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The Role of Biofertilizers: Frequently Asked Questions

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Q 1. What are bio-fertilizers?

Ans. Biofertilizers are eco-friendly products containing living microorganisms that enhance soil fertility and promote plant growth when applied to seeds, plant surfaces, or soil. These microorganisms, such as Rhizobium, Azospirillum, and phosphate-solubilizing bacteria, play a crucial role in improving soil health and crop yield by:

a) Fixing atmospheric nitrogen, which is essential for plant growth.
b) Solubilizing insoluble phosphorus compounds, making them available for plant uptake.
c) Acting as plant-growth promoting rhizobacteria (PGPR), which stimulate plant growth through the synthesis of growth-promoting substances.

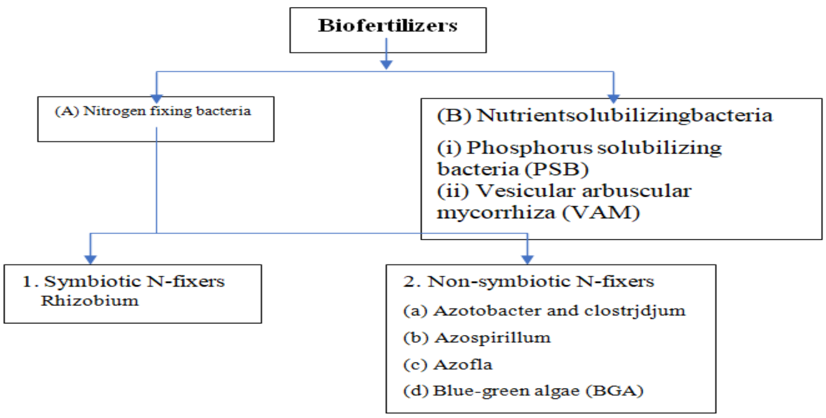
Biofertilizers are advantageous because they:

a) Improve soil texture and yield.
b) Do not allow pathogens to flourish.
c) Are eco-friendly and cost-effective.
d) Protect the environment from pollutants since they are natural fertilizers.
e) Destroy many harmful substances present in the soil that can cause plant diseases.
f) Are effective even under semi-arid conditions.

Biofertilizers are not a complete replacement for synthetic fertilizers, but they reduce the need for synthetic fertilizers and pesticides, thereby reducing environmental pollution and production costs.

Q. 2. Describe different types of bio-fertilizers and their potential impact

Ans. Broadly, bio-fertilizers are classified into following groups depending upon micro-organism involved.



(a) Nitrogen-fixing bacteria: Biological N fixation is the biochemical process by which elemental N is combined into organic (available) form by a number of micro-organisms including several species of bacteria, few actinomycetes and blue green algae.

(1) Symbiotic N-fixation with nodule forming legumes: Rhizobium, a symbiotic bacterium, colonizes specific legume roots, forming root nodules to fix atmospheric nitrogen. It lives independently in soil until it encounters legume roots, penetrating tissues and deriving carbohydrates from the host. In return, the plant benefits from synthesized nitrogenous compounds, enhancing its growth. Specificity between Rhizobium species and host plants determines inoculation success, with certain legumes being favored. Rhizobium-host plant interactions are categorized into seven groups based on specificity.

Rhizobium species	Crop group	Leguminous crops
Rhizabium leguminasarum	Pea	Peas, lathyrus, lentil
R. japonicum	Soyabean	Soyabean
R. phaseoli	Beans (Phaseolus)	Kidney and garden beans
R. trifoli	Clover	Clovers
R. meliloti	Alfalfa	Meliolotus, medicago (alfalfa)
R. lupini	Lupini	Lupines
Various	Cowpea miscellany	Cowpea (Vigina), peanut (Arachis), pigeon pea (Cajanus)

The rhizobium legume association could fix up to 100-300 kg N ha^{-1} in one crop season and in certain situation leave substantial N for the following crop.

Symbiotic N-fixation with nodule forming non-legumes: A large number of non-legumes (several angiosperms) are known to develop nodules and perform symbiotic N-fixation, e.g. angiosperms which are mostly found in forest area form nodules in association with actinomycetes: Alders (Alnus), species of Gunnera, species of Casuarina. The rate of N fixation by the actinomycetes is comparable with legume-rhizobium complexes in agricultural crops. Some blue green algae (Nostac) are known to form nodules to develop N fixing symbiotic relations with angiosperm (Gunnera). The rate of N fixation by Nostac algae is typically 10-20 kg N ha^{-1} (Table 18.1.)

