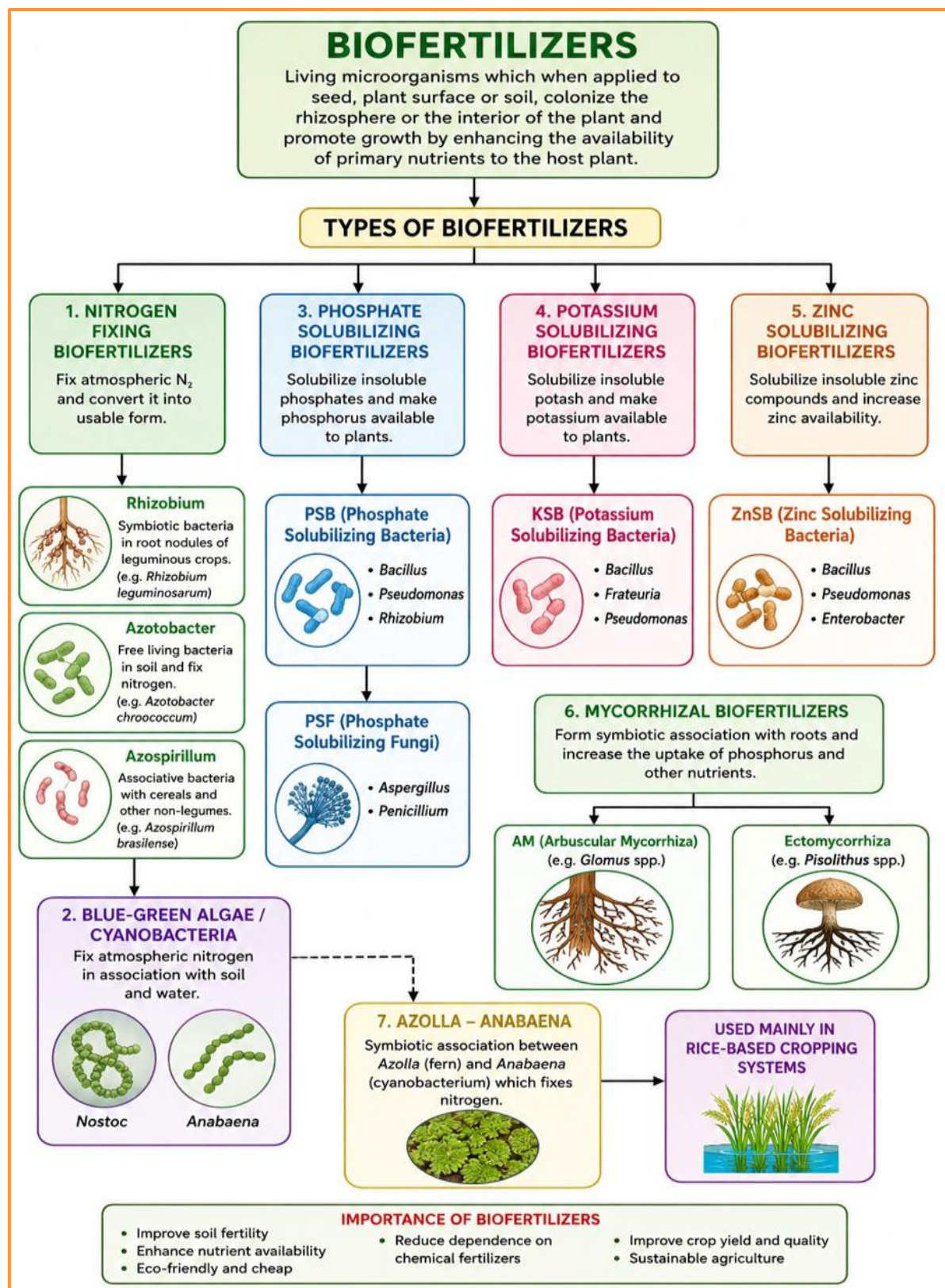
Introduction

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 had led to pollution and contamination of soil and water basins. This results in soil being deprived of essential plants nutrients and organic matters. It led to depletion of beneficial micro - organisms & insects indirectly reducing soil fertility and making crop more prone to diseases. So presently there is growing concern about environment hazards & threats to sustainable agriculture. Therefore, it is need of hour to use the bio fertilizers that alleviate the ill effect of chemical fertilizers. Bio-fertilizers are economical, ecofriendly and productive over chemical fertilizers. Bio fertilizers are eco-friendly microbial formulations that enhance soil fertility and crop productivity. They function through direct mechanisms like nitrogen fixation and nutrient solubilization, and indirect mechanisms such as pathogen suppression and stress tolerance enhancement. These bio fertilizers are living organism found in soil as bacteria, fungi, algae and actinomycetes can mobilize nutrients from the soil and transform them from an unusable form into a usable one through the biological processes such as nitrogen fixation, phosphorus and zinc solubilization, siderophore production, and plant growth-promoting production. Bio fertilizers are applied to seed, roots, soil, or foliar spray to enhance the microbial activity through their multiplication which then mobilizes the nutrients to target plants which remarkably improved the soil fertility and accelerating crop health and productivity. Bio fertilizers play direct role to promote plant growth by fixing atmospheric nitrogen, solubilizing essential nutrients and producing plant growth hormones like auxins, gibberellins, and cytokinins. These activities improve nutrient uptake and stimulate root development. Besides, they enhance plant resistance to pathogens by producing antibiotics, siderophores, and hydrolytic enzymes, and by inducing systemic resistance mechanisms in plants.

Biofertilizers

