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Biofertilizers: A Sustainable Alternative for Modern Agriculture

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One of the best modern agricultural tools is bio-fertilizer. It is a gift from agricultural science of today. In the agricultural area, biofertilizers are sprayed in place of traditional fertilizers. Green manure, compost, and household wastes are all found in conventional fertilizers. They don't work as well as fertilizers made of chemicals. For crop development, farmers so frequently attempt to apply chemical fertilizers in the field. However, it is clear that chemical fertilizers are harmful to the ecosystem. They can disperse substances that cause cancer and are accountable for soil, air, and water pollution. Furthermore, they can eventually deplete the soil's fertility. In an effort to reduce pollution and promote universal health, scientists have created biofertilizers. Microorganisms found in biofertilizer help the host plants receive an appropriate amount of nutrients, support healthy development, and maintain physiological balance. Bio-fertilizers are made with the aid of living microorganisms. Only microorganisms with particular roles in promoting plant growth and reproduction are employed. The microorganisms employed in biofertilizers come in a variety of forms. Being a fundamental element of organic farming, biofertilizer is crucial for preserving soil sustainability and fertility over the long term.

Bio-fertilizer

Biofertilizers are substances that are enriched with bacteria that aid in the growth of trees and plants by providing them with more vital nutrients. It is made up by living things, such as bacteria, blue-green algae, and mycorrhizal fungi.

Need of bio-fertilizers

Synthetic fertilizers have been used indiscriminately, which has contaminated the soil, contaminated water basins, killed beneficial insects and microorganisms, increased crop disease susceptibility, and decreased soil fertility. In order to meet the anticipated output of 321 million tons of food grain by 2020, an estimated 28.8 million tons of nutrients would be needed, but only 21.6 million tons will be available—a shortfall of almost 7.2 million tons. growing fertilizer costs and the depletion of feedstock and fossil fuels (the energy crisis). Small and marginal farmers are finding this to be unaffordable, and the growing disparity between nutrient supplies and removal is eroding soil fertility. Additionally, concerns about environmental dangers are growing, and the threat to sustainable agriculture is mounting. In addition to the previously mentioned advantages, long-term usage of biofertilizers over chemical fertilizers is more affordable, environmentally benign, productive, efficient, and accessible to marginal and small farmers.

Benefits of Bio-fertilizers

- Increase crop yield by 20-30%.
- Stimulate plant growth.
- Activate the soil biologically.
- Restore natural soil fertility.
- Provide tolerance against drought and some soil borne diseases.

Potential Characteristic features of some bio-fertilizers

Nitrogen fixers Rhizobium:

Belongs to the Rhizobiaceae family, which is symbiotic by nature and fixes nitrogen 50–100 kg/ha exclusively in conjunction with legumes. Forage legumes like lucerne and berseem, as well as oil-seed legumes like soybean and groundnut, can benefit from it. Pulsed legumes include chickpea, red-gram, pea, lentil, and black-gram, among others. The availability of a suitable strain of Rhizobium for a certain legume is critical to the successful nodulation of leguminous crops. Certain legumes allow it to invade their roots, forming tumor-like growths known as root nodules that serve as factories for the synthesis of ammonia. Rhizobium and legumes, as well as some non-legumes like Parasponia, can work together symbiotically to fix atmospheric nitrogen. The cultivation of legume crops in the field affects the population of Rhizobium in the soil. The population declines in the absence of legumes. In order to accelerate N-fixation, it is frequently necessary to repopulate the Rhizobium population close to the rhizosphere with efficient strains. For each legume to develop functional nodules, a certain species of Rhizobium is needed.