Table: Nitrogen-fixation from different systems

Crop or Plant	Associated organism	N fixation (kg N ha^{-1} yr^{-1})
Symbiotic		
Legumes (nodulated)	Bacteria (Rhizobium)	
(i) Alfalfa (Medicago)		150-250
(ii) Clover (Trifolium)		100-150
(iii) Soyabean, Cowpea, Lupine, Vetch		50-150
(iv) Bean (Phaseolus)		
Non-legumes (nodulated)		
(i) Alders (Alnus)	Actinomycetes (Frankia)	50-150
(ii) Species of Gunnera	Blue green algae (Nostac)	10-20

Non- legumes (no-nodulated)		
(i) Bahia grass (Paspalum)	Bacteria (azatobacter)	5-30
(ii) Pangola grass (Degetaria)	Bdacteria (azospirillum)	5-30
(iii) Azolla in Rice field	Blue-green Algae (Anabaena)	150-300
Non-symbiotic	Bacteria (Azatobacter, clostridium)	NA
	Blue green algae (Various)	10-50

(2) Non-symbiotic N-fixers: Certain free living micro-organisms exist in soils and water that are able to fix molecular N from air without any symbiosis.

(a) Azotobacter and Clostridium (Heterotrophs): Azotobacter, a heterotrophic aerobic bacterium, fixes nitrogen in the rhizosphere and provides it to plants, particularly cereals and non-leguminous crops. It's sensitive to acidity (pH<6.0) and intolerant to waterlogged conditions but can act as facultative anaerobes in rice soils, utilizing oxygen from algae. While effective under irrigation, it's less so in rainfed soils due to their low organic matter content. Anaerobic bacteria like Clostridium can also fix nitrogen, often working alongside aerobic bacteria in agricultural soils. Clostridium, tolerant to acidity (soil pH=5.0-6.0), fixes less nitrogen than Azotobacter.

The amount of N fixed by these hetero-trophs varies greatly with the pH, soil N level, and SOM available to the micro-organism for energy. Generally, the rate of N fixation by these organisms is much lower than those associated with legumes. The rate of N fixation is in the range of 3-15 kg N ha^{-1} yr^{-1}.

(b) Azospirllum: It is an associative micro-aerophilic N fixer. It colonizes the root mass and fixes N in loose association with plants. It fixes N in an environment of low O_2 tension. These bacteria induce the plant roots to secrete mucilage which creates low O_2 environment and helps to fix atmospheric N. These are found in association with the roots of cereals, millets, grasses etc. especially effective for N fixation in low land rice. High N fixation capacity, low energy requirement and abundant establishment in the roots of cereals and tolerance to high soil temperature (30-40°C) makes these most suitable for tropical conditions. Use of azospirillum inoculums under saline and alkali conditions is also possible because their strains are known to maintain high nitrogenase activity under such stress conditions.

(c) Azolla: Azolla is an aquatic fern and it fixes atmospheric N in symbiotic association with blue green algae (Anabaena). Azolla is widely found both in temperate and tropical natural ecosystems as well as in low land rice growing regions. The association of azolla with blue green algae (Anabaena) is a live floating N factory having energy from photosynthesis to fix atmospheric N, amounting to 100-150 kg ha^{-1} yr^{-1} from 40-60 tons of biomass. Azolla could be used either as a green manure before rice transplanting or as dual crop after transplanting of rice, but latter practice is more beneficial. However, the biggest constraint in the large scale use of Azolla is inadequate availability of its location specific strains. Nonetheless, its multiplication is a cumbersome process as it has to be grown and multiplied in separate ponds.

(d) Blue green Algae (BGA): Among autotrophs capable of nitrogen fixation, blue-green algae (Cyanophyta) are the most significant. In light, they fix both carbon dioxide (CO2) and nitrogen simultaneously. Blue-green algae are free-living nitrogen fixers, renowned for their potential contribution to lowland rice, averaging 20-30 kg N ha-1 yr-1. While nitrogen fixation occurs in upland soils, it's considerably lower than in wetland conditions. Their nitrogen-fixing capacity is enhanced by phosphate and molybdate application, aiding rice nutrition by fixing atmospheric nitrogen and providing oxygen to the root zone through photosynthesis. Biological nitrogen fixation by free-living blue-green algae is non-symbiotic. However, certain species exhibit symbiotic nitrogen fixation, notably with aquatic fern Azolla. An economically important association is between Anabaena blue-green algae and Azolla fern. Challenges in commercial production of blue-green algae include competition from indigenous algal populations, high production costs, sensitivity to temperature fluctuations and water levels, and the need for location-specific, temperature-insensitive strains and dry inoculant formulations for improved handling and transport feasibility.