The word “Biofertilizers” is a combination of **Bio** - Living organisms and **Fertilizers** – Any material that provide nutrient to soil. So bio fertilizers are living organisms that provide nutrient. Biofertilizers are living organisms that provide nutrients to soil, enhancing its fertility and productivity. The fertilizer control order (FCO) defines biofertilizer as products that contain carrier-based live microorganisms that are beneficial to agriculture by fixing nitrogen, solubilizing phosphorus, or mobilizing nutrients to boost soil and crop yield.

Classification of Biofertilizers



1. Nitrogen Fixing Biofertilizers: The living organisms that convert atmospheric nitrogen into forms plants can utilize, enriching the soil and promoting plant growth.

- **Symbiotic:** Relationship or interaction between two dissimilar organisms, in symbiotic relation both microbes & plant benefits each other such as Rhizobium, Azorhizobium, Bradyrhizobium, Frankia, Azolla.
- **Non symbiotic:** No symbiosis, free living in soil & fix nitrogen present in environment and soil such as Azotobacter, Clostridium, Blue green algae.
- **Associative:** Microbes which remain in rhizosphere and fix nitrogen in rhizosphere such as Azospirillum.

2. Phosphorus Solubilizing/Mobilizing Biofertilizers

A. Phosphorus Solubilizing: These secrete organic acid & these acids solubilize tri-calcium & di-calcium phosphate into mono-calcium phosphate. They secrete phosphate enzyme & this enzyme is involved in solubilization of organic form of phosphate. They produce chelating mechanism & by this action phosphorus is available.

Bacteria: *Bacillus sp. (megaterium, polymyxa, subtilis)*, *Pseudomonas striata*.

Fungi: *Aspergillus awamori*, *Aspergillus niger*, *Penicillium digitatum*, *Trichoderma sp.*

B. Phosphorus mobilizing: The symbiotic association between plant roots and fungi is termed as mycorrhizal association. These are two types of mycorrhiza-

- **Ectomycorrhiza:** ex. *Amanita sp.*, *Boletus sp.*, *Laccaria sp.*, *Pisolithus*.
- **Endomycorrhiza:** ex. *Vesicular arbuscular mycorrhiza (VAM)*

3. Silicate and Zinc solubilizers: *Bacillus sp.*

4. Plant-Growth Promoting Rhizobacteria

- **Pseudomonas:** *Pseudomonas fluorescens*

5. Organic Matter Decomposers: Microorganisms decompose organic matter at a faster rate and derive & mobilize nutrients into soil.

