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Biofertilizers and Microbial Inoculants

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INTRODUCTION

Biofertilizers are living microorganisms that enhance plant growth by increasing the availability of essential nutrients through natural biological processes. Unlike chemical fertilizers, biofertilizers are eco-friendly, cost-effective, and contribute to long-term soil health. They play a vital role in sustainable agriculture by improving nutrient cycling, soil structure, and microbial diversity. With rising fertilizer costs and environmental concerns, biofertilizers have emerged as a key component of integrated nutrient management systems.

2. Major Types of Biofertilizers

2.1 Rhizobium

Rhizobium is a symbiotic nitrogen-fixing bacterium that forms nodules on the roots of leguminous crops such as soybean, chickpea, pea, and lentil. Inside these nodules, Rhizobium converts atmospheric nitrogen into ammonia, which plants can easily absorb. This biological nitrogen fixation can supply 40–200 kg N/ha annually depending on crop and soil conditions. It reduces the dependence on synthetic nitrogen fertilizers and improves soil fertility over time.

Rhizobium Species	Common Host Plants (Legumes)	Crop Type
Rhizobium leguminosarum **trifolii**	Clover (*Trifolium* spp.)	Fodder / Pasture
Rhizobium. Leguminosarum **phaseoli**	French bean, Kidney bean	Pulses/ Vegetables
Bradyrhizobium japonicum	Soybean	Oilseed / Pulse
Bradyrhizobium sp. (cowpea group)	Cowpea, Mungbean, Urdbean, Pigeon pea	Pulses
Sinorhizobium meliloti (now *Ensifer meliloti*)	Alfalfa (Lucerne), Sweet clover	Fodder
Mesorhizobium ciceri	Chickpea (Gram)	Pulse
Rhizobium lupini	Lupin	Pulse / Fodder
Azorhizobium caulinodans	*Sesbania rostrata*	Green manure

2.2 Azotobacter

Azotobacter is a free-living nitrogen-fixing bacterium found in neutral to alkaline soils. It is commonly used for non-leguminous crops like wheat, maize, cotton, and vegetables. Apart from nitrogen fixation, Azotobacter produces growth-promoting substances such as vitamins, gibberellins, and auxins, which enhance seed germination and root development.

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2.3 Phosphate Solubilizing Bacteria (PSB)

PSB converts insoluble phosphorus compounds into soluble forms through the secretion of organic acids and enzymes. These microbes increase phosphorus availability, which is crucial for root growth, flowering, and energy transfer in plants. Regular application of PSB can reduce phosphorus fertilizer requirements by 25–30%.

2.4 Mycorrhiza (Vesicular Arbuscular Mycorrhiza – VAM)

Mycorrhizal fungi form symbiotic associations with plant roots and extend hyphal networks into the soil, enhancing water and nutrient absorption, particularly phosphorus and micronutrients. They also improve soil aggregation, drought tolerance, and disease resistance.

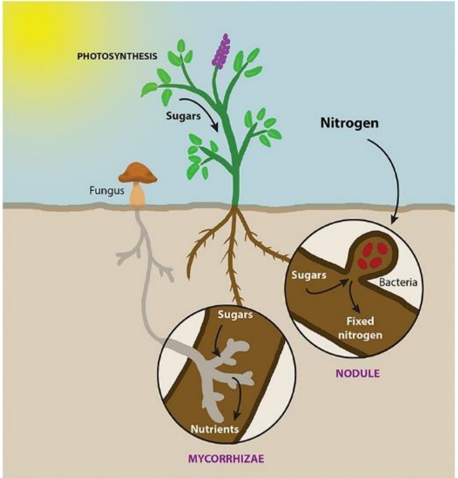

Figure: Plant-Microbe Symbiosis: Mycorrhizae and Nitrogen-Fixing Nodules

2.5 Azolla

Azolla is a small, free-floating **aquatic fern** widely used as a **biofertilizer in rice cultivation**. It grows rapidly on the water surface of ponds and paddy fields and forms a green mat. The uniqueness of Azolla lies in its **symbiotic association with the cyanobacterium** *Anabaena azollae*, which fixes atmospheric nitrogen and makes it available to crops.

3. Carrier Materials in Biofertilizers

Carrier materials are substances used to support and transport microbial inoculants while maintaining their viability. An ideal carrier should be non-toxic, finely powdered, moisture-retentive, and rich in organic matter.

Common Carrier Materials

- Peat soil
- Lignite
- Charcoal powder
- Vermiculite
- Press mud
- Compost and farmyard manure

Quality carriers ensure longer shelf life, uniform application, and higher microbial survival rates.

4. Shelf Life of Biofertilizers

Shelf life refers to the period during which microbial populations remain effective. Generally, biofertilizers have a shelf life of 6–12 months under proper storage conditions. Factors influencing shelf life include:

- Temperature (ideal 4–25°C)
- Moisture content
- Sunlight exposure
- Packaging quality
- Type of carrier material

Liquid biofertilizers often have longer shelf life compared to solid formulations.

5. Methods of Application

5.1 Seed Treatment

Seeds are coated with biofertilizer slurry before sowing. This method ensures early root colonization and is cost-effective.

5.2 Seedling Root Dip

Seedlings are dipped in microbial suspension before transplanting, commonly used in rice and vegetable crops.

5.3 Soil Application

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Biofertilizers are mixed with compost or farmyard manure and broadcasted in the field. This method is suitable for large areas and perennial crops.

5.4 Drip or Foliar Application

Liquid biofertilizers can be applied through irrigation systems, ensuring uniform distribution.

6. Advantages of Biofertilizers

- Environment-friendly and sustainable
- Reduce chemical fertilizer dependency
- Improve soil fertility and structure
- Enhance crop yield and quality
- Promote microbial biodiversity
- Cost-effective for small farmers

7. Limitations

- Short shelf life compared to chemicals
- Sensitive to temperature and storage conditions
- Slower nutrient release
- Crop- and soil-specific effectiveness

CONCLUSION

Biofertilizers and microbial inoculants represent a vital step toward sustainable and climate-resilient agriculture. When integrated with organic amendments and balanced fertilization, they significantly enhance soil productivity, nutrient efficiency, and environmental health. Their wider adoption can reduce input costs, conserve natural resources, and support long-term agricultural sustainability.

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