(B) Nutrient solubilizing bacteria

(i) Phosphorus solubilizing bacteria (PSB): Phosphate solubilizing micro-organisms particularly the soil bacteria belonging to the genera pseudomonas and bacillus, possess the ability to transform insoluble phosphates (PO_4^{3-}) into soluble forms. To work on P solubilizing bacteria began in India with culture obtained from Russia and an indigenous culture obtained from *Cassia occidentalis*.

The P solubilizing bacteria possess the ability to bring sparingly insoluble inorganic or organic PO_4^{3-} into soluble form by secreting organic acids. These organic acids lower soil pH, and in turn bring about dissolution of immobile forms of soil PO_4^{3-}. Some of the hydroxy acid may chelate calcium (Ca), aluminum (Al), iron (Fe) and magnesium (Mg) resulting in effective availability of soil P and therefore, its higher utilization by plants. In general, response to phosphor-bacterin is found in soils high in organic matter and low in available P. Inoculation of seed or seedling of wheat, rice, potato, chickpea with phosphor-bacterin increases the grain yield by 7-50%.

(ii) Vesicular arbuscular mycorrhiza (VAW): Vesicular Arbuscular Mycorrhizae (VAM) fungi, which form specialized structures like vesicles and arbuscles within plant roots, are obligate symbionts. Approximately 90% of plants, including major agricultural crops, are associated with VAM fungi. These fungi enhance the uptake of phosphorus (P) and are believed to aid in the uptake of zinc (Zn), copper (Cu), manganese (Mn), and iron (Fe).

Additionally, VAM fungi:

a) Produce growth promoters.
b) Enhance tolerance to drought, salinity, and transplant shock.
c) Confer resistance to pathogens.
d) Boost synergistic interactions with beneficial soil microorganisms such as nitrogen fixers and phosphate solubilizers.

However, the availability of VAM fungi culture is limited because they require live plants for maintenance and multiplication. Therefore, producing clear and pure inoculum on a large scale is challenging.

Q. 3. Discuss briefly merits of biofertilizer use

Ans. Bio-fertilizers play a vital role in Integrated Plant Nutrition Systems (INPS), optimizing nutrient supply from diverse sources while reducing reliance on energy-intensive chemical fertilizers. Their merits include:

(i) Natural origin: Bio-fertilizers contain living microorganisms from plant roots or soil, generally without harmful effects on soil fertility.

(ii) Small dosage: A small amount, typically 350-500 g per hectare, is sufficient due to high concentrations of viable cells in each gram of carrier.

(iii) Variety and proven utility: Numerous bio-fertilizers are available for various crops, with documented yield increases under different conditions.

(iv) Residual soil fertility: Bio-fertilizers leave beneficial effects on soil fertility beyond the current crop cycle.

(v) Promotion of root growth: Some bio-fertilizers, like Azospirillum and phosphor-bacterin, produce growth-promoting substances, enhancing root growth and crop stand.

(vi) Acceleration of flowering and maturity: Bio-fertilizers can hasten flowering and crop maturity to some extent.
(vii) Adaptability: Rhizobium culture exhibits better adaptability to diverse agro-climatic conditions due to its tolerance to salt and pH variations.
(viii) Cost-effectiveness: Bio-fertilizers offer high cost-benefit ratios without significant risks.
(ix) Bio-pesticidal potential: Certain bio-fertilizers, such as Azotobacterin strains, may act as biopesticides, inhibiting seed-borne pathogens in cereals.
(x) Renewable and eco-friendly: Bio-fertilizers are renewable resources that do not contribute to pollution.
These qualities make bio-fertilizers indispensable for sustainable agricultural practices, contributing to increased yields, soil health, and environmental conservation.

Q. 4. State constraints to the use of bio-fertilizers

Ans.