- **Cellulolytic Organisms:** These organisms possess enzymes called cellulases that can break down cellulose, a major component of plant cell walls. **Bacteria:** *Cellulomonas*, *Clostridium*, *Ruminococcus* **Fungi:** *Trichoderma*, *Aspergillus*, *Penicillium*
- **Lignolytic Organisms:** These organisms produce enzymes like lignin peroxidase, manganese peroxidase, and laccase, which can degrade lignin, a complex polymer that binds to cellulose in plant cell walls. **Fungi:** *Pleurotus ostreatus* (oyster mushroom), *Phanerochaete chrysosporium* (white-rot fungus).

Important Biofertilizers

- 1. Rhizobium:** Rhizobium inoculation is of greatest importance because of their ability to fix atmospheric nitrogen in association with legumes. Rhizobium bacteria live in the root nodule of legume plants through a symbiotic relationship.
- **Azorhizobium:** Stem nodulating bacteria occur commonly in Dhaincha (*Sesbania rostrata*)
- **Bradyrhizobium:** Slow growing; occur in legume like greengram, cowpea, Pigeon pea, Groundnut, Soybean.

Table: Rhizobium strains by which legume inoculated

S. No.	Rhizobium spp.	Legume inoculated	N fixed kg/ha
1.	<i>Rhizobium meliloti</i>	Sweet clover, alfalfa, fenugreek	100-150
2.	<i>Rhizobium trifoli</i>	Clover, Berseem	130
3.	<i>Rhizobium leguminosarum</i>	Pea, vicia, sweet pea, lentil	62-132
4.	<i>Rhizobium phaseoli</i>	Beans	80-110
5.	<i>Rhizobium lupini</i>	Lupine, serradella	70-90
6.	<i>Rhizobium japonicum</i>	Soybean, cowpea, groundnut, crotonaria	57-105

2. **Azospirillum:** Chemoheterotrophic bacteria & develop associative symbiotic relationship with graminaceous plants. Effective in crops like sugarcane, millet, sorghum, maize etc. Growth promoting substance production (IAA), disease resistance and drought tolerance are some of the benefits of inoculation with azospirillum
3. **Azotobacter:** Aerobic, chemo heterotrophic & free living bacterium. Effective in crop like: Rice, wheat, onion etc. The bacterium produces abundant slime which helps in soil aggregation.
4. **Azolla:** Free floating water fern that floats in water. Fix nitrogen in symbiotic association with blue green algae (*Anabaena azolla*) in rice field *Azollapinnata sp.* is most widely distributed in India
5. **Blue Green Algae (BGA):** It is known as cyanobacteria. Cyano means blue that means it is blue bacteria. Nitrogen fix by BGA become available to rice crop after their decomposition as the case with azolla or any organic source
6. **Vesicular arbuscular mycorrhiza:** VAM is come under the endomycorrhiza type. Important role is efficient use of P fertilizer & improving nitrogen fixation. VAM fungi infect plant spread inside root and produce highly branched hyphal structure known as vesicles & arbuscules within host cells. Arbuscular helps in transfer of nutrient from the fungus to root system. Vesicles store P as phospholipid. Effective in agroforestry, sorghum, barley, wheat, rice, tobacco, cotton etc. Increases uptake of nutrients like K, S, Cu & Z.
7. **Sulfur Solubilizer Biofertilizer:** Sulfur solubilizers are also referred to as sulfur-oxidizing bacteria because they convert hydrogen sulfide (H_2S), the most insoluble form of sulfur, into sulfate (SO_4^{-2}), an accessible form of sulfur. The opposite process is called assimilatory sulfate reduction, which is mediated by sulfate-reducing bacteria. The processes of mineralization, immobilization, oxidation, and reduction are the main ways that microbiological activity in the soil transforms sulfur. *Bradyrhizobium japonicum* and *Thiobacillus thiooxidans* are sulfur-oxidizing biofertilizers that have a greater impact on cereal crops. *Allochromatium*, *Chlorobium*, *Rhodobacter*, and *Rhodopseudomonas* are phototrophic anaerobic sulfur-oxidizing bacteria. Obligate anaerobes that are not phototrophic include *Wolinella succinogenes*.
8. **Zinc- Solubilizing Fertilizers:** The zinc solubilization bacteria found in zinc-solubilizing fertilizers create organic acids that solubilize insoluble zinc to Zn^{+2} , increasing plant uptake of zinc. *Bacillus subtilis*, *Pseudomonas striata*, *Serratia*, *Burkholderia cenocepacia*, *Aspergillus niger*, *A. nomius*, and *A. oryza* are a few examples of zinc-solubilizing bacteria and fungi that enhanced soil enzyme activity and zinc availability in crop plants.