Azospirillum

belongs to the heterotrophic, associative Spirilaceae family. Apart from their capacity to fix 20–40 kg of nitrogen per hectare, they also generate compounds that control growth. While this genus has numerous species, such as *A.amazonense*, *A.halopraeferens*, and *A.brasilense*, the benefits of inoculation and their global dissemination have primarily been demonstrated for *A.lipoferum* and *A. brasilense*. Because the Azospirillum grow and fix nitrogen on organic acid salts like malic and aspartic acid, they form associative symbiosis with many plants, especially those that have the Hatch and Slack pathway (C4-dicarboxyliac pathway) for photosynthesis. As a result, it is mostly advised for crops including pearl millet, sorghum, sugarcane, and maize. In addition to remaining on the root surface, a significant amount of the Azotobacter populating the roots also penetrates inside. Not only does the azotobacter that is colonizing the roots stay on the root surface, but a significant amount of them also enters the root tissues and coexists peacefully with the plants. But they don't grow on root tissue or leave any obvious nodules behind.

Azotobacter

belongs to the aerobic, free-living, heterotrophic Azotobacteriaceae family. *A. chroococcum* is the most prevalent species in arable soils, and azotobacters can be found in neutral or alkaline soils. Other species that have been reported are *A. macrocytogenes*, *A. beijerinckii*, *A. insignis*, and *A. vinelandii*. Because of the absence of organic matter and the existence of hostile microorganisms in the soil, the number of Azotobacter rarely reaches 104 to 105 g-1 of soil. The bacterium generates antifungal antibiotics that, to a certain extent, limit seedling mortality by blocking the growth of several pathogenic fungi in the root area.

Blue Green Algae (Cyanobacteria) and Azolla

These are phototrophic organisms that belong to eight different families. They fix 20–30 kg N/ha in submerged rice fields and generate auxin, indole acetic acid, and gibberllic acid. Because they are common in paddy, they are also known as "paddy organisms." The essential ingredient needed in more amount for low-land rice production is N. Lowland rice mostly gets its nitrogen from the soil and from BNF produced by related organisms4. The combination of BNF and soil organic N mineralization by free-living and rice plant-associated bacteria provides the necessary 50–60% N. In order to attain food security via sustainable agriculture, BNF must gradually replace industrial nitrogen fixation as the primary source of fixed nitrogen.

Phosphate solubilizers

Numerous studies have looked at the solubility of several insoluble inorganic phosphate compounds, including rock phosphate, hydroxyapatite, dicalcium phosphate, and tricalcium phosphate. Bacillus, Rhizobium, Burkholderia, Achromobacter, Agrobacterium, Microccocus, Aereobacter, Flavobacterium, and Erwinia are some of the bacterial genera that possess this ability. Both the soil and the rhizospheres of plants contain sizable populations of phosphate solubilizing bacteria. These bacteria are both anaerobic and aerobic, with aerobic strains being more common in submerged soils. The rhizosphere typically has a far higher concentration of phosphate-solubilizing bacteria than non-rhizosphere soil. The more prevalent soil bacteria are those from the genera Bacillus, Pseudomonas, and Fungi.

Phosphate absorbers (Mycorrhiza)

Mycorrhiza is a phrase that means "fungus roots." It is a symbiotic relationship between a particular group of fungi and the root system of host plants. The fungus helps the host by providing it with the carbon it needs through photosynthates, and the host benefits by getting much-needed nutrients—especially phosphorus, calcium, copper, zinc, and other elements—that it would not otherwise be able to access thanks to the fungus's fine-absorbing hyphae.

With the exception of crops and plants in the families Chenopodiaceae, Amaranthaceae, Caryophyllaceae, Polygonaceae, Brassicaceae, Commelinaceae, Juncaceae, and Cyperaceae, these fungi are linked to most agricultural crops.

Zinc solubilizers

Many people recognize phosphate solubilizing bacteria like *B. magaterium, Pseudomonas striata*, and phosphate-mobilizing Mycorrhiza as bio-fertilizers, as well as nitrogen fixers like Rhizobium, Azospirillum, Azotobacter, and BGA. These, however, only provide main nutrients; soil contains a variety of microorganisms that may convert micronutrients, such as zinc, iron, copper, and others, which can be utilized as biofertilizers. Microorganisms such as B. subtilis, Thiobacillus thioxidans, and Saccharomyces sp. can solubilize zinc. These microbes can be utilized as biofertilizers to help fix micronutrients such as zinc become soluble.