Despite their potential benefits, farmers' acceptance of bio-fertilizers remains unsatisfactory due to several constraints:

Production Constraints:

(a) Limited availability of ideal carriers like peat and lignite in India.
(b) Soil and agro-climatic specificity of biological strains restricts widespread use.
(c) Presence of ineffective or antagonistic strains in bio-inoculants reduces overall efficiency.
(d) Mutation during fermentation reduces effectiveness.
(e) High-tech equipment and facilities are needed for contamination-free production.

Marketing Constraints:

(a) Short lifespan of bio-fertilizers, often less than six months.
(b) Lack of proper transportation and storage facilities.
(c) Limited demand due to farmers' unawareness of advantages.
(d) Inadequate promotional support due to low turnover and profitability.
(e) Lack of interest from dealers due to low profit margins and turnover.
(f) Low demand generation due to lack of supply push.

Field Level Constraints:

(a) Soil conditions such as acidity, alkalinity, pesticide use, and high nitrate levels limit inoculant effectiveness.
(b) Presence of toxic elements and deficiencies in P, Co, and Mo hinder bacterial fertilizer performance.
(c) Sub-standard inoculants, faulty inoculation techniques, agro-chemical effects, waterlogging, or drought reduce effectiveness

Q. 5. Give precautions for the use of bio-fertilizers

Ans. Precautions for the use of bio-fertilizers are as follows:
(i) Keep the packet of the culture at a cool and shady place, till their use.
(ii) Use the material before the date of expiry.
(iii) Use a biofertilizer only for the crop specified on the packet, especially in the ease of rhizobium culture.
(iv) Open the packet containing the culture just before use and inoculate only that much seed which could be sown immediately.
(v) Do not put culture in warm or hot water which could destroy the living bacteria contained in the bio-fertilizer.
(vi) For seed treatment, if besides a bio-fertilizer, the seed is also to be treated with a fungicide or insecticide, treat the seed first with a fungicide followed by the insecticide and finally with the bio-fertilizer.
(vii) While using a bio-fertilizer in strongly acidic or saline and alkali soils, it would be desirable to use some soil amendment along with bio-inoculant.

(viii) Adequate nutrition, for instance, with P, Ca, K etc., for the normal growth and activity of rhizobium is a must and should be restored.

Q. 6. Describe in brief production and marketing of biofertilizers in India

Ans. (A) Production and marketing of bio-fertilizers by NAFED: At present, NAFED is producing and marketing following different types of bio-fertilizers for various crops:

(1) Rhizobium culture. These bacteria fix the atmospheric N, nodulated in legume crops. Benefitted legume crops are soybean, groundnut, pulses, leguminous forage etc.

(2) Azotobacter culture. Aerobic bacteria fix N in free living condition. Benefitted crops are cereals, and non-leguminous plants.

(3) Azospirillum. Micro-aerophilic bacteria fix the N in low O_2 tension. Benefitted crops are millets, rice etc.

(4) Super Culture. Balanced formulation of Azotobacter essential micro-nutrients and growth factors. Benefitted crops are cash crops like sugarcane, potato etc.

(5) Flower Care. Formulation or Azotobacter micro-nutrients growth factors and Gibberelic acid. All ornamental crops are benefitted by this bio-fertilizer

(6) Vegetable Care. Azotobacter micro-nutrients growth factors and tricontanol, suitable for all vegetables.

(7) Superphos. Composed of *Pseudomonas striata* and *Aspergillus awamori*, produces organic acids which solublize the insoluble P and make them available to plants. The product is beneficial for all crops.

(8) VAM. Helps in better absorption of N, P and vital micro-nutrients from the soil. The bio-fertilizer is effective on many crops especially suitable for transplanted crops.

(B) Production and marketing of bio-fertilizers by Gujarat State Fertilizers Company (G.S.F.C.): G.S.F.C. is producing and marketing the following four different types of bio-fertilizers for various crops :

(i) Sardar Azotobacter Culture. For cereals cash crops and vegetables.

(ii) Sardar Azospirillium Culture. For cereals, cash crops and vegetables.

(iii) Sardar Rhizobium Culture. For pulses and leguminous crops.

(iv) Sardar Phosphate Culture. For all crops.

(C) Production and marketing of bio-fertilizers by Madras Fertilizers Limited (M.F.I.): M.F.I. is producing and marketing bio-fertilizers like azospirillum for rice, sugarcane, cotton and millets, rhizobium for groundnut and pulses and phosphor-bacteria for all crops.