Table: - Amount of nutrient fixed by biofertilizer

Biofertilizer	Nutrient fixed (kg/ha/year)	Beneficiary crops
<i>Rhizobium</i>	50 to 300 kg N/ha	Groundnut, soyabean, green gram, red gram, lentil, cowpea, chickpea
<i>Azotobacter</i>	0.026 to 20 kg N/ha	Cotton, mulberry, vegetable, rice, wheat, barley, ragi, jowar, mustard, sunflower, tobacco, spices
<i>Azospirillum</i>	10 to 20 kg N/ha	Sugarcane, maize, millets, fodders, oilseeds,
<i>Blue green algae</i>	25kg N/ha	Rice, banana
<i>Azolla</i>	900 kg N/ha	Rice
Phosphate solubilising bacteria & fungi	Solubilize about 50-60 % of fixed P in soil	All crop (non- specific)

Methods of Application of Biofertilizers

- **Seed Treatment:** Coating seeds with biofertilizers before sowing.
- **Soil Treatment:** Mixing biofertilizers with compost and applying to soil.
- **Seedling Dipping:** Immersing seedling roots in a biofertilizer solution before transplanting.

Crop Response to Biofertilizers

Biofertilizers help manage abiotic and biotic stress, improve nutrient uptake, and enhance plant resistance to diseases.

Abiotic stresses: Climate change has intensified abiotic stresses such as drought, salinity, waterlogging, and extreme heat, which adversely affect crop growth and productivity. These stresses cause physiological, biochemical, and morphological changes in plants and are responsible for substantial yield losses worldwide. Beneficial microorganisms, particularly endophytes and biofertilizers, can improve plant tolerance by producing growth-promoting substances such as IAA and ACC deaminase, enhancing nutrient uptake, and reducing ethylene and oxidative stress.

Several beneficial microbes have shown potential in improving crop performance under abiotic stresses. Actinobacteria promote plant growth through metabolite and antibiotic production, while *Pseudomonas* spp. enhance heat tolerance by regulating HSPs and reducing ROS. *Paenibacillus* spp. improve salinity tolerance through siderophore, IAA, and HCN production, whereas *Trichoderma harzianum* enhances root growth under drought. *Bacillus cereus* improves heat tolerance by producing ACC deaminase and exopolysaccharides. Thus, microbial biofertilizers provide an eco-friendly and sustainable approach to improve crop productivity under climate change.

Biotic stress: Plant diseases caused by bacteria, fungi, viruses, parasites, insects, and weeds significantly reduce crop productivity. Biofertilizers and beneficial microbes can activate plant defense mechanisms, including induced systemic resistance (ISR), peroxidase, phenylalanine ammonia-lyase (PAL), polyphenol oxidase (PPO), and hypersensitive responses. Therefore, the use of beneficial microorganisms offers an eco-friendly approach to improve plant resistance against biotic stresses.