Role of bio-fertilizers in agriculture

Numerous researchers have observed that the addition of biofertilizers (N-fixers) significantly increases soil fertility, yield-attributing characteristics, and ultimately final yield. Their incorporation into the soil also enhances the soil biota and reduces the need for chemical fertilizers alone.

Rhizobium inoculation increased yield above the control under temperate circumstances by improving the number of pods plant-1, number of seed pod-1, and 1000-seed weight (g). the 1000-seed weight, the number of seed pods, and the number of pods per plant. When applied to rice grown on low-lying terrain, BGA+ Azospirillum greatly improved LAI and all other parameters that contribute to yield.

It is a well-known fact that phosphate fertilizers have very low efficacy rates (15–20%) because they fix in both acidic and alkaline soils. Sadly, these soil types are more common in India, where they affect over 34% of the country's acidity and over seven million hectares of productive land that are either salinity or alkaline.

In order to restore and maintain the effective microbial populations for the solubilization of chemically fixed phosphorus and the availability of other macro and micronutrients to harvest good sustainable yields of various crops, PSB and other useful microbial inoculants must be injected into these soils.

How biofertilizers are applied to crops

- **Seed treatment**

300–400 ml of water are used to suspend 200 g of nitrogenous biofertilizer and 200 g of phosphotika, and the mixture is well mixed. After applying this paste, ten kilograms of seeds are dried in the shade. It is necessary to sow the treated seeds as soon as feasible.

- **Root dip of seedlings**

In the field, a bed is prepared and filled with water for the rice crop. The roots of the seedlings are dipped in this water for eight to ten hours after recommended biofertilizers have been combined.

- **The treatment of soil**

200 kg of compost are combined with 4 kg of each suggested biofertilizer, and the mixture is left overnight. When planting or sowing, this mixture is mixed into the soil.

How could one get good response to Biofertilizer application

- The biofertilizer product needs to be free of contaminating microorganisms and have a good, effective strain in the right population.
- Use the proper blend of biofertilizers and apply them before the expiration date.
- Apply using the recommended application technique and the recommended timing as indicated by the label's information.
- For best results, use a good and recommended adhesive when treating seeds.
- For troublesome soils, apply remedial techniques such as gypsum or lime pelleting of seeds or lime soil pH correction.

What precautions should take for using Biofertilizers

- Proper mixes of biofertilizers must be used; biofertilizer packets must be maintained in a cool, dry location away from heat and direct sunshine.

- When purchasing biofertilizers, make sure that all necessary information is included in the packet, such as the product name, the crop name for which it is intended, the manufacturer's name and address, the date of manufacture, the expiration date, the batch number, and usage instructions.
- The packet must be used before its expiration, only for the designated crop, and according to the recommended application method. Since biofertilizers are live products, storage must be done with caution.
- Because biofertilizers are live products, storage must be done with caution.
- For optimal results, employ both phosphatic and nitrogenous biofertilizers.
- In addition to chemical fertilizers and organic manures, biofertilizers should be used.

Conclusion

Biofertilizers can help sustain soil fertility over an extended period of time by making nutrients more accessible to plants. As was previously mentioned, certain microbes play a helpful role in biological nitrogen fixation, which provides nitrogen to crops. They also synthesize biomass for rice manuring and solubilize insoluble phosphates into forms that are soluble in plants. Therefore, although biofertilizers are affordable, sustainable, and environmentally beneficial, they cannot completely replace chemical fertilizers. Using biofertilizer is a crucial part of both organic farming and Integrated Nutrient Management. These days, using this technology in agricultural practices is essential. In the upcoming years, biofertilizers will play a bigger role due to the shifting landscape of agricultural methods and the environmental risks connected to chemical fertilizers.

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