The increasing incidence of plant diseases and the harmful effects of excessive agrochemical use highlight the need for sustainable disease management. Beneficial endophytes can colonize internal plant tissues without causing harm and protect plants against bacterial and fungal pathogens. Microorganisms such as *Bacillus*, *Pseudomonas*, *Streptomyces*, *Pantoea*, and *Trichoderma* act as effective biocontrol agents. Among them, *Bacillus thuringiensis* (Bt) is widely used as a biopesticide because of its insecticidal endotoxins.

Endophytic biofertilizers provide a safe alternative to chemical fertilizers and pesticides for managing bacteria, fungi, viruses, aphids, and nematodes. Their ability to colonize plant tissues enables continuous interactions with the host plant. Common endophytes include *Burkholderia*, *Stenotrophomonas*, *Rhizobium*, *Microbacterium*, and *Bacillus*. Their biocontrol activity is largely associated with the production of secondary metabolites, including alkaloids, phenolics, flavonoids, terpenoids, and volatile organic compounds (VOCs), which possess antimicrobial and insect-defensive properties.

Several beneficial microbes have demonstrated strong biocontrol potential. *Streptomyces hydrogenans* can suppress *Meloidogyne incognita*, while *Bacillus velezensis* strengthens rice resistance against *Magnaporthe oryzae*. *Trichoderma asperellum* enhances resistance against *Alternaria alternata* and produces chitinase and β -1,3-glucanase, which degrade pathogen cell walls. *Trichoderma* spp. also suppress pathogens such as *Verticillium dahliae*, *Sclerotinia graminicola*, *Botrytis cinerea*, *Fusarium solani*, and *Rhizoctonia solani*.

Some endophytes induce systemic acquired resistance (SAR) through signaling pathways involving salicylic acid, jasmonic acid, and ethylene. This response enhances the accumulation of pathogenesis-related (PR) proteins and defense-related enzymes, providing

broad-spectrum and long-lasting protection. For example, *Paenibacillus*, *Bacillus aryabhattai*, *Bacillus subtilis*, *Pseudomonas fluorescens*, and *Trichoderma harzianum* have been reported to activate plant defense responses against various pathogens and pests. Thus, endophytic biofertilizers have considerable potential as sustainable biocontrol agents for reducing dependence on chemical pesticides.

Plant hormone or phytohormone

Plant hormone and phytohormone plays a substantial role in plant development, secreted by both plants and microorganisms. Plant hormone production is an important feature of the beneficial microbes which is producing the indole-3-acetic acids, gibberellins, cytokinin, etc. Auxin helped in the differentiation and division of plant cells. Cytokinin prevents the premature leaf senescence of plants. Absciscic acid is also identified as hormone which is produced by plants during stress conditions. Gibberellins are involved in seed germination, shoot elongation, flowering, and fruiting. These hormones are generally secreted by microorganisms under environmental stress conditions to protect the plants by modulating the phytohormone level inside the host plants

Conclusion

The continuous rise in the global population has translated to a direct increase in the demand for food production. The use of these biofertilizers has been reported to boost the food production rate, and they are a safer farm product for consumers; hence, biofertilizers remains a better alternative for producing safer crops and enhancing global food security. Over-dependence on chemical fertilizers, in terms of both cost and environmental impact, is not a viable strategy in the long run due to the costs involved in setting up fertilizer plants and maintaining production, both in terms of domestic resources and foreign exchange. Biofertilizers are products that, once adequate information is available to producers and farmers, are likely to be commercially promising in the long run. The use of biofertilizers in the world will not only have an impact on the economic development of sustainable agriculture, but it will also contribute to a sustainable ecosystem and the overall wellbeing of humans.